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SURVEY OF COLLECTION AND HANDLING OF SEEDS OF FOREST TREE SPECIES AND AWARENESS OF SEED-BORNE FUNGI IN FOUR FOREST DISTRICTS OF THE ASHANTI REGION, GHANA

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Abstract

Forest trees' seeds carry numerous seed-borne fungi which cause considerable damage to seedlings. These fungi can infect seeds while on mother tree, during seed collection and storage. To minimize seed-borne fungi damage, knowledge about them is imperative. Hence, this research sought to establish forest trees' seeds collection, storage practices and awareness of seed-borne fungi infection of four Forest Districts in the Ashanti region of Ghana namely Offinso, Nkawie, Juaso and Mankranso. Respondents comprised only staff of Forestry Commission who are directly involved in seed collection and storage. Structured and semi-structured interview schedules were used for data collection. Data obtained were analyzed using the Statistical Package for Social Science version 23. Descriptive statistics was used and means presented using tables and graphs. From the study, 33.3% of the respondents collected seeds from forest reserves by floor collection only as against plucking only (8.3%) while 58.3% collected seeds by both floor collection and plucking. All the respondents (100%) collected seeds between the months of November and March. Majority of the respondents (58.3%) and (100%) did not clean and treat seeds with fungicides before storage respectively. Most of the respondents (66.7%) mixed same seeds species but different mother trees for storage. Fifty percent of the respondents failed to keep records of seed mother trees and were also unaware of seed-borne fungi infection. It is recommended that, Forestry Commission of Ghana trains its forestry staff in the study areas through workshops on proper seed collection practices, storage and create awareness of seed-borne fungi infections among its staff.

Keywords: Seed-borne fungi, forest district, seed collection, mother tree, infection

Introduction

Afforestation and reforestation are major strategies of ameliorating the high rate of deforestation which is a global concern (Kalu et al., 2014). Humanity, biodiversity and the survival of ecosystems have received great support from forests and trees species. A greater number of the world's population depend on forest resources for food, medicine and other forest values (Amoah & Korle, 2020). Undoubtedly, the activities of both human and other factors have contributed to the reduction in the Earth's Forest cover. According to the 2018 Sustainable Development Report, the Earth's Forest cover reduced by 100 million hectares from 2000 to 2015 (Amoah & Korle, 2020). Considering Ghana's annual deforestation rate of about 2% (135,000 ha/year), the future of forests in Ghana is worrying (MLNR, 2016).

This annual rate of deforestation requires the raising of a great quantity of seedlings from healthy and good-quality seeds for afforestation and reforestation. This can help address the alarming deforestation rate and all the economic and environmental effects associated with it. Healthy seeds are among

the key resources required for successful reforestation and afforestation programs (Gure, 2004). However, one of the barriers to seed supply is infection by pathogenic fungi in both fresh and stored seeds. (Schmidt, 2007). There are numerous types of field plant pathogenic fungi which are carried into storage. Infection of seed-borne pathogenic fungi can lead to germination failure, reduction in seed longevity during storage, cause diseases in seeds and plants, damping-off in the nurseries and they can also permanently settle in the soil (Dhingra et al., 2003, Sutherland et al., 2002). In addition, seed-borne fungi may deteriorate and predispose seeds and seedlings to different soil-borne diseases (Mamatha et al., 2000). Additionally, negative impacts of seed-borne fungi involve diseases of reproductive structures of seeds, twig dieback and stem-cankers (Burgess & Wingfield, 2002; Brown, 2000).

Furthermore, poor quality seeds have the potential to spread diseases to different places by serving as effective carriers of plant pathogens over long distances (Gure, 2004). Undoubtedly, the incidence and severity of numerous seed-borne fungi, is frequently attributed to inappropriate handling of seeds (Prochazkova & Jancarik, 1991). One of the important factors in the acquisition of seed-borne fungi is the contamination of seed with soil, especially when seeds are collected from the forest floor, the ground beneath seed orchard trees. For instance, when beechnuts (*Fagus* spp.) were collected from the forest floor, they were found to have been infected with *Phytophthora cactorum* (Prochazkova & Jancarik, 1991).

Seed tissues may be infected with fungal propagules at any period from flowering to the post-shedding stage. This may occur while the fruits are still on the trees, on the ground, during collection and processing, during transportation or in storage (Dhingra et al., 2003).

