
Guidelines to Produce Quality Planting Material of Agroforestry Species



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Coordination and Technical Editing

A. K. Handa, S. K. Dhyani and Javed Rizvi



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Guidelines to Produce Quality Planting Material of Agroforestry Species

1. Background

Agroforestry—an effective, traditional land management system of integrating trees and shrubs into various crops and crop-livestock production systems—has been practiced in India for centuries. Covered under the umbrella of agriculture before, it was only recently that agroforestry emerged as a distinct branch of science. The past three decades have witnessed a tremendous boost to agroforestry across the world, and India is among those pioneer countries which are taking major actions to step up the research, education, and policy level support to agroforestry.

Organized research on agroforestry started in India with the establishment of the All India Coordinated Research Project (AICRP) on Agroforestry in 1983. The research initiatives gained further momentum with the commencement of forestry education programmes in the State Agricultural Universities (SAUs) of India during 1985-86, and establishment of the National Research Centre for Agroforestry (NRCAF) at Jhansi, Uttar Pradesh in 1988. The Centre was upgraded in 2014 as Central Agroforestry Research Institute (CAFRI). At present there are 37 centres of AICRP on agroforestry representing all agro-climate types of the country. In addition, the Indian Council of Forestry Research & Education (ICFRE) conducts agroforestry research through its institutes and advanced research centres. These initiatives got a further boost with the launch of world's most dynamic National Agroforestry Policy of India in 2014. (<http://www.indiaenvironmentportal.org.in/content/389156/national-agroforestry-policy-2014/>).

In another significant move, the Corporate Social Responsibility (CSR) law of India was modified to include agroforestry as a legitimate CSR activity.

Based on the recommendations of National Agroforestry Policy (NAP), a dedicated Sub-Mission on Agroforestry (SMAF) was established by the Government of India under the framework of National Mission for Sustainable Agriculture (NMSA) with an outlay of Rs 935 crore for a period of four years starting from 2016-17. The SMAF is focussed to achieve increased tree cover to enhance carbon sequestration, enrichment of soil organic matter, availability of quality planting material, and improved livelihoods and productivity. Launching a National Bamboo Mission (NBM) in 2018 was an additional link to the same chain.

The government of India has set a target of doubling farmers' income by 2022-23, which urgently calls for increasing per unit production from agricultural land. One of the most tested and effective ways to diversify farmers' income is to increase the productivity of farming lands by intercropping perennial multi-purpose trees. Agroforestry has the potential to contribute to India's target by creating an additional 5 million ha of tree cover. India has made impressive progress in food production, but faces the threats of climate change and the risks involved in rainfed agriculture.

Agroforestry has been identified as a climate change mitigation and adaptation tool by more than 55 countries. The fact that India currently has only 24.39% forest cover, which is far below the recommended 33% by the National Forest Policy (1952, 1988) calls for using agroforestry to increase the green cover of the country. Massive plantation drives by state Governments are supporting this cause, but the survival rate and the quality of plants used are a cause of concern. The greenhouse gas emission and its alarming consequences imply the need for carbon sequestration mechanisms, while the carbon credit mechanism urges for a green economy. At this juncture, perennial plants, which should be accessible to populations (outside reserve forests) offer the possibility of climate change mitigation with additional advantage of a range of products for consumption, viz., fruits, spices,

medicines, fuel-wood, fodder, timber, pulp and paper, etc. Thus, there is an urgent need to further pursue the strategy to increase Trees Outside Forest (TOF).

To achieve any tangible progress in the areas identified above, easy access to, and unhindered availability of, Quality Planting Material (QPM) of agroforestry species is a pre-requisite. And, to support this, nationally accepted guidelines are urgently needed to ensure production and supply of QPM. The guidelines presented here are focussed for Multi-Purpose Tree Species (MPTS), planted or tended by farmers and exempted from felling and transit regime by the state governments for promotion under agroforestry in different agro-ecological regions of the country. The MPTS include species of *Acacia*, *Albizia*, Bamboo, *Casuarina*, *Eucalyptus*, *Grewia*, *Melia*, *Dalbergia*, *Populus*, *Prosopis*, *Salix*, *Terminalia* and *Ailanthus excelsa*, *Anthocephalus cadamba*, *Azadirachta indica*, *Gliricidia sepium*, *Gmelina arborea*, *Leucaena leucocephala*, *Santalum album*, *Tectona grandis* and others. Therefore, Horticulture and Natural Resource Management (NRM) divisions of ICAR, ICAR-CAFRI; Centres of ICAR-AICRPAF; World Agroforestry (ICRAF); Ministry of Agriculture & Farmers Welfare (MoAFW; GOI), Ministry of Environment, Forests and Climate Change (MoEFCC) and its various institutions; and representatives of nursery owners, farmers and relevant industries, along with more than 200 other stakeholders, have contributed to this initiative.

2. Annual Demand for Planting Material in India

Trees are the core of agroforestry. Guaranteed performance in terms of higher yield and quality of crops could be achieved with reliable planting material and good management practices. The agroforestry (TOF) in the country is mostly practiced on private farmlands, community lands and on government wastelands. Environmental conditions at these sites are often harsh, and may include erratic rainfall, infertile soils, high alkalinity and salinity, waterlogging, excessive biotic pressure and others. At these sites,

nursery-raised plants of appropriate quality to raise agroforestry plantations are of primary importance. The benefits expected from TOFs mainly depend on choice of species, seedling quality and their field management. At present, most of the established plantations/orchards, and planted species, are based on planting material sold by mostly un-regulated private nurseries using non-scientific methods to produce planting material. To meet the increasing demand for agroforestry species, many nurseries do not follow the recommended practices of QPM production. As a result, the quality of planting material in terms of genetic makeup, varietal purity, robustness, and being free from diseases and pests is not reliable. However, private nurseries alone cannot be held responsible for neglecting the quality standards on “stock sourcing” (selection of seed, mother trees, plus trees and other sources), establishment of mother blocks, propagation methods and nursery stock-management practices. Inadequate QPM production guidelines and a lack of relevant training opportunities to the nursery industry are also responsible for the production of poor quality planting material.

The estimated annual requirement of some of the most popular tree propagules, such as eucalypts, poplars, and other Multi-Purpose Tree Species is about 10 million each while the requirement of casuarinas is about 8 million. The country is presently planting annually an estimated 1.5 million ha in forest and in private land using about 3 billion plants. In addition, the requirement for a range of fruit and timber species is enormous, and the demand of QPM for all these species is expected to continue to increase due to factors discussed above. Therefore, a decentralized nursery network operating according to a nationally recognized set of guidelines to produce QPM is the need of the day.

