Chapter 9

Species Selection and Nursery Technique Adoption for Seedling Establishment in Bangladesh — Towards Enhancing Plantation Programme

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Additional information is available at the end of the chapter

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Abstract

Small-scale nursery owners can play a vital role in biodiversity conservation through providing seedlings of forest tree species, horticultural species, flower species and medicinal plants to afforestation, reforestation, social forestry, agro-forestry, shelter belt and home gardening in Bangladesh. The present study of the nursery status of Bangladesh investigated socio-demographic characteristics, farm and farming characteristics, species selection and adoption of nursery techniques by small-scale nursery owners. A survey was conducted of 252 sample nurseries which were selected randomly. The investigation revealed that majority of the nursery owners were mid-aged (30–49 years) male (82.4%) people who took it as primary occupation (86.3%) for more than 20 years (38.1%), but a considerable amount of the respondents had no schooling (34%). Most of the owners rented a small area of land (0.5–5 acre) for the activities on a term basis. About 39.9% of the respondents raised planting materials for horticultural and forest tree species together. The study revealed that fruit-bearing (RF-28.69) and fast-growing species (RF-17.47) were considered as the criteria for species selection. *Mangefera indica, Manilkara zopota, Zizyphus mauritiana, Lichi chinensis, Artocarpus heterophyllus, Spondia dulcis, Citrus citrus, Swietenia mahagoni, Psidium guajava, Cocos nucifera, Albizia lebeck, Citrus grandis, Feronia limonia, Averrhoa carabola, Dulbergia sissoo* were the top-ranked species preferred by the nursery owners. Majority of the respondents practiced grafting and budding for vegetative

propagation and practiced submersion of seeds under water and scarification as pre-sowing treatment for seed germination. On the basis of research findings, it is suggested to facilitate widespread acceptance of forest tree species, along with fruit-bearing species, and take account of small-scale nursery owners' views and preferences for achieving adoption of forest tree-based farming systems in a climate change situation.

Keywords: Seed germination, pre-sowing treatment, vegetative propagation, traditional methods, nursery-based farming system

1. Introduction

Bangladesh is a small and densely populated country with a high population growth (1.32%) [1]. Deforestation and fragmentation of forest land due to shifting cultivation [2], encroachment for agriculture, aquaculture, house and road construction have resulted in greatly reduced biodiversity and consequently have created major challenges for conservation which have made serious imbalance in the ecosystem. The imbalanced ecosystem causes a number of meteorological and health hazards [3-4]. Village forest resources are also depleting at a high rate per annum [5-6]. If this situation continues, the rural homestead forest will be seriously depleted in near future which will affect the demand for food, shelter, fuel and fodder at a geometric rate [7]. Bangladesh has about 17.04% of forestland, but the actual tree-covered area is estimated to be less than 10% [6, 8] where a country needs 25% of forest to its total area. Only seven districts of the country fulfilled the requirements (25% of forest to its total area) of forestland, but there is no state forest at all in 28 districts [6]. In spite of governmental attention to enhance the protected area to 10% of the land [8], conservation of biodiversity in Bangladesh will necessitate main assistance from private, managed patches outside natural and protected area systems.

Under this situation, nurseries can play important roles to make forest cover all over the country. There are about 6000 nurseries all over the country; the majorities among them are situated near the town or city. For this reason, village people get fewer opportunities to reach their homestead with valuable tree or fruit species. If it is possible to establish nursery at grass root level and provide them appropriate technology for species selection, seed germination and seedlings growth at nursery stages, it will be possible to increase seedlings production at the shortest possible time and thereby increase the total forest cover of the country. Indeed, only in a nursery it is possible to provide proper growing conditions to produce healthy vigorous seedlings that nursery can play the fundamental role of the primary stages to increase the forest cover of the country [9]. Many authors discussed about forest nursery status to explore the status of owners and workers, marketing status, species selection, technology adoption for producing better quality of seedlings or clones and thereby enhancing the plantation programme, agroforestry programme, social forestry programme and homestead

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forestry [10-18]. But there is no information available regarding the basis of species selection and technology adoption of forest nursery in Bangladesh. Therefore, an attempt has been taken to carry on this study. The objectives of the study are: (i) to determine the basis of species selection by the nursery owners at forest nurseries and (ii) to find out the techniques used to generate planting materials and differentiate germplasm access and accessibility.

