

## INVOLVEMENT OF LOCAL COMMUNITIES IN NURSERY ESTABLISHMENT AND PRACTICES FOR PLANTATION DEVELOPMENT IN SOUTHERN GHANA

<sup>1</sup>M. M. Apetorgbor and <sup>2</sup>D. E. K. A. Siaw

<sup>1</sup> CSIR-Forestry Research Institute of Ghana, University Post Office Box UP 63, KNUST, Kumasi

<sup>2</sup>Faculty of Forest Resources Technology, KNUST, Kumasi

Email: mape@csir-forig.org.gh

### ABSTRACT

Plantation establishment has become a necessary intervention to decrease pressure on Ghana's dwindling forest resources. The success of plantation development depends on the quality of seedlings produced. This study was carried out to assess cultural practices in various nurseries in southern Ghana, identify seed collection and processing methods and evaluate the effects on tree seedling production. Information was gathered using structured questionnaires administered to 240 seedling producers in nineteen selected districts in four regions in southern Ghana. While about 44% depended on forestry extension officers for knowledge in seedling production, 28% depended on previous knowledge and experience to produce seedlings. *Tectona grandis* seedlings were the most produced, followed by *Cedrela odorata*, *Terminalia superba*, *Ceiba pentandra*, *Triplochiton scleroxylon*, *Khaya* species and *Mansonia altissima* in that order. Sixty four per cent collected seeds from the wild while 34% collected from plantations and the rest from seed orchards. Forty eight per cent of respondents collected seeds from tree tops while the rest collected from the forest floor. Seedlings were raised in polythene pots (polypots) or transplant beds with loamy and sandy soils. Diseases such as damping-off, leaf spot, shoot dieback and wilting were commonly encountered in the nursery. Pests including crickets, termites and squirrels were common problems. Management of nursery diseases and pests is linked to nursery operations; therefore, it is important for nursery managers and operators to undergo formal training in seedling production techniques.

**Keywords:** *Tree seedlings, forest nurseries, nursery practices, Tectona grandis, nursery pests, seedling diseases*

### INTRODUCTION

Ghana is known to have one of the highest rates of deforestation in West Africa (Benhin and Barbier, 2001). Many of the forest reserves are in a degraded state as a result of over-harvesting for timber, forest fires, and farming (Hawthorne and Abu-Juam, 1995). The area of intact forest was estimated at between 10.9 and 11.8% of the

original cover (MES, 2002). It was estimated by MES (2002) that less than 1% of the forest cover was found outside forest reserves, much of it being in small scattered patches in swamps and sacred groves. To restore the integrity of the forest, there is the need to go into plantation establishment to complement timber from the natural forests and sustain timber supply for domestic and international markets.

Plantation establishment is a necessary intervention to decrease the pressure on the forest which is dwindling at a rate of 1.3% per annum (MES, 2002, FPDP, 2002).

The declining forest resources prompted the Government of Ghana to come up with the National Forest Plantation Development Programme with a target of establishing 200,000 ha of plantations over a ten period (Nanang, 2012). Through the government's initiatives on reforestation of degraded forest reserves, 18,000 ha of the targeted 200,000 ha were planted in 2002, as against 1,000 ha planted annually in previous years. The reforestation drive in the country has focused mainly on *Tectona grandis* (Teak) and *Cedrela odorata* (FC, 2007). At the current planting rate of 18,000 ha per year, seedling demand stands at approximately 22 million seedlings per year since most initial spacing used in plantations is 3m x 3m.

Since very few plantations can rely on direct seeding or wildlings gathered from under existing trees, the obvious requirement of successful plantation programmes is to raise high quality seedlings in nurseries for field establishment (Evans, 2004). The quality of seedlings produced depends to a large extent on the care given to the seedlings at the nursery stage (Leuschner, 1984). Adequate quantities and quality of seedlings can be produced if good quality seeds are collected, followed by appropriate seed handling and seedling nurturing techniques.