There are about 6000 small and large plant nurseries in India, of which 70% are privately owned and 30% government owned. There is a need to regulate these nurseries to enable them to produce quality planting material, based on scientific knowledge and principles.

3. Why Nursery?

Quality Planting Material may be defined as *‘the production of uniform, healthy, disease-free planting material raised through seed or vegetative methods with an overall goal to raise the physiological and phytosanitary quality of the plant available to stakeholders to increase productivity’*.

To produce QPM, nursery is one of the best options. A nursery is a place having a standard design, layout, infrastructure and other facilities; and manned by trained manpower, where planting material is propagated and grown to plantable size. Planting material here refers to seeds and vegetative propagules.

The time of sowing/initiation of propagules production depends on how long the seedlings will take to reach an optimum size characteristic for the species and site and purpose of planting. In India plantable size plants should be ready at the time of initiation of monsoon (July for South-West monsoon and October for North-East monsoon areas).

Generally, it is assumed that the area of nursery should be about 1 acre for every 30,000 plants to be produced with an assured daily supply of about 200 litres water per 1000 seedlings.

4. Enforcement of Nursery Act and Rules and Regulations

In order to ensure high quality of seedlings from nurseries it is essential that the nursery laws and regulations are enacted and enforced in each state. An indicative list of quantitative standards of seedlings for plantations issued by the Forest Department of Madhya Pradesh as an example is presented in Appendix 1. Once laws and regulations are in place, the next step could be that all the nurseries are registered with state Government’s designated line departments.

The National Horticulture Board (NHB) has also introduced a system of recognition of horticulture nurseries. If the nursery is producing plants for sale or distribution, registration as

a nursery is required. A format prescribed by NHB to apply for registration is given in Appendix 2. Dealers procuring planting material from a registered nursery for resale must register as Nursery Stock Dealer. NHB has also introduced another system which is different from licensing of Horticulture Nurseries, and uses a five-grade rating based on the number of stars: one star, satisfactory and five stars, outstanding. This can be easily adapted for agroforestry nurseries. Nursery Accreditation is another system (Appendix 3), which is operating in many countries. These actions can lead to a significant improvement in the quality of the planting material.

Once a nursery is registered, recognized, or accredited, it should be empowered to produce high quality planting material following a protocol described in this document. As part of a standard operating procedure, nurseries be required to provide a guarantee of purity, and a phytosanitary certificate for the material produced and sold.

5. General Quality Standards for Nurseries and Plants Produced

Nursery aspects

- Nurseries should have main focus on large-scale production of the species of regional importance and agro-climatic zones.
- All nurseries must be regulated by uniform registration guidelines.
- Proper record of sourcing of stock material by each nursery is mandatory.
- In each region there must be a few star-rated nurseries for large-scale quality production based on their performance.
- A web portal with information about all registered nurseries, availability of planting material, price tag and details of genetic makeup etc. should be initiated.

Raising plants in nursery

- Specific recommendations on the rooting medium, including mist chambers, cold frames, shade net houses, and induced rooting should be followed.

Quality Planting Material Production Guidelines

- Rooting media should be used as per recommendations, and considering their availability and suitability.
- Colour and morphology of leaf should be in accordance with species and variety and the plant should have a vigorous growth in nursery.
- The shoot and root development of nursery plant should be in a proper ratio.
- To produce plants free from weeds, disease and pests, standard phytosanitary measures should be followed.
- Application of optimum and balanced nutrients and use of bio-fertilizers should be encouraged. A good knowledge of which tree can be effectively and efficiently propagated by using which plant part is essential for the success of raising plants in nurseries.
- In case of fruits, if seedlings are being used as rootstock, homogeneity should be maintained by using clonal/vegetatively propagated plants.
- The graft union should be healthy, and the size of scion and rootstock should be equal.
- Tissue culture raised plants need to be acclimatized before supplying to the users.

Shifting of planting material in nursery

- A minimum of 2-3 shiftings of saplings and or seedlings with root trimming in polybags/root trainers to avoid root penetration in the bed is essential for raising healthy plants in nursery.
- Lifting of plants should follow the specifications required for the species, such as age of the saplings, size of the plant and climatic conditions, etc. After shifting, seedlings should look healthy and not show such symptoms as leaf drying, yellowing, stress, etc.

Transportation of planting material

To transport nursery-raised planting material to other locations, proper storage conditions must be maintained.

- During transportation, planting material or seedlings should always be placed in proper conditions and they should not be placed one above the other on the floor of the transporting vehicle, containers, etc. to avoid damage.
- Depending upon the destination, species, mode of

transport, gap in time between lifting and planting, and packing material, appropriate transportation decisions should be made.

- Precaution should be taken not to disturb soil ball during transportation and storage.
- Transportation and shipping of planting material should be conducted as quickly as possible. Seedlings should be shipped at the highest priority level that is economically feasible.

6. Quality Planting Material Production

For raising the important agroforestry species, packages of practices are available in the following publications: Chaturvedi et al., 2017 and Handa et al., 2019.

- Workers of a registered nursery should receive professional training on production of QPM imparted by an institution, where, apart from the techniques to be used in production of QPM, they should be sensitized to the importance and ethics behind production of QPM.
- Required seeds should be collected from designated and well-maintained seed orchards. If no seed orchard is available for the species, nurseries would need to be supported by a scientific institution to select ‘candidate plus trees’ based on the morphology/phenotype method, and seed should then be collected only from Superior Trees.
- Mature pods/fruits should be collected just prior to falling and seeds should be extracted as early as possible without damage. Using fresh seed for seedling production is advocated. If seed has a long viability period it can be stored to be used later. In case of vegetative propagules, fresh scion or buds should be collected from the identified mother plant and used for grafting or budding within 12 hours.
- Seedling germination and/or grafting/budding success percentage can be increased by following appropriate pre-sowing and growth regulator treatments of seeds and vegetative propagules, respectively, as mentioned below.

7. Good Practices of Fruit Collection, Seed Extraction and Storage

Appropriate seed collection activities are very important for the success of any plantation programme. For most MPTS, seed collection is achieved by collecting the fruits containing seed. In order to collect seeds, identification of the best available seed source for the species in question is important. An alternative to collecting seed directly is to purchase it from a dealer or government office (forest department or SAUs) or any other reliable agency.

