# GERMPLASM ACCESS AND PLANTING STOCK QUALITY IN SMALLHOLDER FOREST NURSERIES IN LEYTE, THE PHILIPPINES

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This paper presents the results of a study investigating the germplasm access and quality of planting stocks in the smallholder nursery sector in the province of Leyte, the Philippines. Data were gathered through personal interview and analysed using the SPSS program. A total of 59 smallholder nursery operators and 15 government personnel involved in managing government nurseries were interviewed. Government nurseries were established primarily to provide planting stocks to smallholder tree farmers; however, the farmers either individually or in groups are raising seedlings to meet their own planting stock requirement. The type of species produced is largely determined by species availability. There is no free flow of information on germplasm sources resulting in inefficient distribution and utilisation of available species. This has resulted in the wide production of a few common exotics. Less emphasis is given on the use of genetically superior germplasm due to lack of information on a good-practice germplasm collection protocol and limited access to certified sources. The germplasm pathway in smallholder nursery system operates with a very weak link to agencies dealing with high quality planting materials. High quality germplasm enters the system but in a sporadic and uncontrolled way. Although smallholders possess the basic knowledge of nursery seedling culture, the planting stocks raised are of low quality suggesting the need to refine their skills in seedling production.

## INTRODUCTION

The inability of industrial forestry to benefit the rural poor and address the continuous destruction of the remaining patches of forestland has led the Philippine forestry sector to shift the management of forest resources. From the previous large-scale industrial forestry, forest management programs and policies are currently placing more bias on small-scale forestry. In this scheme, local people, either individually or in groups, are recognised as active partners in planting and managing trees on either communal or privately-owned land and who have chosen to devote labour, financial capital and time in growing trees (Harrison *et al.* 2001).

Species selection plays an important role in the promotion of small-scale forestry. For smallholder tree farmers, each tree corresponds to an investment hence they are selective in the species to plant. Byron (2001) stated that smallholders prefer to plant a variety of multipurpose tree species rather than an even-aged monocrop. The study of Herbohn *et al.* (2001), however, revealed that unavailability of planting stock and use of low quality germplasm[1] impedes the effective promotion of small-sale forestry in the province of Leyte. The decision of smallholder tree farmers about what species to raise is contained within a narrow base of species that are directly available, and proper matching of the species to the growth conditions afforded by the planting site is not given much attention. To facilitate the adoption of small-scale forestry in the province, it is imperative to widen the species base available to smallholder tree farmers and likewise improve the quality of germplasm and

[1] Any plant part e.g. seed, cutting, scion, pollen used for regeneration (Jaenicke, 1999). In this paper, this term also includes wildlings (naturally growing seedlings) used in producing a planting stock

planting stock. This will provide the smallholders more options in choosing the best species that will fit with their resources, needs and priorities. In view of this, a survey investigating the access and pathway of germplasm and assessment of the quality of planting stock produced in small-scale nurseries in the province was conducted. This survey aimed to identify and understand the existing germplasm production and distribution mechanism within the small-scale nursery system and at the same time investigate the technical skills of the nursery operators in planting stock production. This information will serve as input in formulating potential intervention schemes that will be used in improving the supply of high quality planting stock of various species to the level of smallholder farmers.

In this paper, the germplasm access of small-scale nursery operators, diffusion pathways and quality of planting stock are investigated. The importance of doing the research and the methodology adopted in gathering and analysing the data are outlined. The various nursery groups, species preferences and selection process, germplasm sources and collection methods, and germplasm types and distribution flow are discussed. Key constraints are highlighted and potential alternative measures are suggested.

## RESEARCH METHOD

A survey in the nursery sector of the province of Leyte was conducted to collect the necessary data for the study. Primary data were gathered through personal interviews and focus group discussions with the respondents as well as direct observation of the nursery set-up. Destructive sampling of seedlings to assess the seedling quality was also carried out. Secondary data were taken from files and records of the nursery operators and from the offices of relevant government agencies and non-government organisations.