2. Research method

2.1. Study site

The study was carried out purposively at Phultala and Dumuria upazilla of Khulna district, and Satkhira sador, Debhata, and Kaligong upazilla of Satkhira district Bangladesh. Nowadays, a significant amount of nursery seedlings are supplied from these areas to other parts of the country for agroforestry, social forestry, homestead forestry and other plantation programmes. The study areas are located in the south-western part of Bangladesh and they are the part of the largest delta. In the southern part of the delta lies the Sundarbans, the largest unit of mangrove forest in the world. The study areas are situated primarily in the floodplain landmass lying between 22°12′–23°59′ N latitude and 88°54′–89°45′ E longitude. The landscape of these areas is about 4–6 m above sea level. The climate of this region is sub-tropical, with three distinct seasons: winter (November to February), summer (March to June) and monsoon (July to October). The mean monthly temperature is about 28°C. Winters are relatively mild (temperature 7–12°C) and summer typically 25–32°C but up to 40°C [19-20].

2.2. Data collection

A face-to-face interview was conducted with the head of the forest nursery in the presence of other members (if available). A list of private nurseries in study areas was obtained from the nursery owners' association at Satkhira and Khulna, Bangladesh. A random sample of 252 nurseries was selected for the study. A contextual questionnaire was prepared with a combination of closed and open-ended questions, covering the socio-demographic profiles (age, sex and education) of nursery owners, farm and farming characteristics (tenure status: leased / owned land, nursery size in acre, tenure length in year, categories of species preferences), species selection criteria and technology adoption (source of propagation: seed / vegetative parts, means of seed / vegetative parts security: own production or collection, substrates of seed germination: open bed and / or polybag or others, methods of vegetative propagation: grafting, budding, air layering, etc.) for seed germination and seedling growth. Interviews were carried out by the researchers during October–November 2010, January–February 11, November–December 2011. Follow-up visits were conducted where nursery owners were not available on the first visit, and ultimately all the sampled nursery owners were interviewed. The interview schedule was prepared in English and then translated into Bengali. The questionnaire was tested through personal interview of five nursery owners of the study area, and a revised version was done. The surveyed data were recorded on papers and were

tabulated and analyzed using simple statistics and also a weighted score (relative frequency) parameter about species selection, preference and technology adoption by nursery owners.

2.3. Data analysis

Data were analyzed in percentage, frequency, relative frequency and in principal component analysis (PCA). Socio-demographic profiles (age, sex and education) of nursery owners were expressed in percentage. The farm and farming characteristics were also expressed in percentages. Species selection criteria and technology adoption for seed germination and seedling growth were expressed in frequency and relative frequency. Relative frequency was used to rank selected species and to rank the selected criteria. Relative frequency was also used to rank nursery techniques adopted by the nursery owners. PCA was conducted by using past software [21] to find out important components which are correlated with other underlying variables species selection and species selection criteria.

3. Results

3.1. Socio-demographic characteristics

Most of the nursery owners interviewed were male (82.4%) and 86.3% of the respondents mentioned nursery practices as their primary activity, others mentioning agriculture, aquaculture, seed production and grocery selling as their primary occupation. The remaining (13.7%) nursery owners' primary objective was for family subsistence. Income from the nursery sale was a secondary objective. The model age class was 30–49 years. Thirty four percent had no formal education, twenty eight percent had completed primary education only and twenty four percent of the respondents had higher academic or professional education. The median family size was five. Each nursery owner's family had a median of two adult male, two earnings and three literate members (data not shown).

3.2. Farm and farming characteristics

Only 18.3% of respondents conducted nursery activities on their own land and 38.9% of the nursery owners adopted nursery activities on rented land, but almost half (42.8%) operated on both rented and own land (Figure 1a). There were a variety of nursery size, but 45.2% of the respondents implemented it on medium-sized nursery (1–3 acre, 1 acre = 0.4047 hectares). And 37.3% of the respondents had very small to small piece of land for farming and 17.5% of the respondents had a total area of 5 acres (500 decimal) or more (Figure 1b). In terms of tenure length, 38.1% of the respondents were working for more than 20 years though some of them got it by inheritance (Figure 1c). In case of species selection, 35.1% of the nursery owner preferred only horticultural species and 39.9% of the owners desired a combination of forest and horticultural species (Figure 1d). Nearly all nursery owners (97%) managed their nursery with family members. They (86%) spent almost whole day (8–10 h) in peak season (data not shown).

