Original Research Article

Forest Nursery Operations and Knowledge of Plant Parasitic Nematodes in Four Forest Districts of the Ashanti Region of Ghana

ABSTRACT

Nursery establishment for healthy seedlings is an integral part of afforestation and reforestation projects. Plant parasitic nematodes (PPNs) are amid the destructive pathogens that greatly threaten forest nurseries. This study assesses forest nursery operations and knowledge of PPNs of four forest districts of Ashanti region of Ghana, namely Juaso, Mankranso, Offinso, and Nkawie. Respondents comprised only forestry staff involved in managing forest nurseries. A Structured and semi-structured interview schedule was employed for data collection. Data obtained were analyzed using the Statistical Package for Social Science version 23. Descriptive statistics were used and means presented using tables and graphs. From the study, all the respondents (100%) established temporary nursery to meet seedlings demand. Majority of the respondents (83.3%) sourced soil from abandoned refuse dump while few (16.7%) collected top soils from unfarmed sites for raising seedlings. Disease occurrence in the nursery was observed by majority (75%) of the respondents while most (66.7%) of them had no idea of the causes of the diseases observed. Greater proportion (66.7%) of the respondents moreover had no knowledge of PPNs and therefore were unaware of their damage potential. Organising seminars and workshops for nursery managers on proper operations and awareness of PPNs to enhance their knowledge is recommended.

Keywords: Forest operations, nursery, plant parasitic nematode, forest district, seedlings

1. INTRODUCTION

Nematodes are pseudocoelomate unsegmented worms, commonly described as thread-like, typically approximately 5 to 100 µm thick and at least 0.1 mm but less than 2.5 mm long. [1]. Nematodes can be categorized into free-living nematodes and as parasites of animals (animal parasitic) and plants (plant-parasitic). In agriculture and forestry, plant-parasitic nematodes have been reported to be harmful to most economic crops and forest plants. Study has shown that root-knot nematodes are among the most deleterious plant parasitic nematodes in Africa with a wide plant host range [2].

Plant-parasitic nematodes can become established in forest nurseries in several ways. In many cases, the nematodes were probably already established in fields when the land was converted from agricultural crop production or forests. Nursery fields can also become infested with nematodes by practices such as soil movement from elsewhere to the nursery, transplanting infected plants and by wind or flooding [3]. Nursery equipment may also move soil and nematodes within a field and to other uninfested fields. An example of this contamination occurred in a Georgia nursery where initially caused seedling stunting in a few small patches of 3 to 9 m of nursery bed that within a few years spread throughout one-half of a 10-acre (4-hectare) field [4].

Symptoms associated with nematode damage can be highly variable. In some cases, the seedlings will be severely stunted, chlorotic, and even wilted. Adequate moisture and fertilizer can sometimes compensate for nematode damage and minimize aboveground symptoms. In some cases, symptoms of nematode damage may be confused with other factors, including nutrient deficiencies, root disease, insect damage, seasonal effects, and inadequate or excess water [3]. Nematode injury can predispose seedling roots to opportunistic and pathogenic fungi resulting in greater damage and root rot through the formation of diseases complexes. Nematode diseases are difficult to manage because, above ground symptoms usually result from below ground infections, which are not easily observed by growers and nursery managers. Nematode damage to most crops and forest plants is usually related to the initial numbers of the nematode in the soil. Control strategies are, therefore, aimed at reducing these initial numbers [5].

Seedling production is an integral part of most tree-growing programs. Nurseries are established in order to produce seedlings, and are often a major part of most forestry projects [6].
Nematodes are generally soil inhabitants and attack underground parts of plants, and the damage caused by them cannot be diagnosed by above ground symptoms alone, as general symptoms mostly resemble those of several other biotic agents or some nutrient deficiency [7]. Sustainable and high-quality tree seedling production devoid of plant parasitic nematodes can be greatly achieved through knowledge of the occurrence and management of nematodes parasitizing forest plant seedlings. Furthermore, understanding the damage potential of plant parasitic nematodes is very essential for the implementation of nematode management strategies. Therefore, a survey was conducted from August to September 2021 to assess forest nursery operations and knowledge of plant parasitic nematodes in four forest districts in the Ashanti region of Ghana.