### Selection of Respondents

Survey respondents included the small-scale forest nursery operators. In this study, the term ‘small-scale nurseries’ refers to individually operated or communal nurseries that are producing or have produced a volume of less than 50,000 seedlings in every nursery production. It should be noted that the seedling production schedule in most nurseries is irregular therefore no time frame can exactly be used to describe the production frequency say, annually or bi-annually. The nursery survey was initially focused within four municipalities in Leyte Province, namely Isabel, Babatngon, Matalom and Inopacan, all of which are sites for Australian Centre for International Agricultural Research (ACIAR) project ASEM 2000/088 – *Redevelopment of Timber Industry Following Extensive Land Clearing*. The limited number of nursery operators in the proposed study sites, however, resulted in the extension of the survey coverage to include another 20 municipalities within the province. [2]

The respondents were identified using the snowball selection approach starting from the municipalities with continuing small-scale tree planting activities. This was done based on the notion that a nursery will most likely be found in the area or where the people involved in the activity have known somebody who is producing planting stocks. Information about the presence of nursery operators within the municipality was gathered from key informants including personnel from agencies – particularly the Department of Environment and Natural Resources (DENR), Department of Agriculture (DA), Local Government Units (LGUs) – and from local residents. More than half of the total number of municipalities comprising the entire province were included in the study. None of the identified nurseries had exceeded the

[2] Some details of the methodology adopted in this study is also presented in another paper of this proceeding with the title ‘Small-scale Forestry Development: The Central Role of Nurseries’. These papers form part of the same umbrella project

production volume of 50,000 seedlings, thus all the nursery operators in every site were interviewed.

Information about the existence of forest nurseries established by the government was also collected and interviews of relevant staff were undertaken. This was done to collect information about the seedling production and distribution scheme, pathway of germplasm and planting stock and the quality of seedlings produced from government or central nurseries.

### Data Gathering

Personal interviews were carried out using a semi-structured questionnaire. In addition, observation and assessment of the nursery set-up and seedling quality were conducted in all nurseries. When available, three seedlings per species were used for destructive sampling to measure seedling quality parameters, including sturdiness, basal diameter, total height, root-shoot ratio and root morphology. Signs and symptoms associated with any disease were recorded and a chemical analysis of the potting media was carried out. Further, important secondary data about the nursery groups and information pertaining to the programs of the government in support to small-scale forestry were extracted from files and records.

Focus group discussions were conducted with all respondents after the nursery visits and interviews. These were done not only to validate and confirm the data that were gathered during interviews, but also to provide an avenue for nursery operators or managers and personnel from concerned agencies to share their experiences, discuss their problems and formulate possible solutions. Four sessions each lasting for 3-4 hours were held at Inopacan, Villaba, Ormoc and Tacloban. These venues were chosen to provide reasonable access for the respondents to attend the discussion. Each session was attended mostly by the nursery operators from adjacent municipalities of each discussion site, with the presence also of personnel from the DENR, DA and LGUs. Issues concerning the problems in running the nursery, species availability and selection processes, germplasm pathways and extension mechanisms, assistance given by supporting agencies and possible alternative measures to improve the overall forest nursery industry in the province were discussed.

The data were organised using the SPSS statistical program. Descriptive statistics – frequencies, percentages, means and cross tabulations among variables – allow a comparison of the characteristics and performance of the nursery types identified in the study.

## RESULTS AND DISCUSSION

This section discusses the different nursery groups identified and included in the study, objectives of nursery establishment and sources of inputs, species selection and preference, germplasm used, sources and collection method, relevant skills of the operators in nursery management, and quality of seedlings raised in the nurseries.

### Nursery Types

Three nursery groups were identified in the study. These include the government managed nursery and two groups of small-scale nurseries – individual and communal (Table 1). A total of 74 nursery operators in 24 municipalities were identified and interviewed. There are more individually operated nurseries compared with those managed by communities or peoples' organisations (POs). A considerable number of individual farmers are raising planting stock to meet their seedling requirements, indicating a high level of independence from the government nurseries in sourcing planting materials.