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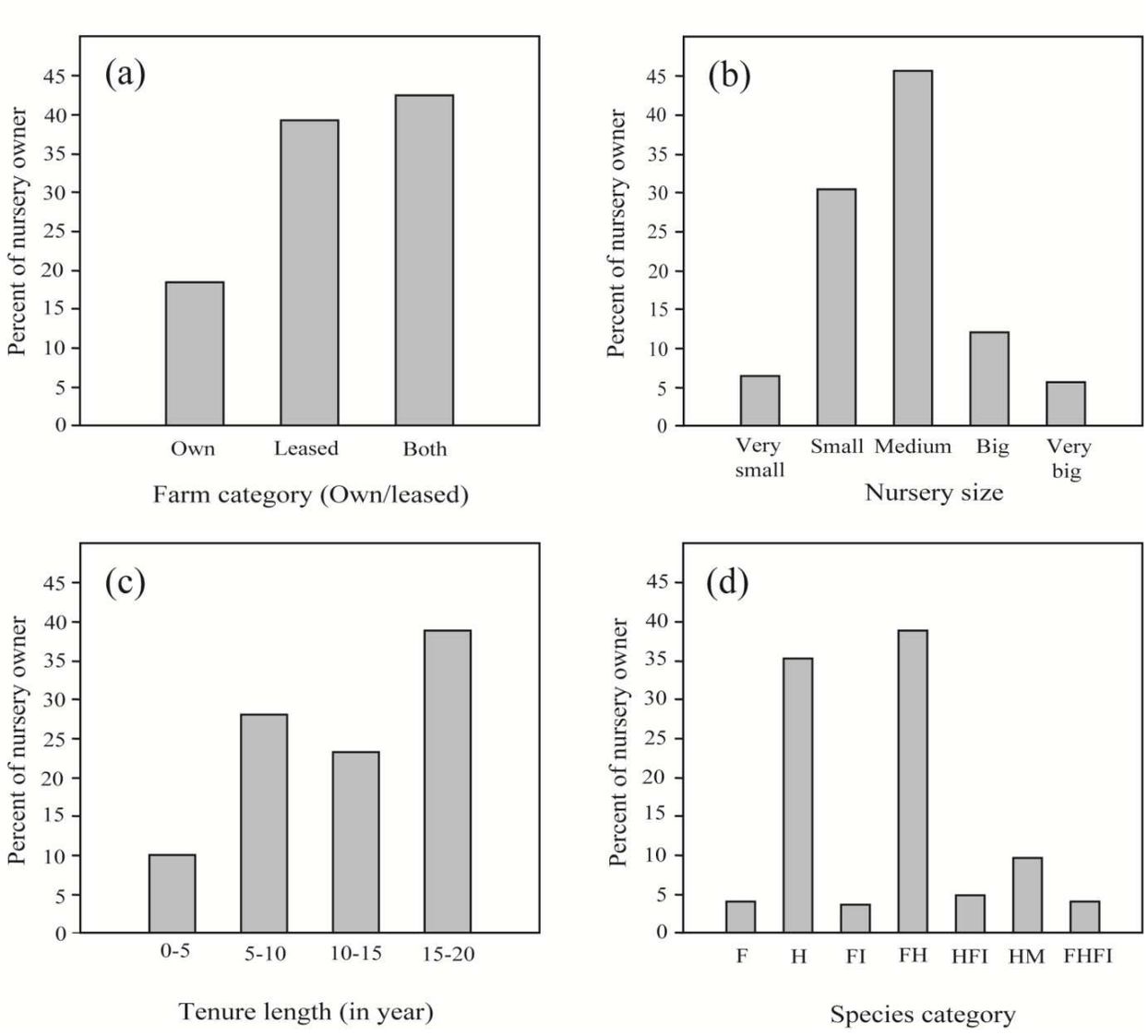

Figure 1. Farm and farming characteristics of small-scale nursery owners in the study area. (a) farm category, (b) nursery size: very small (less than 0.50 acre), small (0.50–1.00 acre), medium (1.00–3.00 acre), big (3.00–5.00 acre), very big (above 5.00 acre), 1 acre = 0.4047 ha, (c) tenure length (d) species category – F: forest species only, H: horticultural species only, Fl: flower species only, FH: combination of forest and horticultural species, HFl: combination of forest and flower species, HM: combination of horticultural and medicinal species, and FHFl: combination of flower, horticultural and flower species.