- Where feasible, fruits/pods should be collected directly from trees to protect them from getting exposed to soil moisture or soil microorganisms.
- Seed should be collected from several mother trees to ensure genetic diversity on the mother's side. Also, collection of mature seed maximizes seed viability, seed storability and results in good quality seedlings.
- In order to collect good quality seed, information on seed collection period is essential. A few MPTS produce seed every year, while some other species produce seed only in cycles of multiple years. However, most species produce seed only during a certain period of the year. For MPTS, the best collection periods and other details are given in Table 1.

Seed sources

- Seed can be collected from (i) seed orchards (ii) seed production areas (iii) natural forest or plantations, or (iv) populations of seed trees (e.g. scattered trees in farmland). Same amount of seed should be collected from at least 20-30 parent trees with spacing depending on species and type of seed sources. Seed can be collected from the floor below trees for such species as *Tectona grandis* (teak) and *Gmelina arborea* during the peak seed maturation season. For other species, mature fruit can be dislodged and collected by shaking the tree. To facilitate collection by in this method, polyethylene/plastic sheets or gunny bags should be placed below the tree before shaking. Seed can be directly collected from trees which are small to medium

Table 1. Seed collection period, pre-sowing treatments and other parameters in respect of some important agroforestry species.

| S.No. | Common name | Scientific name | No. of seeds per kg | Best seed collection period | Pre-sowing treatment | Viability (months) | Germination (%) |
|-------|----------------------|--------------------------------|---------------------|-----------------------------|--|--------------------|-----------------|
| 1 | Eucalyptis, Safeda | <i>Eucalyptus tereticornis</i> | >357000 | Sept.-December | Fresh, mixed with ash/sand | 24 | 90 |
| 2 | Ipil-ipil, Subabul | <i>Leucaena leucocephala</i> | 8000-10000 | April | Hot water treatment for 2-3 minutes | 24 | 90 |
| 3 | Alder, Utis, Kosh | <i>Alnus nepalensis</i> | 18 lakh | Nov.-December | Stratification | 3 | 58 |
| 4 | Whistling tree, Jhau | <i>Casuarina equisetifolia</i> | 760000 | June-December | Fresh, mixed with ash | 12 | 70 |
| 5 | Indian Lilac, Neem | <i>Azadirachta indica</i> | 1750-4000 | June-July | Fresh, de-pulping and sowing | 2 weeks | 50 |
| 6 | Kadamb | <i>Anthocephalus cadamba</i> | 16 lakh | Jan.-Feb., Oct.-Nov. | Overnight water soaking | 6 | 76 |
| 7 | Maharukh, Ardu | <i>Ailanthus excelsa</i> | 9500 | April-May | De-winking, water soaking 12-24 hrs. | 6 | 70 |
| 8 | Teak, Sagaun | <i>Tectona grandis</i> | 2500-3000 | Nov.-January | Alternate wetting and drying for 7-10 days | 24 | 30-60 |

Quality Planting Material Production Guidelines

Table 1 (contd.)

| S.No. | Common name | Scientific name | No. of seeds per kg | Best seed collection period | Pre-sowing treatment | Viability (months) | Germination (%) |
|-------|-----------------------|---------------------------|---------------------|-----------------------------|---|--------------------|-----------------|
| 9 | Indian siris white | <i>Albizia lebeck</i> | 9200 | Nov-Feb | Water soaking for 24 hr | 48-60 | 40-60 |
| 10 | Anjan | <i>Hardwickia binnata</i> | 3900 | April-May | Fresh, no treatment | 12 | 60-80 |
| 11 | Gum Arabic, Babul | <i>Acacia nilotica</i> | 700-11000 | April-June | Fresh, 40-50 min H ₂ SO ₄ scarification | > 24 | 88 |
| 12 | Mangium, Black wattle | <i>A. mangium</i> | | Jan.-June | Soak seed in hot water for 2-5 minutes then in cool water for a day | 24 | 60-80 |
| 13 | Karanj | <i>Pongamia pinnata</i> | 800-1500 | Mar.-May | Fresh, no treatment | 12 | 80 |
| 14 | Tamarind, Imli | <i>Tamarindus indica</i> | 1000-1200 | Oct.-Dec. | Fresh, 15 min H ₂ SO ₄ scarification | 36 | >60 |
| 15 | Jamun | <i>Syzgium cumini</i> | 1200 | June-Aug. | Fresh, no treatment | 1 | 50 |

sized such as *Calliandra calothyrsus*, *Gliricidia sepium* and *Leucaena leucocephala* and others. For medium to large trees seeds can be collected by using ladders or directly climbing by a trained person. Mature fruit may also be collected from trees that are harvested for other purposes.

- About 50% more seed than the estimated requirement should be collected to compensate for poor germination rate, nursery and early field mortality.
- In order to maintain seed quality, seed collection must be followed by proper seed processing and handling, which includes such activities as sorting, extraction, cleaning, grading, drying, storage and transportation. Proper implementation of seed processing and handling activities is essential and is discussed below.

Sorting fruits

- All fruits collected in the field may not be mature or of good quality; therefore, fruits should be sorted. Mature fruits should be processed for seed extraction. Fruits that are undeveloped or infected with insects and disease should be discarded. Also, those fruits that are not fully mature should be separated and allowed to after-ripen. After-ripening is important, because seed extracted from immature fruits can get damaged.

Seed extraction

- Extraction is the process of removing seed from fruits. Extraction methods vary by species and fruit type. The most common extraction methods are presented in Table 2 and described here. Seeds of *Leucaena* spp. and *Calliandra calothyrsus* are extracted by rubbing and crushing the fruits; seeds of *Gliricidia sepium* and *Acacia mangium* are extracted by placing their fruits in sacks and beating them lightly with a stick; seeds of *Santalum* species (sandalwood) are extracted by scrapping with an abrasive material such as sand and ash to remove fleshy material; seeds of *Gmelina arborea*, *Azadirachta indica* (neem) and *Tamarindus indica* (tamarind) are extracted by scrubbing and washing with water to remove fleshy material; while seeds of *Swietenia macrophylla* (mahogany) are extracted simply by breaking open the fruits and removing the seed;

Table 2. Propagation technique and quantitative standards of planting stock of major agroforestry species.