In Ghana, information on tree nurseries and production practices is lacking. This study was therefore carried out to identify seed collection and processing methods, assess cultural practices and evaluate their effects on seedling production in selected nurseries in parts of southern Ghana.

## MATERIALS AND METHODS

The study was carried out in purposively selected Forest districts in the Ashanti, Brong Ahafo,

Eastern, and Western Regions. In Ashanti Region, New Edubease, Bekwai, Konongo, Ejisu, Nkawie, Juaso, Mampong, and Offinso districts were surveyed. In Brong Ahafo, Sunyani, Bechem, Dormaa Ahenkro and Goaso districts were surveyed. In the Eastern Region, Somanya, Begoro, Akim Oda and Koforidua, whiles Bibiani, Tarkwa and Samreboi districts were surveyed in the Western Region (Figure 1).



Figure 1: Map of Southern Ghana showing areas where questionnaires on nursery practices were administered.

Interviews were held by means of structured questionnaires to collect the needed information from the nursery owners and/or their employees.

A total of 240 respondents (at least 10 farmers in each town) were purposively interviewed in their homes. The questionnaires sought to obtain information on the social profile of respondents, seed collection and processing methods, cultural practices at the nurseries and diseases and pests encountered.

The Statistical Package for Social Scientists (SPSS) Software and Excel, 2007 were used to analyze the data.

## RESULTS

### Social profile of the respondents

In general, 55% of the respondents involved in nursery establishment were males and the rest were females. However, males dominated in the establishment of nurseries in Ashanti (72%) and Western (60%) regions, while females dominated in the Brong Ahafo (57%) and Eastern (55%) regions. Generally, it was observed that people in the 31- 40 and 41-50 years age groups were those mostly involved in nursery activities followed by those in the 51-60 and 21-30 years age groups (Figure 2).

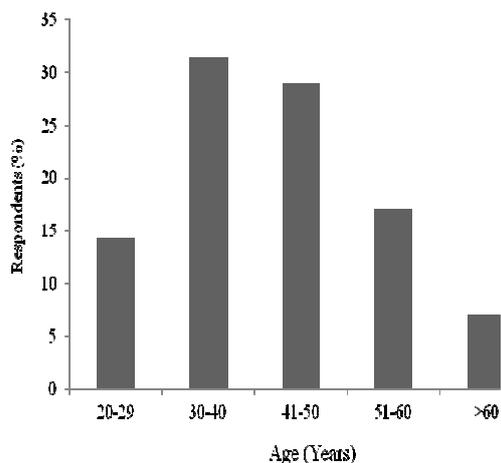


Figure 2: Age of respondents involved in establishment of forest tree nurseries.

Forty three percent of respondents involved in nursery establishment were farmers, 13% were government workers (civil and public servants), 13% were unemployed, 7% were retirees, 6% were housewives and the rest (3%) were traders (Figure 3).

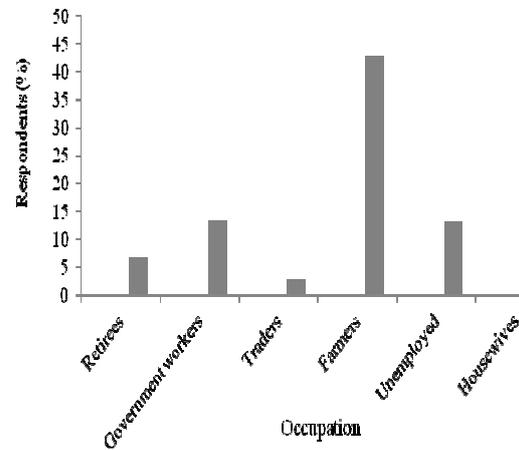


Figure 3: Primary occupation of respondents involved in the establishment of forest nurseries.

When respondents were asked how they acquired knowledge on seedling production, 28% said they produced seedlings based on previous knowledge, 44% said they were introduced to the job by Forestry Extension Officers, 20% were taught by friends, 3% were taught by their spouses and the rest by relatives (Figure 4).

There is an emerging trend that more people are getting involved in seedling production over the last six years. Twenty five percent were producing seedlings for the last six years but the number of producers had increased to 75% as at the time of the interview.