3.3. Species selection for propagation at nursery

The nursery owners mentioned 57 species growing at the nursery. The most were identified in terms of their scientific name with family, but a few were identified by local names only. The species were ranked according to the relative frequency. *Mangefera indica*, *Manilkara zopot*a, *Zizyphus mauritiana*, *Lichi chinensis*, *Artocarpus heterophyllus*, *Spondia dulcis*, *Citrus citrus*, *Swietenia mahagoni, Psidium guajava, Cocos nucifera, Albizia lebeck, Citrus grandis, Feronia limonia, Averrhoa carabola*, *Dulbergia sissoo, Phyllanthus emblica, Syzygium samarangense, Samanea saman*, *Annona squamosa* and *Syzygium cumini* were the top 20 species according to the given rank.

Sixteen of those were fruit-bearing species and the remaining four were forest tree species. A few medicinal plant and flower species were also mentioned (Table 1).

Scientific name	Local name	Family	Frequency	Relative frequency	Rank
Mangifera indica	Am	Anacardiaceae	246	8.11	1
Manilkara zopota	Safeda	Sapotaceae	231	7.61	2
Zizyphus mauritiana	Kul	Rhamnaceae	221	7.28	3
Lichi chinensis	Lichu	Sapindaceae	208	6.86	4
Artocarpus heterophyllus	Kanthal	Moraceae	187	6.16	5
Spondia dulcis	Amra	Anacardiaceae	180	5.93	6
Citrus citrus	Kagochi lebu	Rutaceae	166	5.47	7
Swietenia mahagoni	Mahagani	Meliaceae	154	5.08	8
Psidium guajava	Peara	Myrtaceae	152	5.01	9
Cocos nucifera	Narical	Arecacea/Palmae	142	4.68	10
Albizia lebeck	Sirish	Fabaceae	121	3.99	11
Citrus grandis	Jambura	Rutaceae	115	3.79	12
Feronia limonia	Katbell	Rutaceae	109	3.59	13
Averrhoa carabola	Kamranga	Oxalidaceae	87	2.87	14
Dulbergia sissoo	Sissoo	Fabaceae	63	2.08	15
Phyllanthus emblica	Amloki	Euphorbiaceae	58	1.91	16
Syzygium samarangense	Jamrul	Myrtaceae	57	1.88	17
Samanea saman	Raintree	Fabaceae	52	1.71	18
Annona squamosa	Ata	Annonaceae	43	1.42	19
Syzygium cumini	Jam	Myrtaceae	39	1.29	20
Gmelina arborea	Gamar	Verbenaceae	34	1.12	21
Melia azedarach	Nim	Meliaceae	32	1.05	22
Terminalia arjuna	Arjune	Combretaceae	27	0.89	23
Shoria robusta	Sal	Dipterocarpaceae	26	0.86	24
-	Asfal	-	19	0.63	25
Albizia lucida	Silkaroi	Leguminosae	18	0.59	26
-	Lambu	-	17	0.56	27
Punica granatum	Dalim	Punicaceae	15	0.49	28

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Scientific name	Local name	Family	Frequency	Relative frequency	Rank
Citrus reticulate	Kamla	Rutaceae	14	0.46	29
Baccaurea ramiflora	Latkan	Euphorbiaceae	13	0.43	30
-	Malta	Rutaceae	12	0.40	31
Polianthes tuberosa	Rajanigandha	Agavaceae	12	0.40	31
Jasminum sambac	Beli	Oleaceae	12	0.40	31
Jasminum auriculata	Jui	Oleaceae	11	0.36	32
Jasminum grandiflorum	Chameli	Oleaceae	11	0.36	32
Gardenia jasminoides	Gandhoraj	Rubiaceae	11	0.36	32
Ixora coccinea	Ranggon	Rubiaceae	10	0.33	33
Cestrum nocturnum	Hasnahena	Solanaceae	9	0.30	34
Artabotrus odoratissimus	Kathalichapa	Annonaceae	9	0.30	34
Hibiscus rosa-sinensis	Jaba	Malvaceae	8	0.26	35
Bougainvillea spectabilis	Baganbilas	Nyctaginaceae	8	0.26	35
Mimusops elengi	Bokul	Sapotaceae	8	0.26	35
Anthocephalus chinensis	Kadam	Rubiaceae	8	0.26	35
Butea monosperma	Pallash	Fabaceae	7	0.23	36
Saraca asoca	Asok	Caesalpiniaceae	7	0.23	36
Delonix regia	Krishnachura	Fabaceae	7	0.23	36
Caesalpinia pulcherrima	Radhachura	Fabaceae	6	0.20	37
Plumeria acutifolia	Katgolap	Apocynaceae	6	0.20	37
Nerium odorum	Karobi	Apocynaceae	6	0.20	37
Lagerstroemia indica	Chotto jarul	Lythraceae	5	0.16	38
Rosa damascena	Golap	Rosaceae	5	0.16	38
Cosmos bipinnatus	Cosmos	Asteraceae	4	0.13	39
Tagetes patula	Gadda	Asteraceae	4	0.13	39
Chrysanthemum coronarium	Chandra mollica	Asteraceae	3	0.10	40
Dahlia hybrida	Dallia	Asteraceae	3	0.10	40
Helianthus annuus	Surja mukhi	Asteraceae	2	0.07	41