| S. No. | Common name | Scientific name | Period in nursery | Age (months) | Height (cm) | Collar diameter (cm) | Stock type* |
|--------|--------------------------|--|---|--------------|-------------|----------------------|-------------------|
| 1 | Poplar | <i>Populus deltoides</i> | Jan./Feb. to Jan./Feb. | 12 | 300-400 | 3-4 | Entire Transplant |
| 2 | Eucalypts, Safeda | Eucalyptus (different species and hybrids) | Throughout the year (Under controlled conditions) | 3 | 30 | 0.3-0.5 | Clonal |
| 3 | Eucalypts, Safeda, | <i>Eucalyptus tereticornis</i> | Feb. - August | 5 | 40 | 0.3-0.5 | Seedling |
| 4 | Bakain, Dek, | <i>Melia composita</i> | Feb. - August | 8 | 50-60 | 0.5 -0.6 | Seedling |
| 5 | Bead tree, Bakain | <i>M. azedarach</i> | Feb. - August | 8 | 50-60 | 0.5 -0.6 | Seedling |
| 6 | Malabar Neem | <i>M. dubia</i> | Feb. - August | 8 | 50-60 | 0.5 -0.6 | Seedling |
| 7 | Ipil-ipil, Subabul | <i>Leucaena leucocephala</i> | Feb.-July | 5-6 | 40-50 | 0.4-0.5 | Seedling |
| 8 | Alder, Utis, Kosh | <i>Alnus nepalensis</i> | January-Febr. | 13 | 40-50 | 0.4-0.5 | Seedling |
| 9 | Whistling tree, Jhau | <i>Casuarina equisetifolia</i> | Dec.-May | 5-6 | 40-50 | 0.3-0.4 | Clonal |
| 10 | Indian rosewood, Shisham | <i>Dalbergia sissoo</i> | Feb.-July | 4-5 | 40 | 0.5-0.6 | Seedling/ clonal |

Table 2 (contd.)

| S. No. | Common name | Scientific name | Period in nursery | Age (months) | Height (cm) | Collar diameter (cm) | Stock type* |
|--------|------------------------|------------------------------|-----------------------|--------------|-------------|----------------------|-----------------|
| 11 | Robinia | <i>Robinia pseudoacacia</i> | March-Dec. | 9-10 | 0.5-0.8 | 0.5-0.7 | Seedling/grafts |
| 12 | White willow | <i>Salix alba</i> | Jan.-Dec. | 12 | 80-120 | 0.6-0.8 | Clonal |
| 13 | Elm | <i>Ulmus villosa</i> | March-Feb. | 12 | 50-60 | 0.4-0.5 | Seedling |
| 14 | Indian Lilac, Neem | <i>Azadirachta indica</i> | June-Feb. | 7-8 | 30-40 | 0.3-0.4 | Seedling |
| 15 | Bhimal, Buel | <i>Grewia optiva</i> | March-June | 15 | 60-80 | 0.4-0.5 | Seedling |
| 16 | King of desert, Khejri | <i>Prosopis cineraria</i> | July-June | 12 | 30-40 | 0.3-0.4 | Seedling/grafts |
| 17 | Kadamb | <i>Anthocephalus cadamba</i> | Feb.-July | 4-5 | 35-50 | 0.4-0.6 | Seedling |
| 18 | Toon | <i>Toona ciliata</i> | June-Feb. | 7-8 | 30-40 | 0.5-0.6 | Seedling |
| 19 | Mulberry, Toot | <i>Morus alba</i> | Jan.- July | 6 | 0.7-0.8 | 0.5-0.7 | Clonal/cutting |
| 20 | Sandal, Chandan | <i>Santalum album</i> | June – Feb./Feb.-Aug. | 7-8 | 30 | 0.3-0.5 | Seedling |
| 21 | Mehndil | <i>Lawsonia inermis</i> | March-July | 4 | 30 | 0.2-0.3 | Seedlings |
| 22 | Maharukh, Ardu | <i>Ailanthus excelsa</i> | Dec. - July | 6 | 40 | 0.4-0.5 | Seedling |
| 23 | Mahogany | <i>Swietenia mahoganii</i> | Dec.-July | 6-8 | 40 | 0.4-0.5 | Seedling |
| 24 | Mahua | <i>Madhuca indica</i> | July - Jan. | 6-7 | 30 | 0.3-0.4 | Seedling |

Table 2 (contd.)

| S. No. | Common name | Scientific name | Period in nursery | Age (months) | Height (cm) | Collar diameter (cm) | Stock type* |
|--------|------------------------|---------------------------------|-------------------|--------------|-------------|----------------------|----------------|
| 25 | Pilu | <i>Salvadora oleoides</i> | July-May | 10-12 | 20-30 | 0.3-0.4 | Seedling |
| 26 | Arjun | <i>Terminalia arjuna</i> | June- April | 10 | 30-40 | 0.3-0.4 | Seedling |
| 27 | Bedda nut tree, Beheda | <i>Terminalia bellirica</i> | March-July | 3-4 | 20-30 | 0.5 | Seedling |
| 28 | Harar | <i>Terminalia chebula</i> | June -May | 12 | 40 | 0.4 | Seedling |
| 29 | Semul | <i>Bombax ceiba</i> | June-May | 12 | 50 | 0.4 | Seedling |
| 30 | Teak, Sagaun | <i>Tectona grandis</i> | Jan. - Aug. | 6-7 | 30-40 | 0.5 | Stump planting |
| 31 | White teak, Gumhar | <i>Gmelina arborea</i> | Jan. - Aug. | 6-7 | 40-60 | 0.5 | Seedling |
| 32 | Pink cedar | <i>Acrocarpus fraxinifolius</i> | May-Feb. | 8 | 40 | 0.3 | Seedling |
| 33 | Indian siris white | <i>Albizia lebbeck</i> | Jan.-June | 4-5 | 35 | 0.3-0.5 | Seedling |
| 34 | Albizia | <i>Albizia chinensis</i> | Jan.-June | 4-5 | 35 | 0.3-0.5 | Seedling |
| 35 | Indian siris black | <i>Albizia procera</i> | Jan.-June | 4-5 | 35 | 0.3-0.5 | Seedling |
| 36 | Anjan | <i>Hardwickia binmata</i> | May/June-June | 12 | 40-50 | 0.4-0.6 | Seedling |
| 37 | Gum Arabic, Babul | <i>Acacia nilotica</i> | Jan.-June | 4-5 | 30-40 | 0.3-0.4 | Seedling |

Table 2 (contd.)