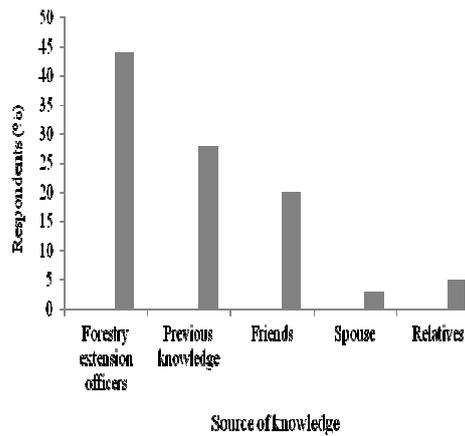


Figure 4: Source of knowledge of respondents involved in seedling production.

### Seed collection and processing

Tree seeds were obtained from three sources, namely plantations, solitary or individual trees in towns or communities or from institutions that collected seeds from orchards. Sixty one per cent of respondents collected seeds from the wild using hired labour. Three per cent of the producers purchased seeds from the Forestry Research Institute of Ghana of the Council for Scientific and Industrial Research (CSIR-FORIG), 29% bought seeds from the Plantation Unit of the Forest Services Division (FSD) while the rest purchased their seeds from non-governmental organizations (NGOs) and people from nearby towns and villages (Figure 5).

Forty eight per cent of respondents indicated that they collected seeds from tree tops using climbing equipment while others collected seeds from the forest floor (Figure 6). Twenty-seven percent of respondents who collected seeds from tree tops said these seeds gave better germination and seedling growth and yield than those collected from the forest floor.

Seeds collected by respondents were mainly *Tectona grandis* (Teak) seeds, or sometimes in combination with *Cedrela odorata* (Cedrela), *Khaya ivorensis* (Mahogany) and *Terminalia superba* (Ofram).

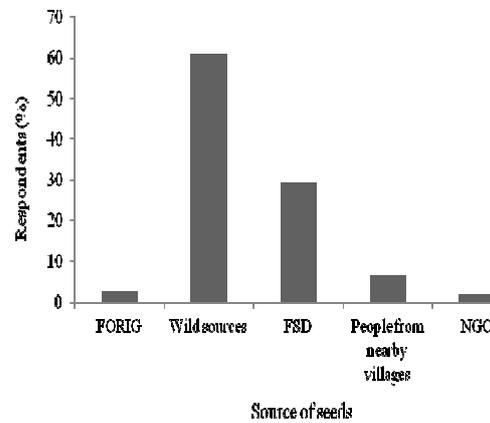


Figure 5: Source of seeds collected by respondents for establishment of nurseries.

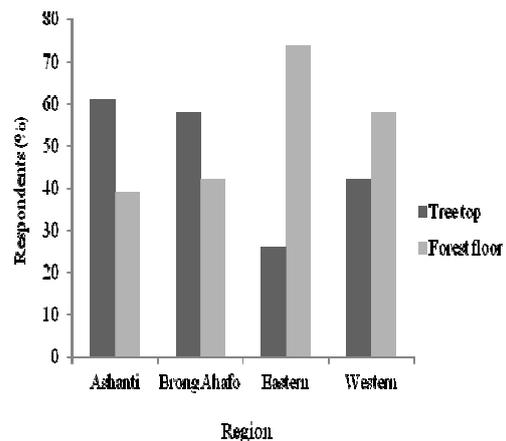


Figure 6: Method of seed collection by respondents in the various regions.

Only few respondents collected and raised teak seedlings together with other species such as *Mansonia altissima* (Opron), *Ceiba pentandra* (Ceiba), *Triplochiton scleroxylon* (Wawa), *Senna siamea* (Cassia) and/or *Eucalyptus* spp. in their nurseries. With regard to those who collected teak seeds, 34% of respondents collected seeds from plantation areas, 64% collected seeds from the wild while a few, such as CSIR-FORIG collected seeds from seed orchards (Figure 7).