**Table 1.** Types and counts of nursery groups included in the survey

| Nursery type | Frequency |
|---|---|
| Individual | 37 |
| Communal | 22 |
| Government | 15 |
| Total | 74 |

*Communal nursery*

'People or community organisation nurseries' are established by a group of people in the community primarily for the purpose of raising planting stock for communal planting and distribution to members of the group (72.7%), and in some cases for sale to landholders (18.2%) and free distribution to interested parties (9.1%). Usually, this is project-initiated and the people are organised by a particular agency to act as partners in implementing a specific forestry project, which may be a Community-Based Forest Management Project (CBFMP), Community-Based Resource Management Project (CBRMP), Rainforestation Project or other development project designed for sustainable management of the natural resources and to improve the socio-economic status of the local people. The majority of this type of nursery have access to some funds, and the seedling production schedule, quantity of planting stock and species raised are decided by the organisation and supporting agency. Nursery infrastructure is mostly established through the 'alayon' or self-help system of organisation members but participating members are mostly paid for their labour in seedling production and maintenance. A formal protocol exists for the sharing of future benefits from community use and sale of seedlings and timbers. The nursery is often located centrally within the community for easy access to all members. In some cases, this is situated close to the communal planting site (which may be far from the barangay) for ease in transporting seedlings during field planting. The nursery structure is semi-permanent to permanent in nature and the volume of seedling production varies depending on the size of the project.

*Government nurseries*

These have been established by government agencies, primarily the DENR and DA. The nurseries of the Philippine National Oil Company (PNOC) and Leyte State University (LSU) are also included under this category, although they operate in somewhat different ways.

The DENR is the national government arm that is responsible for the management of the country's natural resources. Production of planting stocks of forest trees is one of the major activities of this agency. From the regional to the community offices, there is an annual budget allotted for the production of planting stock of forest trees. The DA on the other hand, is the agency in charge of agricultural production-related matters of the country. This agency is mainly producing germplasm and seedlings of agricultural crops and fruit trees but not of timber species. Seedlings of forest trees are only raised in response to the demand of landholders and is not an integral part of the annual operation of the agency.

Government nurseries are usually situated in a major city or town. Seedlings are produced mainly for the purpose of free distribution to all interested parties. Experienced workers who are paid either on a contract or regular salary basis usually carry out the seedling production activities, and the volume of seedlings produced is normally higher than individual and communal nurseries. With a well-established structure, this type of nursery is usually permanent in nature.

## Nursery Origin and Sources of Inputs

The majority (89.2%) of individual nurseries were established through the operator's own initiative while all communal nurseries were project-initiated. Being independently operated, only a small proportion (43.2%) of the individual nursery operators have received assistance in running the nurseries. Conversely, being project-initiated, all communal nurseries have received support from various agencies. Table 2 shows the various supporting agencies and the nature of assistance extended to small-scale nurseries. Most of the support given was in the forms of subsidised seeds or seedlings and technical advice on nursery management and tree plantings. For communal nurseries, however, financial support was also extended basically as part of the project implementation. It seems that for individual nursery operators, membership of organisations is instrumental in having access to support from assisting agencies, so much so that those who are members of a certain community or peoples' organisation have gained support while non-members have not. However, cross tabulation reveals that no significant relationship exists between these variables

**Table 2.** Assisting agencies, type of support received by smallholder nursery operators and conditions for obtaining such support

| Agency/ Organisation | Type of support extended for each nursery type | | | |
|---|---|---|---|---|
| | Individual | Conditions | Communal | Conditions |
| DENR | Free seeds/seedlings<br>Training on nursery management | As member of PO with CBFM project<br>As a seedling production contractor | All nursery inputs except labour<br>Technical advice, training in nursery management | Part of the CBFM project activities |
| DA/LGU/DOF[3] | Free seeds/seedlings<br>Free polybags<br>Technical advice on nursery management and tree planting | None | All nursery inputs<br>Training in nursery management,<br>Technical advice on tree planting | Part of the CBRM project activities |
| LSU | Free seeds/seedlings<br>Training in nursery management | None | Technical advice on tree planting and nursery management | Part of the CBRM project activities |
| FCI[3] | Subsidised all nursery inputs<br>Training in nursery management | As member of PO organised and supported by FCI | | |
| GTZ | | | All nursery inputs except labour<br>Technical advice<br>Training in nursery management | Part of the rainforestation project activities |
| ICRAF | | | Nursery inputs except labour Technical advice Training in nursery management | Part of the project activities |
| PNOC | | | All nursery inputs<br>Training in nursery management<br>Technical advice | Part of CBFM project activities |
| World Vision | | | All nursery inputs except labour<br>Technical advice<br>Training in nursery management | Part of the project activities |