| S. No. | Common name | Scientific name | Period in nursery | Age (months) | Height (cm) | Collar diameter (cm) | Stock type* |
|--------|-----------------------|----------------------------|---|--------------|-------------|----------------------|---------------------|
| 38 | Khair | <i>A. catechu</i> | Jan.-June | 4-5 | 30-40 | 0.3-0.4 | Seedling |
| 39 | Mangium, Black wattle | <i>A. mangium</i> | Jan.-June | 4-5 | 30-40 | 0.3-0.4 | Seedling |
| 40 | Earpod wattle, Acacia | <i>A. auriculiformis</i> | Jan.-June | 4-5 | 30-40 | 0.3-0.4 | Seedling |
| 41 | Gooseberry, Aonla | <i>Phyllanthus emblica</i> | Feb.-April (seed sowing Feb.) | 4-5 | 30-40 | 0.5 | Grafted |
| 42 | Tamarind, Imli | <i>Tamarindus indica</i> | March-July | 3-4 | 30-40 | 0.8-1.2 | Seedling |
| 43 | Jamun | <i>Syzygium cumini</i> | Sowing seeds: June-July | 12-18 | 30-40 | 0.8-1.2 | Seedling |
| 44 | Coconut | <i>Cocos nucifera</i> | Feb.-Aug. | 8-12 | 50-75 | 0.5-0.8 | Seedling |
| 45 | Bael | <i>Aegle marmelos</i> | June-July | 12 | 30-40 | 0.5-0.8 | Seedling |
| 46 | Ber | <i>Zyziphus jujube</i> | March-April seed sown June-Sept. budding | 8-15 | 30-40 | 0.8-1.2 | Grafted |
| 47 | Bamboo | <i>Bambusa</i> spp. | Jan.-June | 6 | 60-80 | 0.2-0.4 | Seedling/ clonal |

* Seedling material could be raised in root trainers or polythene bags of variable sizes.

and fruits of *Tectona grandis* (teak) and *Calamus* species (rattans) are processed by firmly rubbing together to remove the outer skin and other debris. Extraction methods should be conducted carefully to avoid damage to seed.

- If seed extraction and processing cannot be conducted immediately, place sacks or containers of seed in a room with good air circulation. Sacks may also be hung from the ceiling and only mature fruits should be processed for seed extraction. Some common tools used in extraction include sacks, tarps, trays, buckets, tanks and sandpaper (or other abrasive material).

Cleaning and grading

- In order to maintain high seed quality and viability during storage all debris must be removed. A number of simple cleaning methods such as winnowing and sieving, removing wings from winged seeds of *Swietenia macrophylla* (mahogany) and other species, washing and drying are common. After cleaning the seed it is appropriate to grade it according to relevant characteristics.

Seed drying

- If seed is to be sown immediately after extraction and cleaning, no further processing is required. However, if it will be stored, even for a short period, the seed of most species requires drying in order to maintain viability during storage.

- Whether seed requires drying or not depends on whether it is recalcitrant or orthodox.

- Broadly, seeds can be classified as recalcitrant or desiccation sensitive and orthodox. Recalcitrant or desiccation sensitive seed must retain high moisture content to remain viable and generally have short viability. If stored under humid conditions, such as wrapped in a moist cloth or paper, recalcitrant seed may remain viable for longer periods. Species with recalcitrant seed include *Artocarpus heterophyllus* (jackfruit), *Azadirachta indica* (neem), *Calamus* species (rattans), *Durio zibethinus* (durian), *Eusideroxylon zwageri* (ulin), *Theobroma cacao* (cacao) and many dipterocarps (*Shorea*, *Hopea* etc.). Orthodox seed must be dried to a low moisture content (5-8%) before

it is stored. At that moisture content most orthodox seed can be stored for more than one year at room temperature or several years in cold storage with little loss of viability. Some of the species with orthodox seed include *Acacia mangium* (mangium), *Eucalyptus* spp., *Tectona grandis* (teak), *Paraserianthes falcataria* (falcata) and *Gliricidia sepium* (gliricidia). The viability can be improved for most of the species by several months with proper storage.

Seed storage

Seed storage is necessary for a number of reasons such as time of seed ripening and collection often varies which affects seedling production and tree planting, far away location of the seed sources, and for species that do not produce seed every year. In addition, seed storage is needed before its transportation to place of requirement.

Seeds may be stored by following standard practices:

- The length of time the seed will remain viable varies greatly by species and storage conditions. Under fair to good conditions orthodox seed of most species will remain viable when stored for one to two years. However, seed will remain viable for a longer period when stored at a consistent cool temperature, with low moisture content and under low air humidity.
- Seed should be stored in the dark or in covered non-transparent containers or sacks, bags, baskets, tins, plastic or glass jars with air-tight lids.
- Some organic pesticides such as neem oil or leaves, gliricidia leaves, can be used to protect seeds.

Transportation of seeds

- During transportation, seed should always be covered with waterproof material such as tarps or plastic sheets and stored under permanent shelters.
- Seed containers should not be placed directly on the floor of transporting vehicle to avoid moisture, rodents and insects. They should be placed on racks. Transportation of seed should be conducted as quickly as possible. Delays and storage of seed under uncontrolled conditions will reduce seed viability.

Sowing seeds

- Some seed types develop dormancy after collection and, if sown immediately after collection, they may need no pre-treatment. Others may need a pre-treatment before sowing.
- Seed treatment may be by soaking in water, acid pre-treatment, mechanical methods, or biological pre-treatment.
- Dormancy type and germination percentage should be tested before sowing the seeds.

Seed dormancy and pre-sowing treatments

Pre-sowing treatments are intended to overcome seed dormancy and ensure a rapid, uniform and fast seed germination. Most pre-sowing treatments are applied to seeds immediately before sowing. Appropriate pre-sowing treatment methods depend on the dormancy type. The following are some of the common pre-sowing treatments:

- Soaking in cold water
- Soaking in hot water
- Boiled water treatment
- Scarification (acid, mechanical, manual) methods
- Fire or heating methods
- Soaking in chemicals
- Alternate wetting and drying

Seed pre-sowing treatments for some important MPTS in India suitable for agroforestry are given in Table 1.

Asexual plant propagation

- When vegetatively active plant parts are used for propagation, it is referred to as the asexual or clonal propagation. The vegetatively active plant parts also known as primary plant parts, such as the stem, root and leaf, are most commonly used for producing plants. Their cuttings produce new copies of the parent tree or mother plant. Plants produced from a single plant asexually are called clones. One can take cuttings from the branches, roots and even from the leaf in certain species. A branch may be made to root while still attached to the tree through air layering and separated after the roots have developed well. The cuttings could be classified into hardwood, semi-hardwood, and softwood or active, green, immature cuttings.