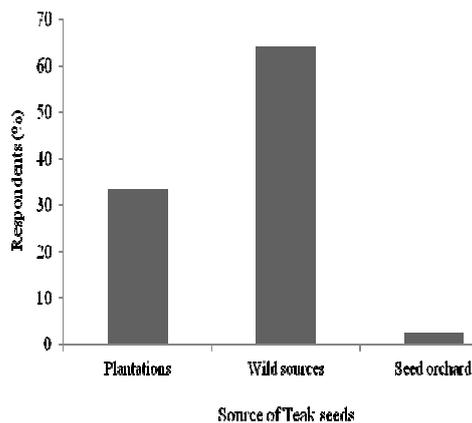


Figure 7: Sources of teak seeds collected by nursery operators.

In considering characteristics of trees from which to collect seeds, 45% of respondents looked at straightness of the tree bole, 19% considered mature trees with good shape and form and 18% preferred disease-free trees. Other seed collectors considered easily accessible trees that bore many fruits and lacked buttresses (Figure 8).

In general, 45% of the respondents processed teak seeds by soaking the fruits in water, extracting the seeds and air-drying them (Figure 9). Thirty one per cent of the respondents dehusked the seeds while 19% beat and dehusked or threshed them depending on the type of seeds collected.

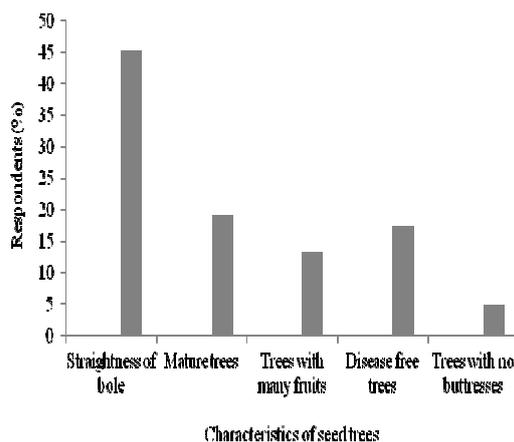


Figure 8: Characteristics for selecting seed trees by nursery operators.

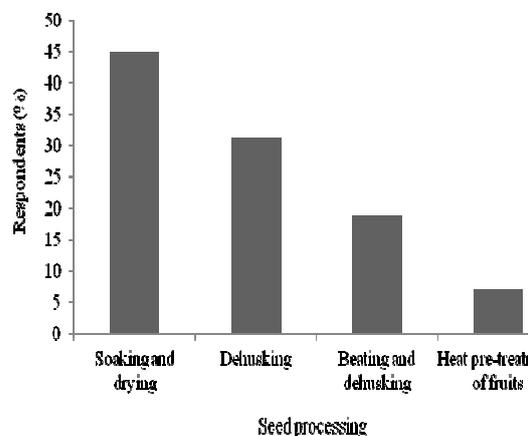


Figure 9: Methods of processing seeds by seedling producers.

The seeds were pretreated by soaking in water for a few days before sowing to reduce the germination period and enhance good germination. Cedrela and mahogany fruits, on the other hand, were dried in the sun to enhance dehiscence and facilitate seed extraction.

## Nursery practices

Generally, sowing, watering, hand picking of weeds, weeding, shading, fertilizer, insecticide and fungicide application were various cultural activities undertaken at the nurseries. Most respondents (76%) did not apply fertilizers to seedlings in the nursery.

Respondents established nurseries around streams, used well water, tap water, borehole or rainwater to water seedlings. Watering of seedlings was done either twice (early mornings or late evenings) or once a day depending on the season.

Seventy three per cent of the respondents raised seedlings in polybags while the rest use transplant beds. For those using polybags, 56% used black polybags while 44% used discarded sachet water polybags. Generally, respondents preferred the use of black polybags because of contract preference; seedlings occupy less space and grow fast and uniformly. Seeds sown on germination beds are later transplanted either into polybags filled with soil or on to transplant beds.