[3] Department of Finance

**Species Selection and Preference**

The availability of germplasm is the bottleneck in species selection. Although the growth performance and timber quality of the species are major considerations, germplasm availability is the key determining factor as to why a particular species is raised in the nursery (Table 3). The table also shows that individual operators place great emphasis on the end use of the species in deciding the species to rise aside from germplasm availability, which indicates that farmers have preferences and in particular with regard to the species of trees that they want to raise. Apparently, if given a wider option of available germplasm, it is likely that they will select those species that fit with their interest and planting objectives. Being project-initiated, species selection in communal nurseries is largely influenced by the recommendation, demand and the species supplied by supporting agencies. As a result, the communal operators, considering that species selection is not actually coming from their own decision, provided no information on the suitability of the species raised to the planting site. Least emphasis was given to saleability of timber of the species which suggests that farmers either do not think about selling the timbers from planted trees or if they are planning to sell the timbers, there is no information on the market potential of the available species.

**Table 3.** Basis on deciding the species to raise

| Basis for choice | Number of times mentioned | | | Total |
|---|---|---|---|---|
| | Individual | Communal | Government | |
| Availability of germplasm | 27 | 11 | 14 | 52 |
| Demand of planting stocks | 13 | 8 | 9 | 30 |
| End use of the tree | 19 | 2 | 4 | 25 |
| Growth quality of the species | 14 | 5 | 5 | 24 |
| Suitability to the planting site | 7 | | 2 | 9 |
| Identified by the supporting agency | | 7 | 1 | 8 |
| Saleability of timber | | 1 | | 1 |

Few of the nurseries have raised fruit trees, the majority of planting stock raised being timber species. Although operators are interested in fruit trees, the absence of germplasm and lack of knowledge about vegetative propagation techniques prevents them from raising the planting stock. The germplasm used in raising seedlings of fruit trees generally comes from consumed fruits that are sold in the market and also from surrounding trees. Only one operator has taken germplasm of fruit trees from a certified source.

The three exotic species of *Swietenia macrophylla, Gmelina arborea* and *Acacia mangium* are the most commonly raised species in all nurseries groups (Table 4). These species were first introduced during the nationwide government-initiated reforestation projects and are now commonly found planted along the road, on school grounds, in municipal parks, around homesteads and on tree farms, giving the operators easy access to germplasm collection. This shows that tree farmers will likely domesticate and multiply the germplasm of a particular species once it is introduced in the area, especially if it is promoted by the government. Indigenous species including narra, lauan, and molave are also commonly raised because of their premium wood quality and high demand for planting stock. However, these species were also identified as among the species wanted by the operators (Table 5). The term ‘wanted’ refers to species preferred by the operators but not raised because of various constraints including unavailability of germplasm and lack of technical knowledge on propagation. Most of the wanted species are indigenous, an indication that many nursery operators are interested in raising native species but that the production of planting stocks is hampered by constraints primarily on sources and availability of germplasm. Among the wanted species, bagras ranks first followed by white lauan. Although mahogany has been

widely grown, the constraint in germinating the seeds of this species and short viability made it difficult for many operators to raise this species.

**Table 4.** Most commonly raised species in each nursery type

| Scientific name | Common name | Family name | Fraction (%) of nurseries growing the species | | |
|---|---|---|---|---|---|
| | | | Individual | Communal | Government |
| *Swietenia macrophylla)* | mahogany | Meliaceae | 67.6 | 72.3 | 100.0 |
| *Gmelina arborea* | gmelina | Verbenaceae | 78.4 | 31.8 | 86.7 |
| *Acacia mangium* | mangium | Leguminosae | 37.8 | 50.0 | 46.7 |
| *Pterocarpus indicus* | narra | Leguminosae | 24.3 | 45.6 | 73.3 |
| *Shorea contorta* | white lauan | Dipterocarpaceae | 8.1 | 40.9 | 20.0 |
| *Eucalyptus deglupta* | bagras | Myrtaceae | 13.5 | 18.2 | 20.0 |
| *Vitex parviflora* | molave | Verbenaceae | 10.8 | 22.7 | 13.3 |