* - = Not identified

Table 1. Species selection for nursery practice by the small-scale nursery owners at study area

3.4. Species selection criteria

Table 2 lists the relative frequency of 13 species selection criteria in order of rank based on the respondents' consideration. Fruit-bearing species as the criteria for species selection headed the list, followed by first-growing species and straight bole structure. Medicinal value as the criteria for species selection was listed as rank 13. Fine grain wood, large crown, suitability as fuel wood, suitability for agroforestry, root system (deep or shallow), big and tall tree, branching habit, flower species, branch angle (larger branching angle indicates the chance of self-pruning) were also listed as species selection criteria (Table 2).

Species selection criteria	Frequency	Relative frequency (%)	Rank
Fruit-bearing species	243	28.69	1
Fast-growing species	148	17.47	2
Straight bole structure	136	16.06	3
Fine grain wood	48	5.67	4
Large crown	42	4.96	5
Fuel wood	41	4.84	6
Agroforestry component	38	4.49	7
Root system	36	4.25	8
Big and tall tree	34	4.01	9
Branching habit (many / few)	28	3.31	10
Flower	23	2.72	11
Branch angle	18	2.13	12
Medicinal value	12	1.42	13

Table 2. Species selection criteria by the small-scale nursery owners at the study area

A PCA of top 20 selected species and major species selection criteria showed that the first principal component (PC1) explained most of the variation (46.51%) and the second principal component (PC2) explained 18.23% of the total variation, with a very large difference in eigenvalues between PC1 (5.98) and PC2 (2.52). The ordination of PCA illustrates distinct groups of species selection and species selection criteria. PCA not only provides an illustrated representation of these relationships but also points out species selecting criteria. The ordination of PCA of the present study shows cluster of fruit-bearing species on one side and cluster of timber species on another side of PC2, though every species has multiple characteristics. Fruit-bearing species as the species selection criteria is pointed among the fruit species. Fast-growing species, straight bole structure, fine grain wood, fuel wood, etc. are pointed among the timber species (Figure 2).