A sustainable production of healthy and good-quality seeds may be challenging to accomplish for some reasons. Firstly, the production of seeds by forest trees is highly diverse. For some species the trees may not produce seeds in certain years, or seed yield could be very low or of reduced quality (Edwards, 1984). Secondly, forest trees are also exposed to diverse biotic and abiotic factors that may affect the normal development of the trees and seeds. Among the biotic factors, pathogens including fungi frequently infect seeds (Sutherland et al., 2002). Hence the effect of fungi associated with forest trees' seeds must be of high priority to forest nurseries and tree improvement programs which are major strategies to combating deforestation. (Sutherland et al., 2002).

Unfortunately, there is inadequate documented information on the level of awareness of forestry staff of seed-borne fungi infection and the possible management strategies. Investigating and documenting information on seed-borne fungi infection and management strategies has the potential to facilitate the production and supply of quality seeds for the country's afforestation and reforestation programmes.

This study, therefore, sought to assess forest tree seed collection, storage practices and awareness of seed-borne fungi among forestry staff.

Materials and Methods

Study area

The study was conducted in four (4) out of nine (9) Forest Districts in the Ashanti region of Ghana. The forest districts studied were Offinso, Nkawie, Juaso and Mankranso. The remaining five (5) forest districts which were not studied due to resource constraints were Kumasi, Mampong, Kumawu, Bekwai and New Edubiase. The Forest Districts overlap one another with regards to political or administrative districts. The Ashanti region is located in the middle portion of Ghana, within longitudes 0.15^{o} E and 2.25^{o} W and latitudes 5.50^{o} N and 7.46^{o} 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 (https://www.cwsa.gov.gh/ashanti-region/). The region experiences double maxima rainfall in a year, with peaks in May/June and October. Mean annual rainfall is between 1100 mm and 1800 mm. The mean annual temperature ranges between 25.5^{0}C in the southern districts and 32^{0}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. High humidity induces proliferations of fungi and hence a precursor to high plant fungal infections and diseases in the region (Li et al., 2014). The Ashanti region has two main soil types, forest ochrosols and savanna ochrosols. The southern districts has the forest ochrosols whilst the savanna ochrosols are found in 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. *Triplochiton scleroxylon* (Wawa), *Milicia excelsa* (Odum) and *Entandrophragma cylindricum* (Sapele) are some of the economic trees found in the region. Lumbering activities 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 which support the production of cash crops such as coconut, cocoa, coffee, oil palm, mango and food crops like cocoyam, cassava, plantain, maize, and vegetables (https://mofa.gov.gh/site/directorates/regional-directorates/ashanti-region). Figure one illustrates the Forest Districts in Ashanti region of Ghana.