Forty seven per cent of the respondents used soil from around their nurseries, 8% used soil from refuse dumps, 19% bought top soil from contractors while the rest collected soil from termite hills or used any other soil available.

Eighty one per cent of respondents used palm branches or Cassia leaves as shading material for their seedling beds, 17% raised seedlings in unshaded areas while the rest used black nylon shade nets.

It was observed that only few (5%) of the respondents weighed seeds before sowing to enable them know the number of seeds which germinated per unit weight and to determine the cost involved. Although respondents are not aware of the number of seeds which weigh one kilogramme, they estimated the number of seedlings expected when one kilogramme of seeds was sown as follows: *Tectona grandis*, 2,000 -

10,000; *Terminalia superba*, 2,500 - 3,000; *Cedrela odorata*, 4,500 - 5,000; *Khaya ivorensis*, 3,000 - 4,500; *Mansonia altissima*, 1,000 - 1,600; *Ceiba pentandra*, 1,800 - 2,000; *Triplochiton scleroxylon*, 4,000 - 5,000.

Seedlings were produced mostly for commercial purposes. Forty nine percent of the respondents produced seedlings to generate or supplement income or establish their own plantations. Of those who invested in seedling production, 62% of them used their own capital, or took bank loans, while others mobilized funds from the Ghana Government (HIPC Plantation Project), or non-governmental organisations (NGO) and spouses or other family members.

Twenty per cent of the respondents produced below 10,000 seedlings annually. Twenty eight per cent produced 11,000 - 20,000 seedlings, 10% produced 41,000 - 50,000, 4% produced 100,000 - 200,000 while 5% produced more than 200,000 seedlings annually.

Teak seedlings were raised by all respondents interviewed. Thirty three per cent of respondents indicated that they raised large quantities of *Tectona grandis* seedlings together with a few of either *Cedrela odorata*, *Khaya ivorensis*, *Terminalia superba*, *Ceiba pentandra*, *Triplochiton scleroxylon*, *Senna siamea* or *Mansonia altissima* depending on customer preference. Large quantities of *Tectona grandis* seedlings together with few of *Senna siamea* or *Terminalia superba* were raised in nurseries in the Brong Ahafo Region while majority of respondents raised *Tectona grandis* and *Cedrela odorata* seedlings in the Ashanti Region.

Seventy eight per cent of respondents had no formal training in raising seedlings. Most of them look up to the government and NGO's for sponsorship to such training programmes. As to record keeping, most of them did not have any knowledge; only a few kept notebooks/diaries to record activities carried out in the nursery.

### Pests and diseases and their control

Concerning the health of seedlings in the nursery, 21% of the respondents said they encountered pest and disease problems during seedling emergence while 16% encountered pest and disease problems at the onset of the rains. Other respondents encountered these problems during transplanting periods, usually a week after transplanting, while 59% did not encounter any pest and disease problems (Figure 10).

Pests commonly encountered in nurseries were mainly lizards, snails, termites, caterpillars and crickets. These attacked and chewed the seeds or leaves of seedlings on the beds. Domestic fowls and goats often trampled seedlings in nurseries located around homes that lacked fencing.

Forty four percent of seedling producers encountered disease attacks such as leaf spot, wilting, damping-off and shoot dieback (Table 1).

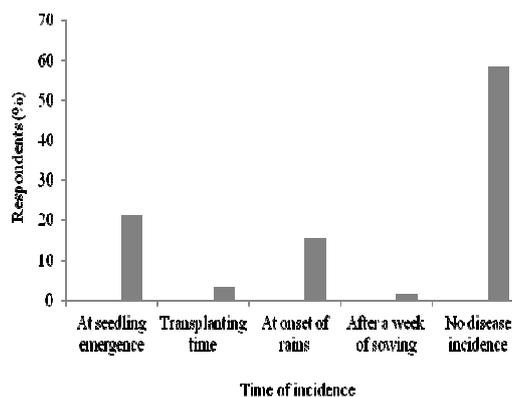


Figure 10: Timing of incidence of diseases and pests in nurseries.

Table 1: Pests and diseases encountered in nurseries in the study area.