2. MATERIALS AND METHODS

2.1 Study Area

The study was conducted in four (4) of nine (9) forest districts in the Ashanti region of Ghana. They are the Juaso, Mankranso, Offinso, and Nkawie forest districts. The other five (5), New Edubiase, Kumawu, Bekwai, Kumasi, and Mampong forest districts, could not be covered due to resource constraints. The forest districts overlap with regard to political or administrative districts. The region is located in the middle portion of Ghana, approximately within longitudes of 0.15° E and 2.25° W and latitudes of 5.50° N and 7.46° S. It shares boundaries with Bono East Region to the North, Western Region to the West, Eastern Region to the East and Central Region to the South. Administratively the Region is divided into Forty-three (43) Metropolitan, Municipal and District Assemblies (MMDAs). These are one (1) Metropolis, Eighteen (18) Municipalities and Twenty-Four (24) Districts. [8] The

region experiences double maxima rainfall in a year, with peaks in May/June and October. The mean annual rainfall is between 1100 mm and 1800 mm. The mean annual temperature ranges between 25.5 °C in the southern districts and 32°C in the northern parts of the region. Humidity is high, averaging about 85% in the southern districts and 65% in the northern part of the region. Soils in the Ashanti region are mainly of two types, forest ochrosols and savanna ochrosols. Forest ochrosols are found in the southern districts, whilst savanna ochrosols are confined to the northern districts. About 3,180 sq km, representing 22.5% of Ghana's forest reserves, are in the region. About 2,340 sq km (65%) of the forest is being exploited, whilst the remaining 1,240 sq km (32%) is protected. Some economic trees found include Wawa, Odum, Sapele and others. Lumbering activities, therefore, take place in almost all the districts in the region. Agriculture is the dominant sector in the region's economic activities, and it is endowed with abundant arable lands that support the production of cash crops such as cocoa, coffee, oil palm, mango, and food crops like cassava, plantain, maize, and vegetables [9].

Figure 1 shows the forest districts in Ashanti region of Ghana.