**Table 5.** Species mostly wanted by the small-scale nursery operators and main reasons for not raising

| Species | Reason for not raising |
|---|---|
| Bagras (*Eucalyptus deglupta* | Unavailable germplasm, difficulty in germinating seeds, expensive seeds |
| White Lauan (*Shorea contorta*) | Unavailable germplasm, lack of information on how to raise |
| Mahogany (*Swietenia macrophylla* | Unavailable germplasm, difficulty in germinating seeds, short viability of seeds |
| Molave (*Vitex parviflora*) | Unavailable germplasm, difficulty in germinating seeds, takes a long time to germinate |
| Narra (*Pterocarpus indicus*) | Unavailable germplasm |
| Bagalunga (*Melia dubia*) | Unavailable germplasm, difficult to germinate |
| Fruit trees | Unavailable planting materials, expensive planting materials, lack of knowledge about vegetative propagation |

When asked about their attitudes towards various reforestation species, smallholder nursery operators put the highest preference on mahogany followed by dipterocarps and narra (Table 6). The high preference on mahogany is attributed to its fast growth and high wood quality. Dipterocarp species and narra are favoured because of their superior wood quality for structural and furniture purposes, respectively. Gmelina is not highly preferred but is commonly raised because of abundant seeds and wildlings. In fact, several farmers have developed an apathy to this species because of the notions that it can rapidly deplete soil fertility, is toxic to livestock, and decreases water yield with subsequently drying up of rivers and streams. Eucalyptus was identified as the topmost wanted species, but surprisingly this came out as not highly preferred. Many farmers are interested in raising Eucalypts but lack of knowledge in seedling production, high cost of seeds and limited source of germplasm have deminished their preference for this species. Teak, on the other hand, has superior wood quality, but most of the farmers are unfamiliar with this species, therefore ranking it as least preferred among the identified species.

**Table 6.** Attitudes of the smallholder nursery operators towards various reforestation species promoted by the government

| Species | Species preference (1 least prefer; 2 slightly prefer; 3 quite prefer prefer; 4 moderately prefer; 5 highly prefer) | | | |
|---|---|---|---|---|
| | Individual | | Communal | |
| | Mean | Mode | Mean | Mode |
| Mahogany | 4.24 | 5 | 4.32 | 5 |
| Dipterocarps | 3.54 | 5 | 3.91 | 5 |
| Narra | 3.59 | 5 | 3.64 | 5 |
| Mangium | 3.57 | 5 | 2.77 | 1 |
| Gmelina | 3.08 | 3 | 2.22 | 1 |
| Eucalyptus | 3.11 | 1 | 2.00 | 1 |
| Falcata | 1.97 | 1 | 1.59 | 1 |
| Teak | 1.27 | 1 | 1.00 | 1 |

The result suggests that farmers' preference on various tree species is primarily based on two characteristics, namely wood quality and growth rate. This means that, if given a wider choice of species, farmers will probably raise those species with not only premium wood quality but that also exhibits fast growth. These properties must go together in a species to make it attractive to smallholders. Mahogany is a highly preferred species because it possesses both characteristics. Falcata is also fast growing but is not favoured because of its inferior wood quality as structural material. Emtage (2004) revealed that farmers in Leyte are planting trees primarily for own use of timber for construction, thus species selection is mostly attuned to this objective.

**Germplasm Type and Collection Method**

The operators in raising the planting stock use two types of germplasm: seeds and wildlings. While the majority of the operators prefer seeds, wildlings are commonly used for three reasons. First, wildlings are more available and easier to collect compared to seeds. Many timber species are fine-seeded making it difficult to collect the seeds from the ground. Second, there is a lack of information on the phenology of various trees, particularly indigenous species. As a result, operators are usually unable to judge the optimal time to collect seeds while these are still attached to the mother trees or when these have not germinated and anchored on the ground. Lastly, wildlings are used especially by those who are selling seedlings because of a cost-effectiveness advantage due to a shorter management period in the nursery. While the use of wildlings offers these advantages, experience of the operators revealed that the use of this type of germplasm usually results in a high mortality of the potted seedlings and the production of planting stock with deformed root systems.