Tree Species	Local Name	Pest	Disease
<i>Cedrela odorata</i>	Cedrela	Snails, crickets, termites, millipedes	Damping-off, wilting, stem rot, leaf spot
<i>Khaya ivorensis</i>	Mahogany	Snails, <i>Hypsipyla robusta</i>	Leaf spot
<i>Terminalia ivorensis</i>	Emire	Caterpillars with hairs	Leaf spot, dieback of shoot
<i>Terminalia superba</i>	Ofram	Caterpillars with hairs, termites, millipedes, crickets	Leaf spot, damping-off
<i>Ceiba pentandra</i>	Silk cotton tree	Millipedes, crickets	Dieback of shoot, leaf spot
<i>Tectona grandis</i>	Teak	Crickets, termites	Leaf spot, wilting of seedlings, root rot, damping-off
<i>Senna siamea</i>	Cassia	-	Leaf spot, damping off
<i>Mansonia altissima</i>	Mansonia	-	Wilting of seedlings

Respondents mentioned that exotic seedlings like *Tectona grandis* were able to withstand pests and diseases better than indigenous seedlings such as *Terminalia superba*, *Khaya ivorensis* and *Ceiba pentandra*. The number of seedlings affected per bed varied from < 10% to 50% or whole beds in some cases.

Eighteen percent of respondents who had pest and disease problems did not make any attempts to control them. Those who made attempts used insecticides, combinations of fungicides and insecticides, fungicides alone or wood ash. Only one percent of the respondents took samples of the disease-infected plant part to CSIR-FORIG and FSD to seek control measures.

## DISCUSSION

### Collection and processing of seeds

This study has revealed that many of the respondents do not follow standard procedures for seed collection and processing even though a code of practice exists for tree seed collections. However, Evans (2004) indicates such practices are not adhered to mainly due to ignorance. Earlier studies by Cobbinah *et al.* (2001) reported that in Ghana, improved seeds from Forestry Research Institute of Ghana orchards are recommended because the seedlings possess desirable characteristics as compared to those obtained from other sources. The fact that only 3% of respondents obtained seeds from CSIR-FORIG suggests that they were not aware of the availability of high quality seeds from this source, or could not afford to pay for the higher cost.

The fact that most respondents collected mature seeds from tree tops suggests that they appreciate the importance of using the appropriate seed collection methods. Germination test carried out by Oppong and Quarshie-Sam (2000) reported that the quality of tree seeds depends on maturity and the method of collection and that seeds from tree tops are of good quality. Apetorgbor *et al.*

(2003) also showed that seeds collected from the forest floor have higher incidence of fungal infection than those from the tree top. Additionally, predation by insects and ground foraging animals may be a problem to fallen fruits on the ground especially those with fleshy fruits (Evans, 2004).

With regard to seed processing, the results of the study showed that teak fruits were air-dried before seeds were extracted. Cedrela and mahogany seeds on the other hand were extracted from the fruits and sun-dried on sheets or containers. While these processes may be appropriate, Shepherd, (1986) noted that fleshy fruits need to be processed soon after collection as fermentation can damage the seed through bacterial and fungal infection. Evans (2004) also noted that seed processing carries with it the risk of damage by machines, heat, chemicals or prolonged soaking in water. It is therefore noteworthy that seeds need to be processed with care to avoid damage.

### Seedling production

Respondents' high preference for the production of Teak seedlings was attributed to high demand by plantation developers. This high demand probably derives from the high growth rate (Foli *et al.*, 2007) and its resistance to all weather conditions and fires (Bhat *et al.*, 2005).

### Nursery practices

Sowing, watering, shading, weeding, fertilizer and pesticide application were common cultural activities in nurseries.

Generally, respondents preferred the use of polythene bags because of higher preference by clients. It is common knowledge that the use of polythene bags optimizes the use of nursery space and ensures fast and uniform seedling growth. Evans (1992) and Jinks, (1994) reported that the great advantages of using the potting method for seedling production are excellent survival at planting, low field planting risks, extended

planting season and fast growth in controlled environment. Owusu-Sekyere (2007) however noted that potted seedlings are bulky for transportation and roots of seedlings are unable to grow outwards but tend to coil inside the container.