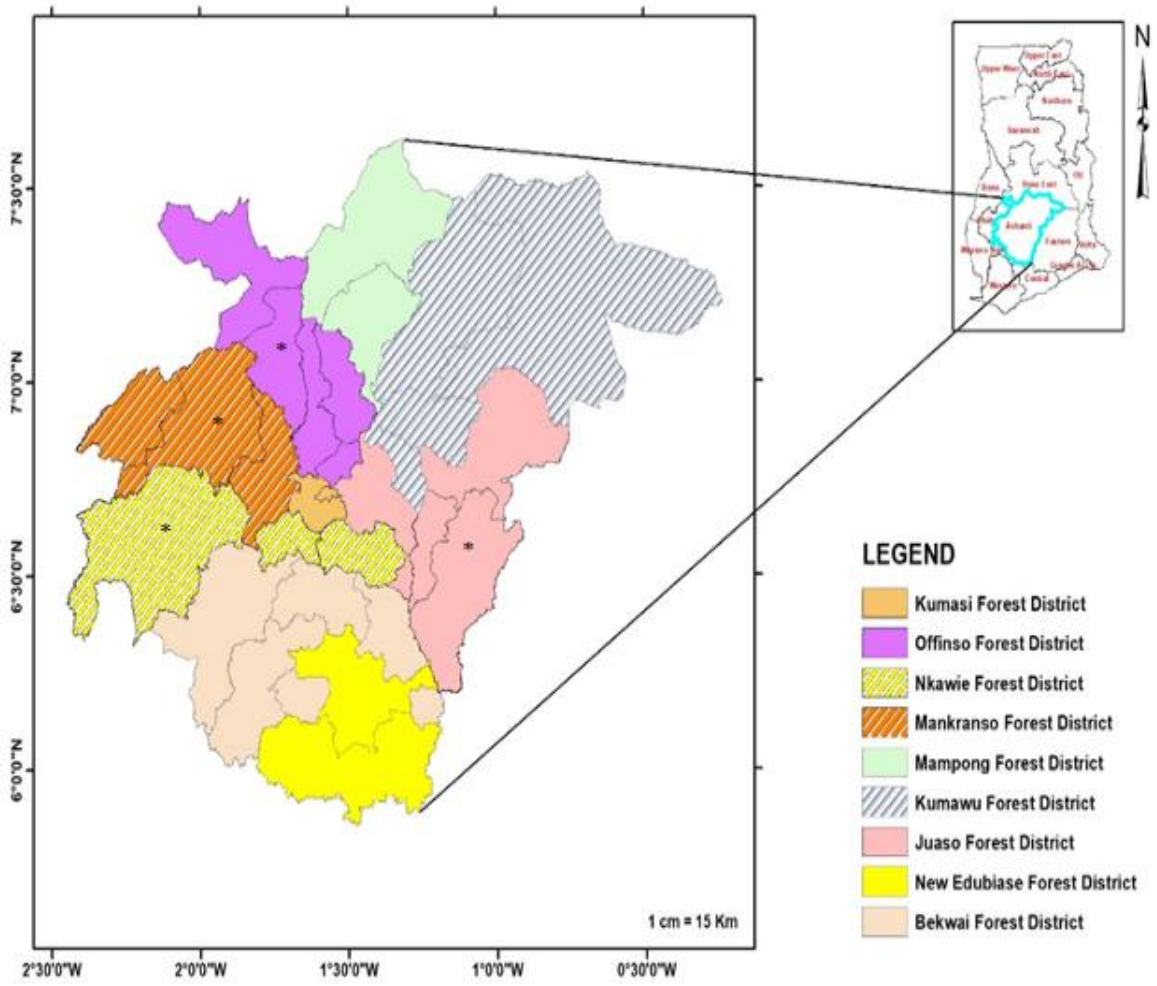

Figure. 1. A map of Ashanti region showing Forest Districts in the region.

Areas indicated by * are the study Forest Districts.

Source: *(Resource Management Support Center (RMSC) of Forestry Commission, Ghana)*

Research design

A mixed-method research design combing qualitative and quantitative methods of data collection was employed for the study but relied more on qualitative data by means of detailed structured and semi-structured interviews. Data was collected from August to September 2021. The respondents were mainly staff from the Forestry Services Division of the Ghana Forestry Commission. Forest District managers in the study areas were contacted to provide names, contacts and communities of staff who collect forest tree seeds for the establishment of nurseries and raising of forest tree seedlings. The maximum and minimum number of staff given by the District managers were four and three respectively. Three respondents each were purposively sampled from the four Forest Districts. Purposive sampling was used bearing in mind the categories of groups or persons within the Forest Districts whose core mandate is the collection and storage of forest tree seeds for the establishment of nurseries and raising of forest tree seedlings for reforestation and afforestation purposes. The sample size seems to be less due to the reason that only forestry staff in the various Forest Districts who have the responsibility of collecting and storing seeds were targeted. The interview schedules comprised open-ended and closed-ended questions but placed more emphasis on the open-ended questions to permit respondents to freely express themselves on the subject under study. The research instrument was tailored for obtaining information on the collection of forest tree seeds, seed storage and the awareness of the incidence of seed-borne fungi.

Table 1. Forest Districts and number of respondents interviewed

Forest district	Number of respondents
Offinso	3
Nkawie	3
Juaso	3
Mankranso	3
Total	**12**

Source: *Field survey, 2021*

Data Analysis

Data collected were analysed using the Statistical Package for Social Science (IBM SPSS) version 23. Descriptive statistics were used and means were presented in tables and graphs.