It seems that the operators who collected germplasm for seedling production ignored the quality of mother trees during the collection process. About 64.5% and 69.2% of individual and communal nursery operators respectively, did not consider the appearance of mother trees. Although nearly all (88.6%) of the operators knew the benefit of collecting germplasm from phenotypically superior trees, most of them are not paying any serious attention to this aspect. It was pointed out that the scarcity of mother trees and limited availability of germplasm compelled them to merely collect whatever is available. This could be true particularly for native species where the supply of germplasm is a great problem. However, even if there is abundant supply of germplasm as in the case of most exotics, still the physical trait of the mother tree is not given much attention. This is a crucial aspect in tree farming considering that the physical, physiological and genetic qualities of mother trees have direct impact on subsequent growth of planted seedlings. Mulawarman *et al.* (2003)

stated that germplasms that are taken from healthy, mature and straight stem tree would more likely exhibit superior growth compared to those taken from defective trees.

It was noted that the collection of germplasm did not follow the standard procedure to ensure high quality. The collection process is limited to a few trees and the distance between the mother trees is not considered. This practice results in the collection of seedlots with narrow genetic base. Dawson and Were (1997) pointed out that seeds should be collected from a minimum of 30 trees that are at least 50 m apart to ensure a broad genetic base. Koffa and Rosethco (1999) argued that it is important for smallholders to collect germplasm from a broad genetic base to prevent the possible genetic erosion of future populations of trees on the farm that will serve as the next sources of germplasm.

Table 7 shows the various criteria used by the small-scale nursery operators who collected their own germplasm. These criteria indicate that the operators highly rate the timber quality of the mother trees. Since the objective of most smallholder tree planting activities is to produce construction timber either for sale or for own use, characteristics such as good stem form, large stem diameter, maturity and freedom from diseases were highly considered.

**Table 7.** Characteristics of mother trees preferred by smallholder nursery operators

| Characteristics of the mother tree | Percent of operators using each criteria | |
|---|---|---|
| | Individual (n = 11) | Communal (n = 4) |
| Good stem form | 100 | 100 |
| Fast growth | 9.1 | |
| Big diameter | 36.4 | |
| Healthy | 45.4 | 50 |
| Prolific seeder | 27.3 | |
| Mature | 36.4 | 25 |

While the importance of collecting germplasm from phenotypically favourable trees is a common knowledge, still a number of operators are still left unaware of this aspect. They believed that the appearance of mother trees will not affect the subsequent growth of the seedlings, rather it is the silvicultural treatments that will matter.

**Sources of Germplasm**

The government extends free planting materials but the distribution scheme has not reached the majority of the landholders. The majority (83.8%) of the individual nursery operators have independently collected their own germplasm for the production of planting stocks. Conversely, just over half (59.1%) of the communal nurseries obtained germplasm from personal collection, while a bulk proportion of them were supplied by the supporting agencies.

The quality of germplasm is largely associated with the selection of germplasm sources. Seed orchard and seed production areas offer the best quality, but unfortunately these do not exist in the province. For most forest tree seedling production, germplasm is collected from unselected sources such as from planted or naturally growing trees on the farm, trees along the road, those on the school grounds, from private or government tree plantations and sometimes from the natural forest. These trees were not established for seed production purposes and do not guarantee high physical, physiological and genetic quality germplasm. In a very few cases, operators were able to receive certified seeds from supporting agencies basically as part of a research project. Some operators have also obtained germplasm from friends, neighbours, relatives, other nurseries and local seed dealers.

## Experience in Nursery Management

About two thirds (64.9%) of the individual nursery operators had no previous hands-on experience of forest nursery-related activities. However, during the course of their nursery operation, many of them attended training courses in nursery management sponsored by both government agencies and non-government organisations. Similarly, most of the managers in the communal nurseries (72.7%) had no prior experience in nursery management but almost all of them (86.4%) have attended forest nursery and related training courses. Most of this training was provided as part of community forestry project activities.