Seedling producers were not particular about the source of soil used. Majority of them used loamy soil while a few used sandy or clayey soil. Soil for filling containers must be light enough to provide free drainage, sandy loam or loamy sands which organic matter content can stabilize soil structure and maintain pore size (Pyatt, 1994). The majority of modern nurseries raise seedlings in containers and use washed river sand, composted organic matter and peat. This is because of the poor physical properties and pathogens associated with soil based mixes. It is suggested that before establishing a permanent nursery the soil should be physically and chemically analysed (Evans, 2004).

Shade protects seeds and seedlings from direct sun light, wide temperature fluctuations, desiccation and heavy rains (Napier and Robins, 1989). The need for shading differs according to tree seedling species, stage of seedling development and nursery location (Evans, 2004).

In the present study, palm branches and / or Cassia leaves were used as shading material for seedlings, but some seedling producers raised seedlings in the open and others used nylon shade nets. Other shading materials like banana leaves, grass, wood or bamboo strips, veneer off cuts and netting are also known to be suitable. For Teak, however, no shade was provided. According to Evans (2004), Teak does not need any shading and grows satisfactorily from the time of germination in an open bed.

Fertilizer application was not practiced by most respondents. Production of healthy seedlings however depends on adequate supply of plant nutrients (Speight and Wylie, 2001). Poor plant

nutrition results in poor seedling development, reduced growth and greater susceptibility to pests and diseases. Therefore, fertilizer needs to be applied where necessary either before sowing, during bed preparation, or potting (Proe, 1994; Evans, 2004).

### **Pests, diseases and their control**

The incidence of pests and diseases in nurseries, as observed in this study could be attributed to insects and other arthropods. Cobbinah *et al.*, (2001) found that although serious pest problems have been noted in native species plantations such as *Triplochiton scleroxylon*, *Mansonia altissima*, *Khaya ivorensis* and *Terminalia superba* in Ghana, exotic species such as *Cedrela odorata* and *Tectona grandis* have so far been free from any serious pest problems in nurseries.

Leaf spot, wilting, damping off and shoot dieback were some diseases encountered in the nurseries. These could be attributed to overwatering, excessive shading or poor ventilation. Damping-off of seedlings and defoliation of young plants might be as a result *Cylindrocladium* spp. which are common pathogens in nurseries when nursery operators collect soil from gardens, plantations and forests and around nurseries as planting medium as well as irrigate seedlings using stream water (Roux *et al.*, 2005). Leaf spot of *Ceiba pentandra* and wilting of *Cedrela odorata* leaves were encountered by some seedling producers. Serious outbreaks of leaf spot in *Ceiba pentandra* which resulted in dieback have caused high mortality in various nurseries in Ghana (Apetorgbor *et al.*, 2003).

Seedling producers who encountered pest and disease problems in the nurseries applied insecticides, fungicides and wood ash. Some sought advice on control measures from CSIR-FORIG and FSD. Therefore with only limited knowledge in nursery establishment, it is important for seedling producers to consult

scientists and other experts in the field for assistance.

## CONCLUSION

The study has revealed that most nursery operators depended on their own limited knowledge and experience to produce seedlings and they were unaware that poor cultural practices frequently contributed to the production of poor quality seedlings appropriate nursery practices are necessary in order to reduce the incidence of diseases and pests and ensure the production of high quality seedlings. It is therefore important for nursery managers and operators to undergo formal training in seedling production practices.

## ACKNOWLEDGEMENT

We wish to express our sincere gratitude to Mr. Alfred K. Apetorgbor (KNUST) for his valuable contribution in the questionnaire and script preparation, Mrs. Theresa Peparah (CSIR-FORIG) for her technical contributions, Ms. Millicent K. Mensah and Mr. Felix K. Kporxah, students of Faculty of Forest Resources Technology, KNUST, Sunyani campus for the field work.