Results

Gender, educational level, specialisation, position and experience of respondents in forestry

Of the forestry staff interviewed, there were more females (66.7 %) than males (33.3 %). (Table 2**)**. All the respondents were formally educated and had formal education. Majority (91.7 %) of the respondents had tertiary education while the remaining (8.3 %) had secondary education (Table 2**)**. A greater percentage (83.3%) of the respondents had their speciality in forestry, 8.3 % in General Agriculture and 8.3 % had only secondary education without specialisation (Table 2**)**. With respect to respondents' positions in the various Forest Districts studied, majority (83. 3 %) were Range Supervisors who also manage nurseries while 16.7 % were only nursery managers (Table 2**)**. Respondents' experiences in forestry varied; majority (41.7%) had worked in the Forestry department for 26-30 years while 25% and 16.7% had served for 21-25 years and 11-15 years respectively. It was also found that 8.3% of the staff had worked for 6-10 years and

another 8.3% had served for more than 30 years in the department (Figure. 2).

Table 2. Background information of respondents

Background information	Frequency	Percentage
Gender		
Male	4	33.3
Female	8	66.7
Total	**12**	**100**
Educational level		
Secondary	1	8.3
Tertiary	11	91.7
Total	**12**	**100**
Specialisation in education		
Forestry	10	83.3
Agriculture	1	8.3
No specialisation	1	8.3
Total	**12**	**100**
Position		
Range supervisor	10	83.3
Nursery manager	2	16.7
Total	**12**	**100**

Source: *Field survey, 2021*

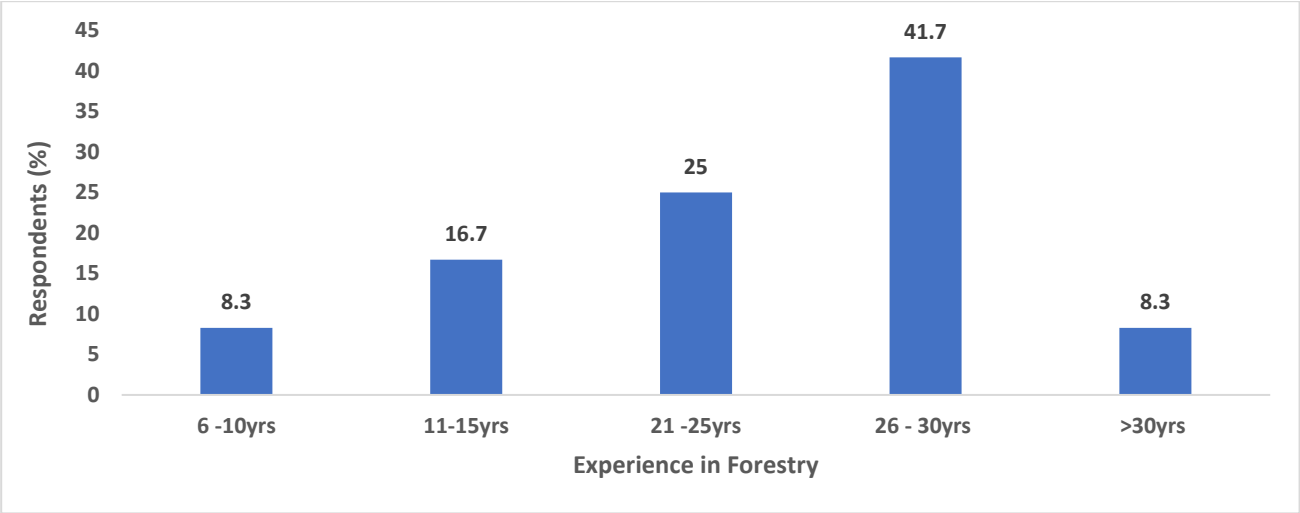

Figure 2. Respondents' experiences in Forestry
Source: *Field survey, 2021*

Timber tree seeds collection

Respondents collected seeds from two major sources; the Forest Reserves (FRs) and Forest Research Institutions (FRIs) for raising seedlings for afforestation and reforestation programs. Most of the respondents (91.7%) collected seeds from both FRs and FRIs, 8.3% of them collected seeds from only the FRs (Table 3**)**. Majority (58.3%) of the respondents who collected seeds from the FRs employed both the method of floor collection and plucking, 33.3 % collected seeds only

from floors while the rest (8.3%) collected seeds only by plucking from the FRs (Figure 3**)**. Fifty percent (50%) of the respondents mixed plucked seeds with those seeds collected from floors while the remaining 50% separated plucked seeds from seeds collected from the floor (Table 3**)**. Half (50%) of the respondents kept records on seed mother plants while the other half (50%) did not (Table 3**)**. All the respondents (100%) collected seeds between the months of November and March.