- Hardwood cuttings are generally used for propagating deciduous and softwood trees. Many of these plants can also be propagated with semi-hardwood cuttings with care. Softwood or green tip cuttings are mostly used in propagating herbs, vegetables, flowers, etc.

Parent material for vegetative propagation

Vegetatively propagated plants can be produced from vigorously growing branches and root parts of most tree species. However, not all plant parts are suitable, so a good knowledge of which tree can be effectively and efficiently propagated from which plant part is essential. The criteria for selection of the parent tree for vegetative propagules are similar to those used for collecting the seed. Special attention should be paid to the following criteria:

- Select a healthy, disease and pest free tree.
- Take the healthy plant part for propagation or when used for grafting, budding, etc.
- Take the cuttings from woody branches.
- The cut branches should have at least four bud eyes or nodes.
- Make clean cuts of the branches by using a sharp knife or pruning shears.
- Make the flat cut on the top portion and a slant cut at the base of a branch. This reduces drying out and provides larger area for producing roots.
- Make the top cut about 3 cm above the node and the lower cut just below the node.
- If leaves are to be taken for propagation, take out the leaf along with the petiole (trimming the stem) from the branch by using a budding or grafting knife.
- Root cuttings should be used for propagating plants that produce suckers. Take 5-8 cm long and half a cm in diameter root, store for callus formation and plant when desired.
- Mark clearly each batch of the cut parts of a species, a variety, a cultivar, etc. and keep them separately. Store the branches in horizontal position during transport to avoid the outflow of the sap from them.
- Keep as many leaves as possible on the cut branch to ensure food production during root formation for proper

growth of the new plant. However, remove all the leaves that may have come in contact with the rooting medium.

- Plant the cuttings at a 45° angle by keeping about two-thirds of their length in a suitable rooting medium and at least two nodes over the ground facing upward.
- The rooting medium should be light, moist, and well drained for good aeration.
- It is critical to induce rooting as quickly as possible while preventing the top of the plant from drying. Intermittent mist, use of hormones (indole-3-acetic acid, IAA; indole-3-butyric acid, IBA; and alpha-naphthalene acetic acid, NAA) and providing bottom heat may be applied for this.

Using standard horticultural tools and techniques for asexual propagation of the selected material

Asexual propagation can be categorized into apomictic seed, and specialized vegetatively active part used for cutting, layering, grafting, budding, etc.

Layering: Layering is a propagation method in which roots are induced to form on stem/branches of the parent plant. After the roots have formed, the branch is severed from the parent plant and planted as a new plant. Layering has proved effective for several fruit trees, e.g. guava and lime. Layering can be done by bending and covering the bent portion of the branch with soil in shallow trenches. In air layering, a branch is girdled, the cambium lightly scraped, and the girdled part is wrapped with moist material in plastic covering. Rooting is improved if rooting hormone (IAA, IBA and NAA) is applied to the girdled part.

Grafting: Grafting is a method used to produce early fruiting of selected genotypes of trees. It is used both for fruit production and production of propagation material. Grafting is a method of uniting two or more distinct genotypes into a compound genetic entity, in which the stock and scion are fused anatomically. The part of the plant which will provide the root system is called the root stock, and the part which will form the above ground portion is called the scion. Usually the stock is from a genotype that has genetically superior characteristics for the growth site, and the

scion is from a genotype whose products, mainly fruits, are desired for consumption or seed production.

Grafting methods: There are several methods of grafting, adapted to different species. Some of these methods include inarching, wedge, tongue, cleft and bridge grafting, each with its own technique, advantages, and disadvantages. Some general recommendations are summarized below.

- Use similar diameter-size of stock and scion plants in splice grafting, wedge grafting and whip grafting.
- Use a sharp grafting knife or a grafting machine for making the graft to avoid rough cutting of the stock and scion.
- In V wedge grafting, the size of the wedge on the stock shoot and the base of the scion made into V shape should be of the same size.
- In order to obtain a successful graft, the following conditions must be met.
- The stock and the scion must be graft compatible, meaning they must be closely related botanically (normally the same species but sometimes different species in the same genus are compatible).
- Whatever the graft method employed, it is necessary to obtain a perfect stock and scion cambium layer match. Callus tissue from the cambium or immature xylem and phloem adjacent to the cambium seals the union of the stock and the scion.
- The graft region must be protected from drying until the graft union is formed. This can be achieved by coating the graft union site with grafting wax and wrapping the union with plastic strips or grafting tape. The wrapping is also important for keeping the two parts in place until they have united.
- Remove all the branches coming from below the graft union, to avoid the root stock developing its own branches, which may compete with the scion and reduce the chances for graft union.
- Plant the grafted plants in such a way that the graft union is above the soil surface.

Micro-grafting is also a grafting technique in which the scion tissue is grafted on the root stock tissue with the microscopy under aseptically *in vitro* conditions using sterilized growing media. This technique has been found most effective to obtain grafted plants free from virus and diseases.

Budding: Budding is a special variation of grafting in which the scion contains a single bud along with a small portion of bark with or without the wood. Budding is preferred in plant species in which grafting does not work well. Budding is, for example, used if scions tend to desiccate easily (e.g. large leaved plants) or form branch-like growing habits (plagiotropic growth). There are several budding methods used, the most common are shield budding, T budding, patch budding and ring budding. The details of each of the budding methods can be accessed from the literature. The precautions to be taken in budding, i.e. in relation to union and desiccation are similar to grafting.

Micro propagation

Vegetative propagation of plants by tissue culture is known as micro propagation. It is a kind of clonal propagation that is carried out under controlled environmental conditions in growth chambers, under aseptic conditions. Micro propagation has many advantages, such as the freedom from pests and diseases, economy of resources and space, rapid multiplication, etc. However, it is capital intensive, highly sensitive and requires sophisticated laboratory, contamination-free environment and a high-level of expertise at all stages.

These techniques can produce significantly high number of grafted virus-free plants in a short span of time. They are an effective tool in separating the virus and virus-like agents.

Clonal multiplication of industrial tree species

Clonal multiplication of industrial tree species like eucalyptus or *Leucaena* is done using root trainer technology for faster multiplication of planting material. In root trainer technology stem cutting from coppice obtained from a known gene bank is used

and grown in inert material like vermiculite. This needs controlled conditions (mist chamber) for rooting and sprouting of the cutting. It is followed by hardening under a shade net with proper fertigation regime. Trained manpower is essential to produce and handle planting material. Clonal propagation is preferred for a true-to-type planting material with a broader genetic base.