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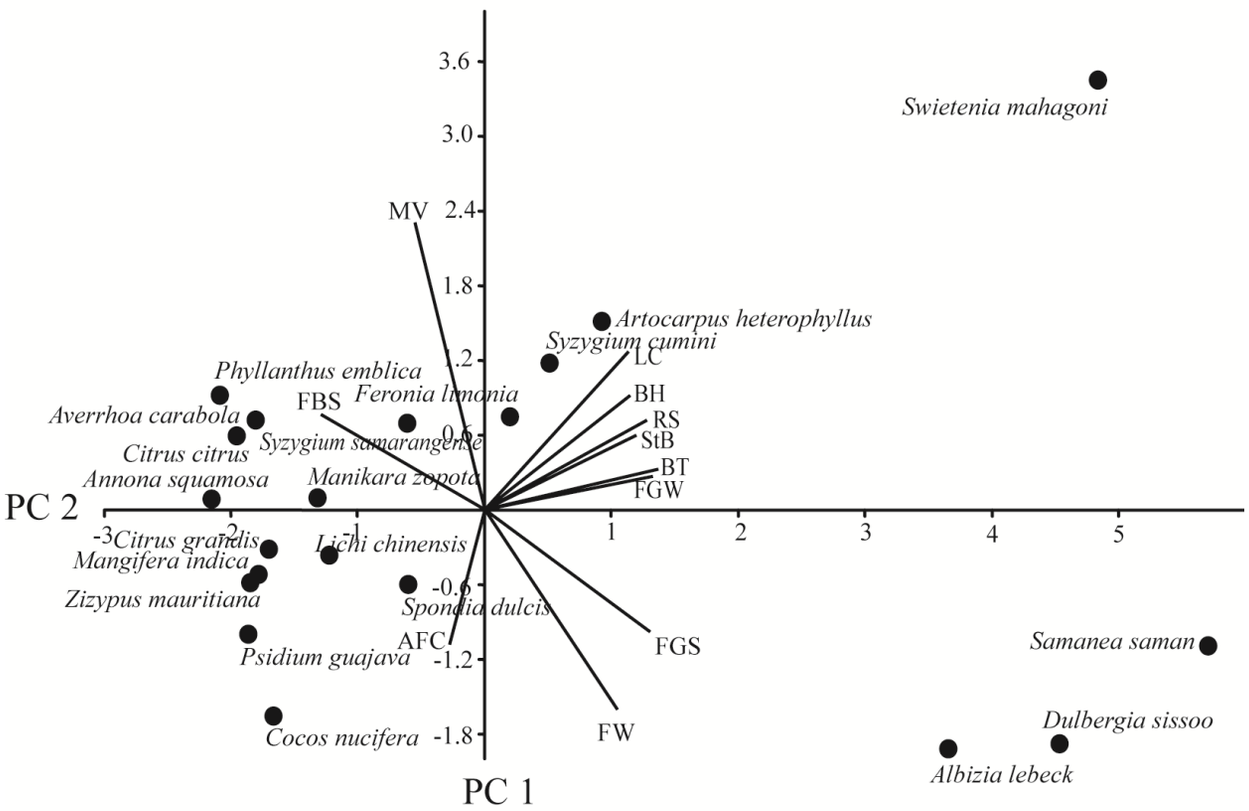

Figure 2. Principal component (PC) ordination of top 20 species and major species selection criteria. The horizontal axis of the ordination plot shows PC1 with an eigenvalue of 5.98, explaining 46.51% of total variation of species selection and species selection criteria; the vertical axis shows PC2 with an eigenvalue of 2.52, explaining 18.23% of total variation of species selection and species selection criteria. Note: FBS: fruit-bearing species, FGS: fast-growing species, StB: straight bole structure, FGW: fine grain wood, LC: large crown, FW: fuel wood, AFC: agro-forestry component, RS: root system, BT: big and tall tree, BH: branching habit (many/few), MV: medicinal value.

Table 3 shows the relative frequency (RF) of different nursery techniques adopted by the nursery owners in order of rank based on the respondents' consideration. Most of the respondents used both seed and vegetative material for propagation (RF – 70.24%), followed only vegetative parts (RF – 26.59) and seeds only (RF – 3.17). For this purpose, most of the nursery owners used their own propagules (seeds and/or vegetative part) to produce seedlings and clones. Open bed headed the list of RF in case of seed-germinating substrates. On the other hand for vegetative propagation, combination of grafting and budding secured highest RF (60.32). Most of the respondents adopted different categories of water treatment as pre-sowing treatment for seed germination purpose.

Items	Category	Frequency	Relative frequency (%)
Source of propagation	Only seeds	08	03.17
	Vegetative propagation (VP)	67	26.59
	Both (Seed and VP)	177	70.24
Means of securing seeds	Own production	121	48.02
	Bought from others	36	14.28
	Both ways	95	37.70
Seed germinating substrates	Open bed	131	51.98
	Polybag	21	08.33
	Both open bed and polybag	88	34.92
	Open bed, polybag and tob	12	04.74
Vegetative propagation method	Grafting	11	04.37
	Budding	06	02.38
	Branch cutting	05	01.98
	Grafting and budding	152	60.32
	Grafting and branch cutting	11	04.37
	Grafting, budding and cuttings	78	30.95
Means of securing vegetative materials	Own collection	134	53.17
	Bought from others	16	06.35
	Both ways	102	40.48
Pre-sowing treatments for seed germination	Hot water treatment	12	04.76
	Cold water treatment	11	04.37
	Sun heated water treatment	06	02.38
	Acid treatment	09	03.57
	Scarification	17	06.75
	Hot, cold, and sun heated water treatment and scarification	163	64.68
	Water and acid treatment	16	06.35
	Water, acid and scarification	18	07.14

Table 3. Nursery techniques acceptance by the small-scale nursery owners in the study area