Table 3. Timber tree seeds collection practices

Seed collection practice	Frequency	Percentage
Source of seed collection		
Forest reserve only	1	8.3
Forest reserve and Research institution	11	91.7
Total	**12**	**100**
Mixture of floor collected seeds with plucked seeds		
Yes	6	50.0
No	6	50.0
Total	**12**	**100**
Records on seed mother trees		
Yes	6	50.0
No	6	50.0
Total	**12**	**100**

Source: *Field survey, 2021*

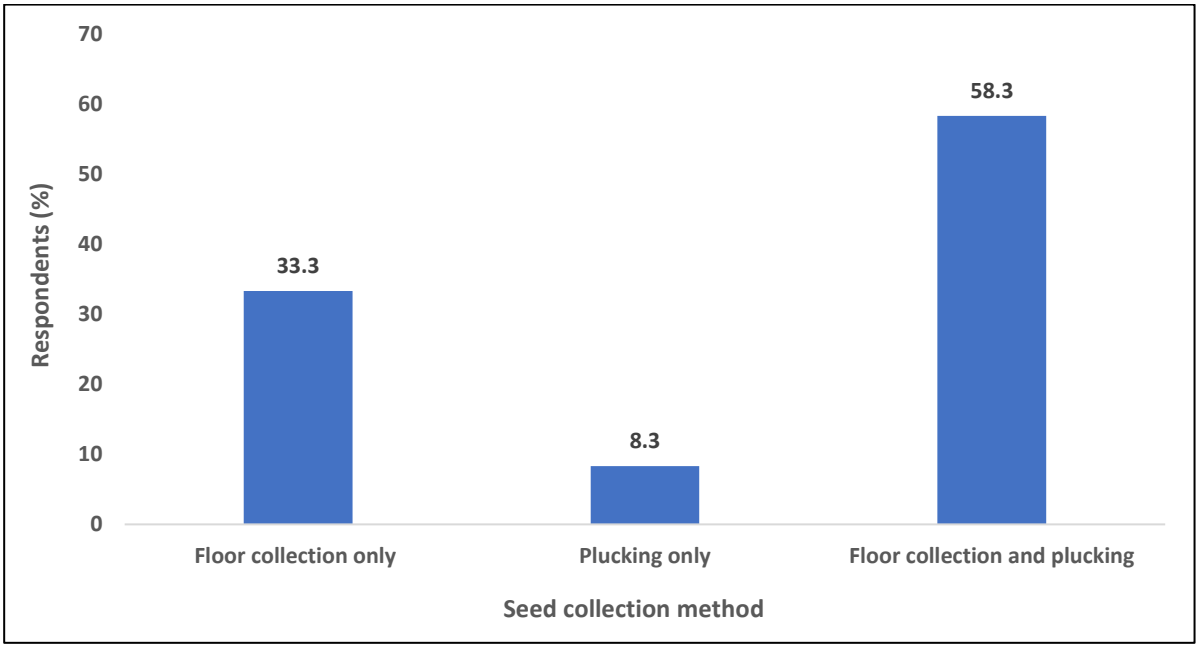

Figure 3. Seed collection methods by respondents
Source: *Field survey, 2021*

Seed storage

All the respondents (100%) stored seeds for not more than three months. Majority of the respondents (58.3%) did not clean their seeds before storage but waited till seeds were ready to be used before they performed the floatation method to exclude diseased and

insect infested seeds. None of the respondents treated their seeds against seed-borne diseases before storage. Two storage containers; polythene bags and polypropylene (PP) bags were mainly used by respondents for seed storage. A greater percentage (91.7%) of the respondents stored seeds in PP bags while the remaining (8.3%) stored seeds in polythene bags (Table 4**)**. Majority of the respondents (66.7%) mixed same seeds species but from different mother trees before storage while the rest (33.3%) stored seeds in separate containers for different mother trees (Table 4**)**.