Propagation techniques and quantitative standards of planting stock of major agroforestry species are presented in Table 2.

8. Origin of Quality Planting Material

Planting material of authentic vegetative or seed origin produced in advanced technology nurseries or tissue culture labs, with proven track record of high survival percentage in the field, faster growth, higher yield, resistance to pest and diseases, adaptability to local bio-physical, climatic and socio-economic conditions, and with high market demand, will be eligible to qualify as Quality Planting Material. It should originate from properly established seed orchards, clonal orchards, plus trees, produced by advanced technology nurseries. The mother stock used for production of QPM in hi-tech and satellite nurseries (temporary nurseries established near the plantation sites) should be of diverse genetic origin.

9. Certification of Quality Planting Material

Identification of source of planting material

Correct identification of tree species should be done by an acknowledged expert in tree taxonomy. A panel of such experts should be appointed and made accessible to the accrediting agencies. The use of DNA barcoding for precise identification is a modern technology that could be further developed and used to confirm the species identity.

Genetically superior trees at the mature stage of growth and with the flowering cycle documented should be used for multiplication in accredited nurseries. Establishment of clonal

and seed orchards at the nurseries or State Forest Departments, research institutes, and agricultural universities will ensure that tested seed and clones are available for mass propagation.

Mass production of planting material

Correctly identified seeds and genetically superior clones of a tree species obtained with the necessary certificates of origin will be mass propagated and the planting material conforming to the quality standards will be labelled as Certified Planting Material by certified nurseries following guidelines issued by a certified agency.

Maintaining traceability

Documentation of the chain-of-custody of seed and or vegetative material used for producing planting stock will be maintained by the accredited nursery at all stages from the certified mother trees through any of the mass propagation systems to the point of sale from where the farmers procure the planting stock.

10. Certification Procedure

- The nursery, after having identified the species and specific clones for propagation in its premises, obtains and maintains the necessary documentation attesting to the species and clonal identity. If procured from research organizations/agricultural universities/State Forest Department or other agencies, the certificate will be provided with the exchange of plant material. The procedure for Certification of QPM is presented in Appendix 4. Clearly labelled clones will be maintained in the seed/clonal orchard and used for multiplication.
- Any of the popular sexual/clonal propagation methods can be used for mass propagation. This includes propagation through seed, rooted stem cuttings, branch cuttings, layering, grafting, rhizome offsets and tissue culture. Macro-proliferation of the resulting planting stock is a method that can be followed to maintain stocks for many cycles. The details are given in the Guidelines and Manual for Certified Bamboo Nurseries (Pandalai and

Muralidharan, 2014a and 2014b, and Muralidharan and Pandalai, 2014). For tissue culture plantlets the NCS-TCP norms (DBT, 2013) are recommended.

• Accredited Nurseries will issue certificates (Appendix 5) for quality planting material they produce. Such planting material will carry labels (see format in Appendix 6) that declare the essential information that gives an assurance to the tree grower of the quality. Tree planting stock carrying the label of “Certified Quality Planting Material” sold from an Accredited Nursery will ensure:

1. Correct species identity
2. Uniform and established clonal identity
3. Disease- and pest-free material
4. Plant quality and health

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Appendix 1

Sample Guidelines[#]

Indicative List as Provided by the M.P. Forest Department for Quantitative Standards of Seedlings for Plantation

| S. No. | Species | Age | Height (Min.) | Collar radius |
|--------|---|---------------------------|---------------|---------------|
| 1. | Bamboo plant raised by Rhizome | 1.5 to 2.0 years | - | 3-5 cm. |
| 2. | Teak | 1 to 1.3 years | 9 inch | 4-8 cm. |
| 3. | Indian Rosewood (Shisham), Neem, Indian siris (white), Indian siris (black), <i>Cassia</i> , Eucalypts, Babul, <i>Terminalia arjuna</i> , <i>T. bellirica</i> , Jamun, Kadamb, Gumhar etc. | 1 year | 45 cm | 1.5-2 cm. |
| 4. | <i>Acacia catechu</i> , <i>Mahua</i> , <i>Hardwickia</i> , <i>Adina cordifolia</i> , <i>Terminalia chebula</i> , Indian gooseberry, <i>Aegle marmelos</i> , Tamarind, Sandal, etc. | 2 years | 45 cm | 2-3 cm. |
| 5. | <i>Peltoforum</i> , <i>Delonix regia</i> , <i>Cassia siamiae</i> , <i>C. fistula</i> , <i>Putranjeeva</i> , <i>Alstonia</i> , <i>Bauhinia purpurea</i> , <i>Spathodia</i> , Jakranda, Karanj, Mango, Neem, Kadamb, Shisham, Bougainvillea, etc. | 2 years | 90 cm | 3-5 cm. |
| 6 | Grafted Aonla | 3-4 months after grafting | 45 cm | 2-3 cm. |
| 7. | Clonal eucalypts | 3-4 months | 30 cm | 1.5-2cm |

Quality Planting Material Production Guidelines

Appendix 1 (contd.)

| S. No. | Species | Age | Height (Min.) | Collar radius |
|--------|------------------------------------|--------------|---------------|---------------|
| 8. | Bamboo (polythene raised) | 1.5-2 years | | 3-5 cm. |
| 9. | Pre-sprout Teak (polythene raised) | 1-1.25 years | 9 inch | 3.5-5 cm. |
| 10. | Gumhar (<i>Gmelina arborea</i>) | 3-6 months | 45 cm | 1.5-2 cm. |

#Modified from GOI (Government of India). 2016. Operational Guidelines Sub-Mission on Agroforestry (SMAF) under NMSA, Department of Agriculture, Cooperation & Farmers Welfare, Ministry of Agriculture & Farmers Welfare.