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4. Discussion

In this article, we studied socio-demographic characteristics, farm and farming characteristics, species selection for propagation, species selection criteria and nursery techniques acceptance by the small-scale nursery owners. The result revealed that most of the owners rented small piece of land (0.5–5 acre) for the activities for a long time (10–20 years and above). Only few nursery owners had above 5 acres of land for nursery practices (Figure 1). It may be due to unavailability of land, being a member of the most densely populated developing country like Bangladesh. Horticultural and first-growing timber species were the most preferred species, but some flower species and medicinal plants were also listed at the bottom of the selected species. In case of species selection, nursery owners mentioned 57 species, among them a considerable amount was from fruit-bearing species. From the top-ranked 20 species according to the preference of nursery owner, 16 were fruit species. The top-ranked forest tree species, *Swietenia mahagoni*, was listed at the eighth position and other forest species, flower species, were ranked at the bottom. The PCA ordination also justified the grouping of selected species with species selection criteria. The main factor that affected farmers' adoption was the fruit-bearing species which was in demand as the best in the locality. The other dominant/co-dominant factors like fast-growing species, fine grain wood, agro-forestry component, fuel wood, etc. were in demand in the timber species among the localities. Ahmed et al. [13] discussed urban nurseries in Bangladesh and found similar result. Mercado Jr. and Duque-Pinon [18] conducted a study on tree seedling production systems in Northern Mindanao, Philippines and found that similar combination of forest and horticultural species was preferred by the nursery owners.

In case of nursery technique adaptation, most of the nursery owners used both seeds and vegetative parts for seedling 'and' or 'or' clone establishment. Majority of the nursery owners collected seeds or vegetative parts from their own collection. Only eight respondents mentioned that they used only seed for seedling establishment; on the other hand, sixty-seven respondents used only vegetative part for propagation. It may be due to some of the forest tree species that produce a huge amount of seeds every year. On the other hand, horticultural species and some of the forest tree species have the ability to produce new offspring from vegetative parts. Majority of the respondents used grafting and budding methods for vegetative propagation, especially for the horticultural species. It may be due to the fruiting ability within the shortest possible time. Most of the nursery owners practiced pre-sowing treatment for seed germination to speed up the germination process, breaking the seed dormancy and thereby increase the germination percentages. Majority of the respondents used water (hot, cold and sun-heated water) and scarification as pre-sowing treatment for seed germination. It may be due to water treatment which can be capable of softening the seed coat of some forest tree seed and scarification can be made permeable where imbibitions will start. Literature supported water treatments for seed germination of *Cassia siamea* [22], *Albizia procera* [23], *Albizia lebbeck* [24]), *Xylia kerrii* [25], *Dalbergia sissoo* [26], *Hippophae salicifolia* [27], *Albizia richardiana* [28] and *Melia azedarach* [29]. Literature also supported scarification for seed germination of *Prospis flexuosa* and *P. alba* [30], *Tamarindus indica* [31], *Hippophae salicifolia* [27], *Lagerstroemia speciosa* [28].

5. Conclusion

Nursery owners can contribute a significant role through supplying seedlings to afforestation programme, social forestry programme, agroforestry programme and home garden plantation programme in Bangladesh. Beside these, young educated people can also participate in the nursery sector as there was a crisis of job market in Bangladesh, resulting in the young educated people to be self-dependent; the nursery sector will be promoted and thereby the country will be developed gradually. The investigated results showed that most of the small-scale nursery owners adopted horticultural species due to huge demand of fruit-bearing seedlings 'and' or 'or' clones at local, regional and national levels. Furthermore, fruit trees are involved in achieving farmer's manifold domestic objectives, producing food and other products and providing a defending measure in environmentally fragile landscapes. But at the same time, the demand of forest tree species should also be increased in a country like Bangladesh, critically hazardous to climate change effects. The government, non-governmental organization and policy makers should come forward to assist widespread acceptance of forest tree species, medicinal plants with fruit-bearing species and there is need for recognition of small-scale nursery owners' views and preferences for achieving adoption of forest tree-based farming systems. From the overall findings of the study, it can be concluded that the small-scale nursery owners have diverse ideas about nursery practices, but their diversity of ideas does not fully assure the success of the farming system because their practices were not scientific; furthermore, they rely on the knowledge from experiences. Short courses and trainings on nursery practices may be helpful for the development of the nursery sector.

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