Table 4. Seed storage practices by respondents

Seed storage practice	Frequency	Percentage
Container for seed storage		
Polypropylene bags	11	91.7
Polythene bags	1	8.3
Total	**12**	**100**
Cleaning		
Yes	**5**	41.7
No	**7**	58.3
Total	**12**	**100**
Mixture of same seeds species but different mother trees		
Yes	8	66.7
No	4	33.3
Total	**12**	**100**

Source: *Field survey, 2021*

Seed-borne fungi awareness

Seed discolouration, rots and deformities were observed by all the respondents (100%) during seed collection. Majority of the respondents (75%) observed disease symptoms such as leaf spots, dumping off, pale yellowing of leaves and leaf curl in the seedlings at the nurseries. A significant number (25%) of the respondents indicated they did not observe any disease in their nurseries (Table 5). All the respondents (100%) could not trace seedling showing disease symptoms to the seed mother tree. Fifty percent of the respondents were aware of seed-borne fungi infection while the other 50% had not heard of seed-borne fungi infection (Table 5).

Table 5. Seed-borne fungi awareness by respondents

Seed-borne fungi awareness	Frequency	Percentage
Observation of diseases in the nursery		
Yes	9	75.0
No	3	25.0
Total	**12**	**100**
Knowledge of seed-borne fungi		
Yes	6	50.0
No	6	50.0
Total	**12**	**100**

Source: *Field survey, 2021*

Discussion

Gender, educational level, specialisation in education, experience and position in forestry

The results obtained from this study has shown that more females (70%) are involved in forest trees' seeds collection and storage than males. Women in forestry departments are mostly engaged at the nursery which may be due to their inherent nurturing ability. Since seedling production starts with seeds collection and storage, it is not surprising that more women were tasked in that respect. This study agrees with Anyakoha (1999) who also found that more women were involved in forestry and stated that women are very active in afforestation programmes and thus champion the management and development of communal forests. Again, women involvement in policymaking is found to enhance natural resource governance (Leisher et al., 2016), reduce disruptive conflicts (Coleman & Mwangi, 2013) and improve conservation outcomes (Agarwal, 2009; Leone, 2019). The 2030 Agenda for Sustainable Development (UN, 2015d) to some extent, concerned women's participation in social forestry management and climate change mitigation. Moreover, UN (2015c) clearly stated that effective community-based forestry requires both women and men to become actively involved and be equally represented in decision-making at all levels.

All the respondents had formal education with majority attaining tertiary education and some training in forestry. The high level of education of respondents could enhance their managerial and technical skills (Battese & Coelli, 1995). Education is believed to promote the respondents' capability in the utilisation of existing technologies in forest management (Owour & Shem, 2009). Most of the respondents were highly experienced in forestry and were Range Supervisors. High working experience could be a precursor to high quality work and performance since respondents might have learnt on the job. Schmidt et al. (1988) observed that the non-interactive hypothesis connotes that work experience promotes the performance of both high and low-ability employees at the same rate.

Forest tree seeds collection

Most of the respondents (91.7%) collected seeds from the forest reserve and research institutions and this gives an indication of obtaining quality seeds for afforestation and reforestation programs. Seed mother trees in forest reserves are often times intentionally left unharvested for the purpose of seed production; therefore, they are matured enough with good quality traits desired in the seeds they produce for afforestation purposes. Most of the respondents collected seeds from forest reserves by employing the method of floor collection mostly due to the height of the trees. The implication of floor collection method of forest seeds is that the seeds may be contaminated with fungus and other soil-borne pathogens. Young and Young (1986) reported that collecting mature seeds from floors is not advisable because those seeds are of low-quality and can be contaminated with fungi and other pathogens. Sutherland et al. (2002) also confirms that one of the prime factors in the attainment of seed-borne fungi is the contamination of seeds or fruits with soil. There may also be the risks of collecting immature seeds and the uncertainty in identifying the mother trees from which seed is collected especially in areas where same tree species are in clusters.

Half of the respondents mixed seeds collected from the forest floor with seeds collected by plucking and they stored the seeds for not more than three months. This practice could lead to high fungi infection of seeds when floor collected seeds have contacted fungi on the forest floor as observed earlier (Young & Young, 1986).