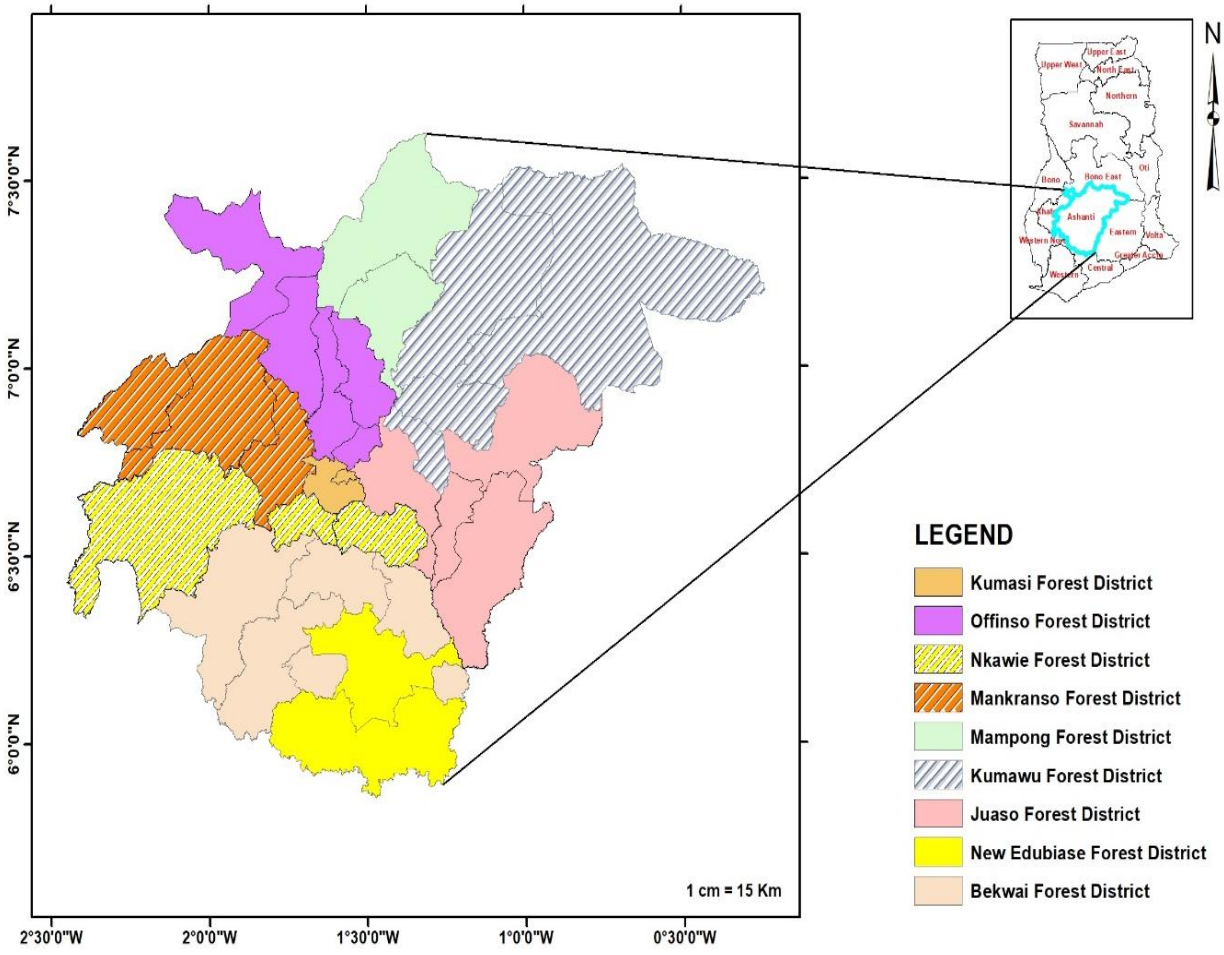

Fig. 1. A map of Ashanti region showing forest districts in the region.

Source: (Resource Management Support Center (RMSC) of Forestry Commision, Kumasi)

2.2 Data Collection Method

A survey was conducted from August to September 2021 using in-depth structured and semi-structured interview schedules to obtain data on forest nursery operations and knowledge of plant parasitic nematodes. Forest District managers of the study areas were contacted to provide names, contacts and communities of staff who have prime duties of undertaking and managing nursery operations. The maximum and minimum number of staffs provided by the District managers were four and three respectively. Three respondents each were purposively sampled from the four forest districts. Purposive sampling was employed targeting staffs of the forest districts who had core mandate in the establishment of nurseries and raising of forest tree seedlings for reforestation and afforestation purposes and therefore understood the phenomenon under study. The less sample size is as a result of targeting only forestry staffs in the various forest districts who have duties of managing and undertaking nursery operations. The set of structured interview schedules comprised both open-ended and closed questions but placed more emphasis on the former to allow respondents to express themselves freely and give detail accounts of the subject under study for the purpose of obtaining information on nursery operations and knowledge of plant parasitic nematodes.

2.3 Data Analysis

Data collected were analysed using the statistical package for social science (IBM SPSS) version 23. Descriptive statistics were used and the means were presented using tables and graphs.

3. RESULTS AND DISCUSSION

3.1 Gender, Educational Level, Specialisation in Education, Position and Experience in Forestry

Findings from the study showed that both male (33.3 %) and female (66.7 %) were into forestry, where female forestry staff clearly dominated in the study forest districts (Table 1**)**. The increased participation of women in forest management and practices may be driven by benefits such as monthly salaries and allowances obtained for their livelihoods and to support their families. This study agrees with [10], whose work reported a high participation of women in forestry and stated that women are very active in afforestation practices, and thus advocate for community forest management and development. Furthermore, women's participation in decision-making has been found to improve natural resource management [11], reduce destructive conflicts [12], and improve conservation outcomes [13, 14]. To some extent, the 2030 Agenda for Sustainable Development [15] also referred to women's participation in the social management of forests and climate change mitigation.

All respondents had formal education and at least a secondary education. The majority (91.7%) of the respondents had tertiary education, while the rest (8.3%) have completed their secondary education (Table 1). The highest percentage (83.3%) of the respondents specialized in forestry, 8.3% in agriculture, and only 8.3% had secondary education without a specialization (Table 1). The higher level of education and forestry specialization of respondents can improve their technical and managerial skills [16]. Education is believed to increase respondents' ability to use current technologies to achieve greater efficiency [17] in forest management.

Regarding respondents' positions or designations in the various forest districts studied, the majority (83.3 %) were noted to be Range supervisors who also managed nurseries, while 16.7 % were only Nursery managers (Table 1). Respondents' experiences in forestry varied. The majority (41.7%) had been in forestry for 26-30 years, while 25.0%, 16.7%, and 8.3%

were experienced in forestry for 21-25 years, 11-15 years, and both 6-10 years and above 30 years respectively (Figure. 2). Most of the respondents had significant experience in forestry and therefore rose to the rank of Range supervisors. High working experience could be a precursor to high quality work and performance since respondents might have learnt on the job as in the case of [18] whose work supported the non-interactive hypothesis which holds that work experience increases job performance of high- and low-ability employees at the same rate.