## REFERENCES

- Apetorgbor, M. M., Siaw, D. E. K. A. and Gyimah, A.** (2003). Decline of *Ceiba pentandra* seedlings, a tropical timber species in nurseries and plantations. *Ghana Journal of Forestry*, **11** (2): 51-62.
- Bhat, K. M., Nair, K. K. N., Muralidhoran, E. M. and Sharma, J. K.** (2005). Quality product of Teak from Sustainable Forest Research Institute, India. pp. 80 - 82.
- Benhin, J. K. A. and Barbier, E. B.** (2001). The effects of adjustment in Ghana of the structural program on deforestation. *Agricultural and Resource Economics Review*, **30** (1): 66-80.
- Brown, C. H.** (1967). Afforestation Programme in Relation to National Economy. Proceedings of the World Symposium on man-made forest and their importance. FAO, Rome. pp. 150-177.
- Cobbinah, J. R., Siaw, D. E. K. A. and Gyimah, A.** (2001). Guide to tree planting in Ghana. Forest Plantation Development Centre. pp. 24-30.
- Evans, J.** (2004). *Plantation Forestry in the Tropics*. Revised Edition. Clarendon Press, Oxford. pp. 102-107.
- Evans, J.** (1992). *Plantation Forestry in the Tropics*, Oxford Science Publications, Oxford University Press. 424 pp.
- Foli, E. G.** (2007). 100 Years of Forestry in Ghana: Ensuring Sustainable Timber Production through Plantation Development. Invited paper presented at the 12<sup>th</sup> Ghana International Furniture and Industry Exhibition (GIFEX 2008), at the International Trade Fair Site, La, Accra. 21-24 October, 2008.
- Forestry Commission.** (2007). Ghana Forestry Commission, Annual report, 2007. Accra.
- Forest Plantation Development Project** (2002). Annual Report Ghana Forestry Commission, Accra. 472 pp.
- Hawthorne, W. D. and Abu-Juam, M.** (1995). *Forest Protection in Ghana*. Forest Conservation Series. 14. IUCN, Gland.
- Leuschner, W. A.** (1984). *Introduction to Forest Management*. John Wiley and Sons Inc., New York. pp. 87-106.
- Ministry of Environment and Science** (2002). National Biodiversity Strategy for Ghana. Ghana National Biodiversity Country Study Report. 62 pp.
- Napier, I and Robbins, M.** (1989). Forest seed and nursery practice in Nepal. Nepal-UK Forestry Research Project (Kathmandu). 139 pp.

- Nanang, D. M.** (2012). *Plantation Forestry in Ghana: theory and applications*. Agronomy Research and Development. Nova Science Publishers, Inc. New York. 288 pp.
- Nyland, R. D.** (1996). *Silviculture: Concepts and Applications*. Second Edition. McGraw-Hill, New York. 631 pp.
- Oppong, S. K. and Quashie-Sam, S. J.** (2000). *Manual of agroforestry technology and tree nursery polypots*. Commonwealth Forestry Institute, Oxford. 111 pp.
- Owusu-Sekyere, E.** (2007). Effects of Poultry manure application on raising of seedlings in polypots. FFRT, KNUST. 40 pp.
- Proe, M. F.** (1994). *Plant nutrition*. Forestry Nursery Practice (Ed.) Aldhous, J. R. & Mason, W. L. Forestry Commission Bulletin III. London. HMSO. pp. 37 - 65.
- Roux, J., Meke, G., Kanyi, B., Mwangi, L., Mbaga, A., Hunter, G. C., Nakabonge, G., Heath, R. N. and Wingfield, M. J.** (2005). Diseases of plantation forestry trees in Eastern and Southern Africa. *South African Journal of Science*, **101**:409 - 413.
- Shepherd, K. R.** (1986). *Plantation Silviculture*. Martinus Nijhoff, Dordrecht, the Netherlands. 85 pp.
- Speight, M. R. and Wylie, F. R.** (2001). *Insect Pests in Tropical Forestry*. CABI Publishing, CAB International, Wallingford, UK. 307 pp.