While seedling production is mostly new to the operators, the attendance of training courses and actual learning by doing have given them the basic skills needed to raise the seedlings. Nevertheless, it is apparent that the experience of the operators is limited to a few species that are commonly raised in their respective nurseries and there is still a dearth of knowledge on seedling production techniques for many exotic and native timber species and a variety of fruit trees.

## Quality of Planting Stocks

Central to the success of any tree-farming endeavour is the quality of the planting stock. Also, the quality of planting stock suggests the management skills of the operator. This justifies the importance of assessing the quality of planting stock before they are planted. Three parameters in assessing the seedling quality were adopted in the survey, namely the sturdiness quotient, root-shoot ratio and root morphology. Sturdiness quotient (SQ) – the ratio of the height of the seedling to the root collar diameter – expresses the vigour and robustness of the seedling. The ideal value for a seedling to be considered sturdy is less than six.

The root-shoot ratio (RS) refers to the proportion of the root dry-weight to the shoot dry-weight. This reflects the capacity of the roots to support the above soil biomass not only for anchorage but also in absorbing water and nutrients from the soil. High root-shoot ratio indicates high absorption and storage capacity of water, which is of advantage especially in the condition of limited moisture in the soil. A root-shoot ratio between one and two is considered as optimal (Jaenicke 1999). Root morphology or form is another seedling aspect that needs serious consideration, since it is crucial for the survival and subsequent growth performance of seedlings once they are outplanted. Deformed roots impede the uptake of water and nutrients from the soil. Further, a bent or looped primary root does not provide strong foundation for anchorage of the growing plant, hence making the plant vulnerable to windthrow as it grows older.

Among the 20 species taken from all nurseries, only two species have desirable sturdiness quotient values (Table 8). This indicates that most of the seedlings raised were basically lanky or etiolated. With regards to root-shoot ratio, none of the seedlings sampled from the nurseries attained the desired value. All of the seedlings have values of less than one, which means that shoot biomass is too high compared to root biomass. These findings indicate that the seedlings raised both in small-scale and government nurseries are of sub-optimal quality and unlikely to withstand the adverse conditions in most planting sites.

**Table 8.** Mean sturdiness quotient and root shoot ratio of sample seedlings

| Species | Individual | | Communal | | Government | |
|---|---|---|---|---|---|---|
| | SQ | R:S | SQ | R:S | SQ | R:S |
| Mangium (*Acacia mangium* | 13.5 | 0.19 | 13.3 | 0.16 | 13.77 | 0.16 |
| Lanete (*Wrightia pubescens*) | 9.4 | 0.35 | | | | |
| Narra (*Pterocarpus indicus*) | 8.9 | 0.38 | 12.2 | 0.26 | 12.2 | 0.38 |
| Mahogany (*Swietenia mahogani*) | 8.2 | 0.22 | | | 9.6 | 0.22 |
| Gmelina (*Gmelina arborea*) | 7.1 | 0.35 | | | 7.9 | 0.50 |
| Molave (*Vitex parviflora*) | 10.0 | 0.33 | 8.6 | 0.29 | | |
| Makawalo | 8.7 | 0.36 | | | | |
| Malakauayan (*Podocarpus rhumpii*) | 11.4 | 0.26 | | | | |
| Ilang-Ilang (*Cananga odorata*) | 12.3 | 0.35 | | | | |
| Red lauan (*Shorea negrosensis*) | | | 11.8 | 0.38 | | |
| Dao (*Dracontomelon dao*) | | | 6.5 | 0.37 | 6.6 | 0.43 |
| Bagtikan (*Parashorea malaanonan*) | | | 5.5 | 0.47 | | |
| Dalingdingan (*Hopea foxworthyi*) | | | 9.2 | 0.34 | | |
| Bolong-eta(*Diospyros philosanthera*) | | | 5.3 | 0.29 | | |
| Yakal kaliot (*Hopea malibato*) | | | 8.9 | 0.24 | | |
| Anislag (*Securinega flexuosa*) | | | | | 8.6 | 0.64 |
| Rain tree (*Samanea saman*) | | | | | 8.1 | 0.29 |
| Malapanau (*Dipterocarpus kerrii*) | | | | | 7.1 | 0.84 |
| Kalumpit (*Terminalia microcarpa*) | | | | | 8.1 | 0.46 |
| Balobo (*Diplodiscus paniculatus*) | | | | | 8.0 | 0.67 |