Table 1. Background information of respondents

Background information	Percentage
Gender	
Male	33.3
Female	66.7
Total	**100**
Educational level	
Secondary	8.3
Tertiary	91.7
Total	**100**
Specialisation in education	
Forestry	83.3
Agriculture	8.3
No specialisation	8.3
Total	**100**
Position	
Range supervisor	83.3
Nursery manager	16.7
Total	**100**

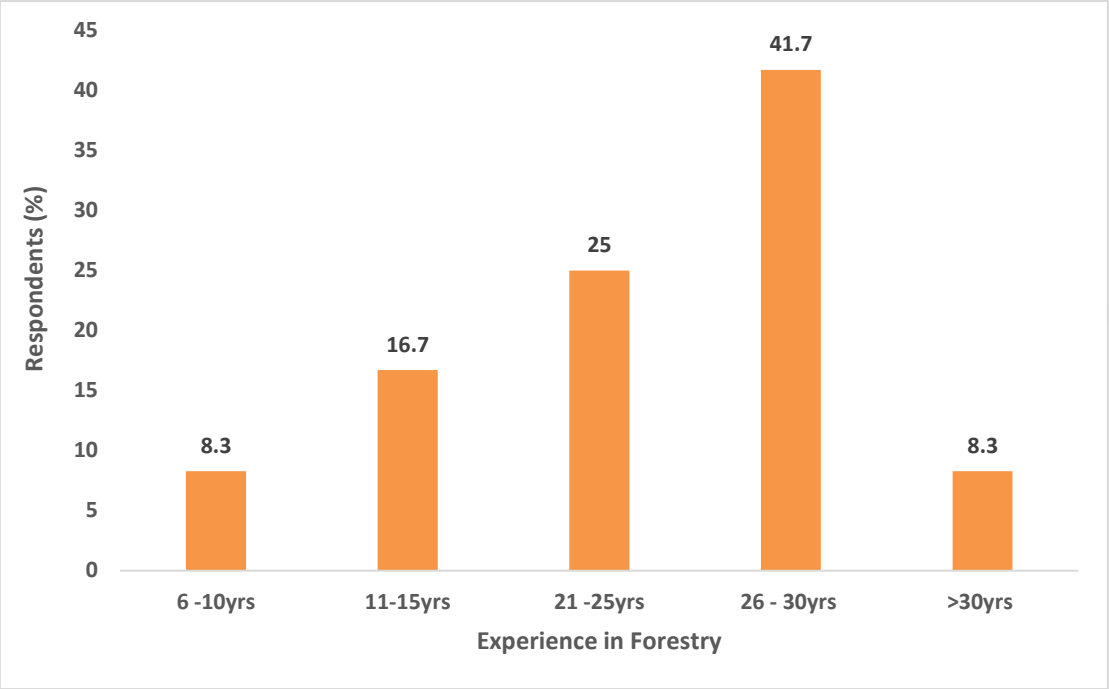

Figure. 2 Respondents experiences in Forestry

3.2 Type of Nursery, Operations and Soil for Nursery Establishment

All the respondents (100%) practiced temporary nursery establishment to supply planting stock for a very short period of time, and therefore, their nurseries were sited near to the areas to be regenerated without any permanent nursery structure. Their opinion of the temporary nursery was its quick and cheap transport of seedlings without any serious damage or shock. Notwithstanding their opinion, proper supervision or care could be obstructed since the nursery is sited very far away from the manager. This could lead to high seedling mortality when there is a sudden incidence of diseases and pest infestation. Moreover, there will be no seedlings to supply in or fill-in dead transplanted seedlings, which could greatly affect negatively the tree density of the area of regeneration.

All the respondents (100%) mentioned loamy or "black soil" as they popularly called for their nursery; majority of them (83.3%) sourced their soil from abandoned refuse dump while the remaining (16.7%) collected top soils of unfarmed sites. Soil from abandoned dump site could have high nutrient capacity to sustain the growth and development of the seedling as asserted by [19] that the deposition of wastes impacted the physical and chemical properties by improving soil organic matter content and increasing nutrient contents, thus enhancing soil fertility and productivity status of the soil for maximum plant growth. In addition, the use of soil from refuse dump site is an unconscious way of reducing nematode populations through direct or indirect stimulation of predators and parasites of plant-parasitic nematodes in forest nurseries as reported by [20] that refuse dump significantly reduced plant-parasitic nematode populations on tomato.