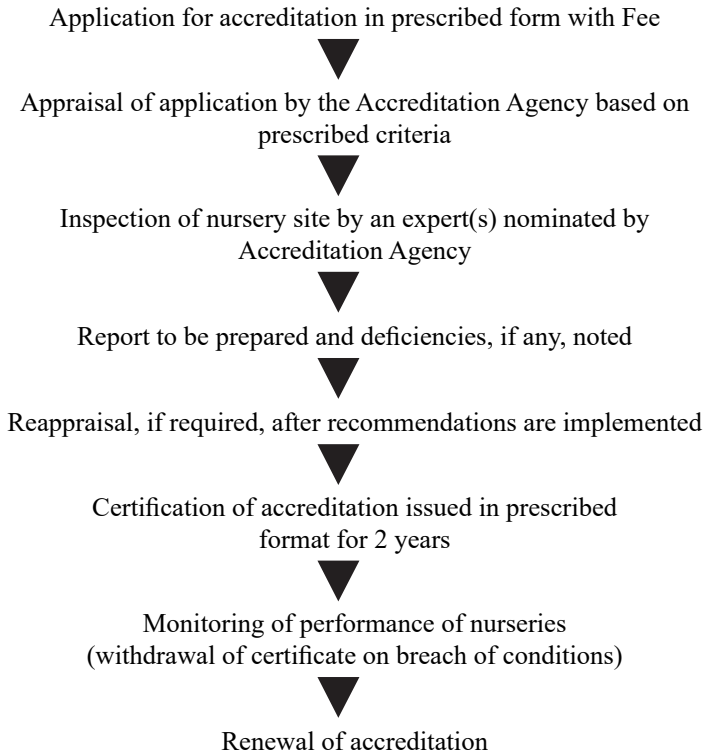
Appendix 2*

Application for Recognition of Accredited Nursery

| | | |
|----|--|--|
| 1 | Name of applicant | |
| 2 | Name of nursery | |
| 3 | Full address | PIN: Email ID |
| 4 | Location of nursery | State: District: Town/village: GPS Coordinates: |
| 5. | Constitution | Govt. / Private /Regd. Trust /Society: |
| 6. | Year of establishment | <i>(Mention year of initiating propagation)</i> |
| 7 | Number of trained staff | <i>(Give categories and technical qualifications, if any)</i> |
| 8 | Facilities | Area: <i>(Provide a layout map)</i> Fenced or not: Propagation facilities available: Mist chamber : Green Houses: Nursery buildings: Masonry/Thatched/ other Equipments, if any Water Source: Irrigation system: |
| 9. | List of mother plants available for multiplication | <i>(List with details of origin)</i> |
| | Fees paid | <i>(Give details of mode of payment)</i> |
| | | <i>Signature of applicant with date)</i> |

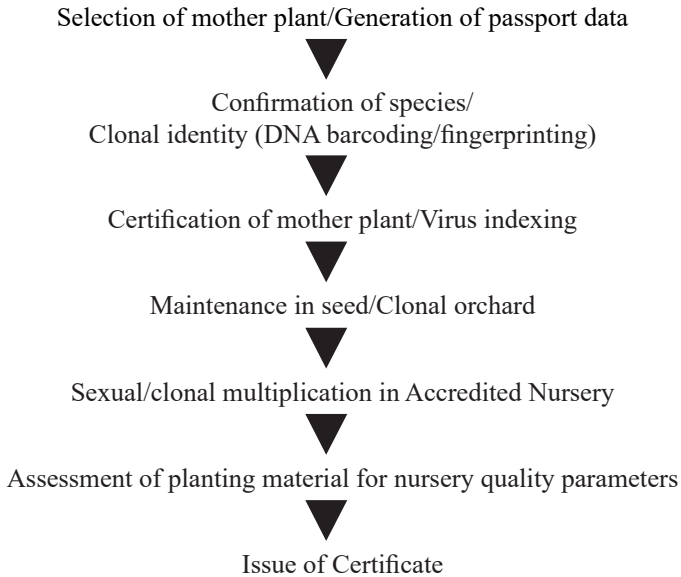
Appendix 3*

Procedure for Accreditation of Nurseries



Appendix 4*

Procedure for Certification of Quality Planting Material



Appendix 5*

Format of Certificate to be issued by Certified Nursery*

| | |
|---------------|--|
| <i>(LOGO)</i> | Name of Certified Nursery |
| | Certificate of Planting Stock |
| | Valid from: _____ to: _____ |
| | (To accompany each Batch of Planting Material produced in a Certified Nursery) |

| | | |
|-----------|---|---|
| A | Full address and contact details of Certified Nursery | |
| | Details of Certificate issued by Nursery Certifying Agency | |
| B | Name of species | |
| I | Scientific name | |
| II | Variety name/local name (if any) | |
| C | Origin of Planting Material | |
| I | Accession No./Clone No. | |
| II | Batch No. | |
| III | Batch size | |
| IV | Details of certification from competent authority | |
| V | Expected year of flowering | |
| D. | Propagation | |
| I. | Mode of propagation | <i>(Seedlings/Rooted culm cuttings rhizome offsets / micropropagation).</i> |
| II | Details of certification from NCS-TCP, DBT for TC plants | |

Quality Planting Material Production Guidelines

Appendix 5 (contd.)

| | | |
|--|---|---|
| E | Silvicultural Quality | |
| I | Age of planting material | |
| II | Number of healthy (leafy) tillers | Above 50 cm: |
| | | Emerging: |
| III | Quality of rhizomes | Well-developed/Acceptable/Poor |
| IV | Quality of root system | Well-developed/Acceptable/Poor |
| F | Plant Health | |
| I. | Prophylactic treatments given | |
| II. | Incidence of diseases | |
| III | Incidence of pest | |
| IV | Whether certified virus free | |
| V | Symptoms of nutritional deficiencies, if any | |
| G | Approved Commercial end use | |
| I | Biomass for timber/ energy | |
| II | Eco-restoration | |
| III | Others (specify) | |
| H | Labelling | |
| I | Attach sample of label accompanying planting material | |
| II | Bar code | |
| Signature, name, designation and seal of certified nursery | | Signature, name, designation and seal of designated official from appropriate Certifying Agency |
| Date: | | Date : |

Appendix 6*

Format of Label for Certified Quality Planting Material

| | |
|---|-----------------------------|
| <i>Logo here</i> | <i>Name of Nursery here</i> |
| Certification No. | Validity period: |
| <i>Address and contact numbers, etc.</i> | |
| CERTIFIED QUALITY PLANTING MATERIAL | |
| 1. Name of species: | |
| 2. Common name (in local language): | |
| 3. Clone No. and name, if any: | |
| <i>Declaration</i> | |
| The planting material meets the specifications and standards set by accreditation agency for certified Quality Planting Material. | |
| 4. Expected date (year) of next flowering: | |
| 5. Age of planting material: | |
| 6. Price: | <i>Print Bar code here</i> |
| (Signature of supplier with seal) | |
| In case of complaints, write/ call: | |
| Telephone: | Email: |

*Appendix 2, 3, 4, 5, and 6 modified from the Draft National Accreditation System for Bamboo Nurseries and Certification of Quality Bamboo Planting Material (GOI 2018b).

Entries in italics are for instruction only and not to be printed.

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