Root deformation in the form of J-rooting, twisting and curling was commonly observed fin sample seedlings. This is alarming considering that it will not only impair the uptake of water and nutrients from the soil but also will make the plant vulnerable to windthrow as it grows older (Carter 1987)**.** The J-rooting probably results from lack of care in the nursery such as when the taproot is bent during potting operation. The risk of developing J-roots increases when wildlings are used especially if taproot pruning is not practiced prior to potting. The lack of taproot pruning (in a situation where most of the nurseries are using wildlings) arises because many operators believe that root pruning would risk the survival of potted seedlings. Rather than cutting the long taproot, the usual practice is to bend, twist and in some cases wind the taproot so its entire length can be accommodated in the container. This could be the principal reason for the widely observed occurrence of J-rooting.

## CONCLUSION

The nursery industry in Leyte Province is not well established. Germplasm procurement and the production and distribution pathway are not formally structured. The government sector produces planting stock for free distribution to landholders but most of the landholders are independently collecting germplasm and raising their own planting materials. Constraints on lack of financial capital, technical skills in nursery operation and unavailability of germplasm impede operators in producing the preferred species and achieving high in quality planting stock. Species choice is centred on direct availability of germplasm resulting in the production of mainly a small number of exotic species and particularly those that were introduced by the government.

The germplasm pathway that operates in the small-scale nursery is sub-optimal. Germplasm used is mostly collected from unselected sources and the collection method seldom adopts

the accepted standard to ensure high germplasm quality. Less appreciation is given to the genetic quality of the planting materials, which can be attributed not only to the lack of information on germplasm collection protocol, but also to unavailability of certified germplasm sources in the province. Although government agencies including the DENR and DA extend free planting materials to individual farmers or assist organisations in choosing and raising the planting stocks needed for forestry development projects, these agencies operate mostly on a quantity-oriented basis rather than providing high quality materials to landholders. There are instances – for example research projects on species and provenance trials with research agencies – where high quality germplasm enters the system but the access is infrequent and uncontrolled. Further, high quality germplasm is not managed well and is planted in such a way that it interbreeds with inferior varieties subsequently diluting the superior traits.

The result of the study clearly indicates that support is needed in smallholder nurseries to improve access on high quality germplasm of various species and produce high quality planting stocks. A formal extension contact with supporting agencies may prove useful. This could be in providing information or education campaign in the form of training, distribution of extension materials such as manuals, leaflets or flyers pertaining to appropriate nursery propagation techniques of various species, and improved germplasm collection procedures. This is imperative considering that many farmers are raising planting stocks to meet their own seedling requirement. The information should not totally deviate from, but rather bank on, the knowledge of the farmers to refine their local practices. Farmers are willing to adopt new technology if it fits with their resources and capabilities, and more importantly if it will prove useful to them. Creating a database of sources of germplasm of various species and passing this on to farmers is also a useful way of improving farmers' access to a wider array of species. It was found that germplasm tends not to flow properly in the system and a particular species may be in short supply in many areas but may be abundant in other localities. By having information on the corresponding sources of respective species, the species base will be widened and it is likely that germplasm diffusion will be facilitated.

Another important consideration that would likely improve the access of smallholders to high quality germplasm of several species is to link the smallholders in the germplasm pathway that distributes high quality seeds. Generally, susperior quality germplasm only revolves within international research organisations, international seed companies, national research organisations and large private plantations. Understandably, it is difficult for the smallholders to directly connect to this pathway. Although, as mentioned earlier, high quality germplasm sometimes enters through the smallholder nursery system from national and international research agencies, this is infrequent and uncontrolled. However, smallholders will have a stronger though indirect connection with the improved germplasm pathway through national extension agencies. These agencies have more access to the pathway and can purchase high quality planting materials for distribution to smallholders. Further, they can establish seed orchards from improved germplasm as smallholders' source of high quality planting materials. Lastly, these agencies could possibly liaise a group of smallholders to the pathway to provide opportunity for them to purchase high quality germplasm.

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