Moreover, all the respondents (100%) processed their soil by breaking large lumps, removal of debris and plant roots and at times sieving of soil to be used for tiny tree seeds. These

practices carried out by the respondents could enhance adequate soil aeration, drainage, unconscious reduction of nematode to new areas through removal of plant roots that might harbour parasitic nematode from soil source. None of the respondents fertilize their soil; this could be as a result that soil from abandoned refuse dump is fertile and enough for supporting seedling growth. [19]

3.3 Disease Occurrence

Disease occurrence was noted to be observed by the majority of the respondents (75%) in the nursery, while a few (25%) reported no disease observation. Some of the diseases reported by the respondents were leaf curl, stunting, root knots, leaf yellowing, chlorosis, and leaf spots. Less proportion of the respondents (33.3%) stated that the diseases they observed were caused by an inadequate supply of water, while greater proportion (66.7%) had no idea of the causes of the diseases observed. Most of the respondents (75%) did not uproot diseased seedlings to observe roots for further diagnosis. Leaf curl and spots as observed by the respondents require in-depth diagnosis to adequately determine the particular pathogen as the cause, but root knots, leaf yellowing and stunting could be suggestive of nematode activities on the seedlings as observed by [21] that most root systems of olive plants grown in *Meloidogyne incognita* or *Meloidogyne javanica* infested soils were galled within the gall index range of 1.4 – 6 and main shoot length was significantly suppressed by *Meloidogyne incognita*. Leaf yellowing and stunting could, moreover be suggestive of soil nutrient and water deficiencies. Typical symptoms of nematode injury can involve both above ground and below ground plant parts. Foliar symptoms of nematode infestation of roots generally involve stunting and general unthriftiness, premature wilting and slow recovery to improved soil moisture conditions, leaf chlorosis and other symptoms characteristic of nutrient deficiency[22]. Despite the high level of education and experience of respondents in forestry, the majority inability to determine the causes of the various diseases encountered in their nursery is an indication of a low level of knowledge of plant diseases which needs to be improved.

3.4 Nematode Awareness

The Majority of the respondents (66.7%) had never heard of nematodes as a pathogen as at the time of interview and therefore were not aware of them, while only 33.7% had heard about them but did not know about their damage potential to forest seedlings. Greater proportion of the respondents (75%) were not aware that soil used for nursery could harbour potential pathogens that could cause severe diseases to seedlings while few (25%) of them were aware. Damage caused by nematodes is common in forest tree and ornamental plant nurseries [23]. Respondents' unawareness of plant parasitic nematodes could be the reason for their failure to uproot diseased seedlings to observe roots for diagnosis. Soil-borne fungal pathogens such as *Fusarium* spp., *Rhizoctonia* spp., *Pythium* spp. and *Phytophthora* spp. are devastating due to their attack on young seedlings in forest nurseries [24, 25]. As they may cause pre- and post-emergence damping-off, stem rot, foliar blight and root damages (root rot, root dieback) of forest tree seedlings in nurseries [26]. Nematodes may also form inter-relationships with fungal pathogens to form disease complexes. The Majority of the respondents' unawareness of soil having the capability of harbouring soil-borne pathogens could lead to an outbreak of soil borne diseases in their nurseries since measures would not be taken to manage them.

4. CONCLUSION

From the study, it can be concluded that the majority of the respondents were females, which is a good representation of gender equity. Most of the respondents being highly

educated and experienced in forestry could enhance effective and efficient forest management. Respondents' practice of temporary nursery establishment is a hindrance to the continuous availability of seedlings for filling-in or supplying-in. Sourcing soil from abandoned refuse dumps for nursery by respondents is an encouraging practice, but soil should be fumigated to reduce soil borne pathogen infections. Seedling diseases reported by the respondents were: leaf curl, stunting, root knots, leaf yellowing, and leaf spots. The majority of the respondents had no knowledge of plant parasitic nematodes and soil borne pathogens. Respondents' low level of knowledge in plant diseases can enhance disease outbreaks in nurseries.

It is therefore recommended that permanent nurseries be established to ensure a continuous supply of seedlings for afforestation and re-forestation programs and also to have enough seedlings to fill-in or supply-in planted dead seedlings. The use of soil from abandoned refuse dumps is encouraged for its fertility and effectiveness in reducing nematode populations. It is also recommended that forestry staff in the study areas be refreshed through seminars and workshops on awareness of plant parasitic nematodes and soil-borne pathogens to enhance their knowledge. Similar work should be conducted on the remaining forest districts in the Ashanti region to ascertain nursery operations and knowledge of plant parasitic nematodes in those forest districts.

COMPETING INTERESTS DISCLAIMER:

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

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