From the study 50% of the respondents did not keep records on the seed mother trees and therefore did not know the physiological changes that occur in the seed tree. The implication is that whenever there is a negative physiological change that could undermine the quality of seeds produced by that tree, respondents may not be aware and still collect seeds from such trees which in the long run may negatively affect the viability

and seedling vigour from the seeds of such trees.

Handling of seeds by respondents

The study revealed that the seeds were mostly stored for a short duration of not more than three months and the quantities were mostly small and insufficient for major afforestation and reforestation programs. This is indicative that for a year of failure of mother tree seed production due to any uncertainty that could occur, such as the alarming climate change, there will be no seeds for raising seedlings for afforestation and reforestation programs which is a great threat to forest conservation.

The failure of most of the respondents to clean seeds before storage is a medium for seed-borne pathogen infection of stored seeds as reported by Wall & MacDonald (2007). Despite the fact that respondents stored seeds for shorter periods, none of them treated their seeds against seed-borne fungi before storage. Fungal propagules infect parts of seeds at any period from flowering to the post-shedding stage (Dhingra et al., 2003; Sutherland et al., 2002). This may occur while the fruits are still on trees, on the floor, during collection and processing, during transportation or in storage (Dhingra et al., 2003). These fungi when not managed by treating seeds with recommended fungicides before storage may negatively impact the seeds by decreasing storage longevity, rotting of seed, reduction in seed vigour, decrease in germination and damping-off in the nurseries (Berjak, 2000; Dhingra et al., 2003).

The study also revealed that majority of the respondents stored seeds in PP bags. These bags had been proven to be good storage containers for seeds as observed by Nyo et al. (2020)

Most of the respondents indicated they mixed same seeds species but different mother trees for storage. Such a practice could lead to high disease infection in cases where some mother trees produce diseased seeds. Vertical pathogen transmission guarantees the persistence of a microorganism from parents to offspring (Barret et al., 2016; Darrasse et al., 2010). Moreover, when there is a high germination failure of seeds, there may be the uncertainty of identifying which seed mother tree produced such seeds of poor quality for management practices to be applied.

Awareness of seed-borne fungi

Seed discoloration, rots and deformities were observed by all the respondents during seed collection from the forest reserves. This phenomenon suggests that seed-borne fungi infection can lead to seed deformities such as discolouration and rots as observed by Sutherland et al., (2002). A greater percentage of respondents observed seedling diseases such as leaf spots, dumping-off, pale yellowing of leaves and leaf curl in their nurseries and this suggests the incidence of seed-borne fungi infection. Nursing or planting of seed-borne infected seeds could lead to seedling diseases (Burgess & Wingfield, 2002), similar to observations made by respondents in the current study.

None of the respondents could trace diseased seedlings to the seed mother tree. This phenomenon could be as a result of the mixture of seeds from different seed mother trees which was common among the respondents. The implication of mixing seeds from different seed mother trees could be that any uncertainty such as diseases of seedlings cannot be traced to the respective seed mother trees. Even though majority of the respondents had higher education and are well experienced in forestry, yet only half (50%) of them had heard of incidence of seed-borne fungi diseases in forest tree seeds. This is why majority of them did not treat seeds before storage. This could be a major setback to forestry since one of the approaches to counteracting the alarming rate of deforestation and the resultant economic and environmental effect is to intensify the rate of afforestation or reforestation by producing a large number of seedlings, raised from high-quality seeds devoid of seed-borne fungi and diseases for a successful nursery management and sustainable forest establishment and conservation.

Conclusion and Recommendation

From the study, it can be concluded that the floor method of seed collection largely employed by respondents could negatively impact the health of seeds. The practice of mixing seeds from floors and trees and from different mother trees can promote the spread of disease pathogens during storage. Failure of some respondents to keep records on seed mother trees does not auger well for proper management of forests. The failure of a greater proportion of the respondents to clean and treat seeds with recommended fungicides before storage could impact negatively on the seed health and provide grounds for fungi proliferation. Despite the high level of education and experience of the respondents in forestry, their unawareness of seed-borne fungi could be the reason why they mixed untreated floor collected seeds with plucked ones and same seeds species from different mother trees for storage.

It is therefore recommended that the Forestry Commission provide in-service training for the forestry staff to improve their knowledge and skills in seed collection and handling techniques.

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