

**Manual
for
Establishment and Management of
High-Tech Bamboo Nursery**

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Introduction

The Department of Agriculture & Cooperation, Government of India, is implementing the National Bamboo Mission (NBM) as a centrally sponsored scheme which aims at holistic development of the bamboo sector in the country. The activities of NBM are focused on forest and non-forest sectors with the major objective of increasing productivity of bamboo through species selection, use of quality planting material and scientific management of plantations. The importance of quality planting stock in ensuring higher productivity in bamboo plantations cannot be ignored. The basic principles that are accepted for agricultural and forestry crops are applicable to bamboo also. In practice there are problems such as wrong identification of species, non availability of sufficient planting material, lack of genetically superior planting material, problems encountered in large-scale multiplication and lack of guidelines and package of practices for establishing and managing bamboo nurseries and plantations. Some of these issues are being resolved through the process of certification of planting material, selection and testing of superior clones of different species and developing procedures and guidelines for the production of quality planting material and raising plantations scientifically. NBM is in the process of bringing out a series of guidelines and manuals for helping farmers and entrepreneurs for achieving this target. The present manual is an attempt on these lines and aims to throw light on scientific establishment and management of bamboo High-tech Nurseries and production of quality planting stock.

1. Nursery site

- Nursery site should be well drained
- Easy accessibility with good motorable roads.
- Availability of adequate labor force from the vicinity of the nursery
- Round the year availability of good quality water
- Located in area where edaphic and climatic conditions are conducive to rapid multiplication and healthy growth of propagules of the species of bamboo.
- Availability of good quality top soil preferably of alluvial type, sand.
- Site free from any legal encumbrances.
- Not affected by human interventions and wild animals.

Sites having all the above attributes can be developed as an ideal High- Tech Bamboo Nursery. NBM provides Rs. 40 lakh for the development of a High-Tech nursery in an area of 2 ha and Rs. 10 lakh for a 0.5 ha Small Nursery. Once all the legal documents pertaining to the land to be developed as the high-tech nursery is critically examined and found satisfactory, the area will have to be demarcated after proper surveying and fenced preferably with chain links or barbed wire using concrete posts. The fence should have a height of 1.5 meters above the ground level. Use of chain links will be advantageous as it will prevent the entry of porcupines and wild pigs in to the nursery. However in the case of barbed wire fencing, providing a separate wire mesh barrier at the bottom of the fence will also check the entry of small animals in to the nursery.

2. Division into sectors

The demarcated and fenced nursery site will have to be divided into smaller sectors so that nursery infrastructure, propagule production and management and maintenance of parent stock (clones for propagation) and all such nursery activities can be planned and implemented only in these sectors. This will help in managing the system more effectively and effortlessly. Overall nursery establishment cost will also be drastically reduced.

3. Sector-1

High-tech nurseries developed from NBM funds should have certain basic infrastructure facilities in order to meet the NBM standards and productivity targets. The essential infrastructural facilities include nursery office building, laboratory, implement/fertilizer/vehicle shed, compost shed, potting shed, etc and should be accommodated in this sector. All future infrastructural developments should be planned and implemented only at this sector.

4. Basic nursery infrastructure

4.1 Office building

The office building is best located by the side of the main entrance so that visitors can get first hand information about the availability, price and procedures for obtaining certified *b*amboo planting stock from the high-tech nursery. The office building with an office room for the officer in charge, a spacious hall for the clerical, technical and skilled staff with separate space for the storage of nursery records are essential requirements in a high-tech nursery. A front room with a reception desk and display boards indicating the nursery certification document, species available for sale, selling price, and current stock position are information that should be available to the visitors. Visitors lounge, drinking water/ toilet facilities are other infrastructure facilities to be provided.

4.2 Laboratory

A laboratory equipped with an electronic balance, oven, refrigerator, seed purity board, glassware, chemicals and growth hormones are primary requirements in high-tech nurseries. The laboratory will be used by the technical/skilled staff for preparing hormone solutions, gathering information on the growth, development, disease/pest infestations and nutritional deficiencies/imbances observed in bamboo propagules being raised in the nursery. Any abnormalities observed during the developmental stages of the propagules are to be documented and timely remedial measures taken. Maintenance of all the above data and their proper documentation will be an important criterion for getting the funding and authority for certification of the planting stock.

4.3 Stores

Separate store rooms with wall mounted shelves will be required for safe keeping of nursery implements; machineries like weed cutter, branch pruner, hedge cutter and chain saw, mechanical/hand sprayers etc. Separate store rooms are required for fertilizers (urea/di-ammonium phosphate etc.), sieved soil, sand, insecticides/pesticides etc. information regarding antidotes, method of usage and dosage should be clearly displayed in the respective stores and main office building.

4.4 Nursery vehicle

The facility of a trailer jeep/mini truck will be a requirement in a high tech nursery for easy transportation of the planting stock to distant planting areas, for which hire charges should be levied from the customers in order to make the facility self sustainable. A vehicle will be use for transporting nursery items like manures, fertilizers and other stationery items to and from the nursery. A vehicle shed attached to the nursery will ensure safe parking of the vehicle. While designing the nursery layout smooth and unhindered movement of the vehicle within the nursery premises for loading and unloading of materials should also be kept in mind.

4.5 Composting unit

It is always advisable to reduce the quantity of soil being used in potting mixtures and the best substitute for soil will be the mixed weed compost. Mixed weed compost is a rich source of organic matter and hence can be used as an active ingredient in the potting mixture along with clean soil and sand. Mixed weed compost can be easily and economically made in the nursery through aerobic composting and will involve only minor initial investment. The unit for aerobic composting will consist of a well ventilated hall (Fig.1) of any convenient size with roof so that rain will not spoil the composting process. The partially open side walls ensures free air circulation during the composting process. A separate room for the storage of the clean, sieved compost is required and must ensure its availability round the year in the nursery. A weed chopping machine is the major equipment required for composting in the shed and may cost only less than Rs. 50,000/-. As monitoring and controlling the temperature in each of the composting heap is an important activity, a set of digital thermometers, locally available in the market will be useful, though manual checking is also equally reliable.

The procedure for aerobic composting is available on line from number of web sites.



Fig.1. Composting unit showing a well ventilated hall and a weed chopping machine.

4.6 Soil sterilization

Soil used as a major ingredient in the potting mixture and even in the propagation beds should be free from extraneous materials like stones, roots and plant debris and plastic wastes and all these can be eliminated manually. However the soil should be sterilized and this can be achieved easily and economically through the process of “Solarization”. Through solarization the soil will be disinfected and will be free from harmful fungi, bacteria, viruses, nematodes and other soil borne tiny pests. Traditionally solarization makes use of the solar energy for heating the soil to a high temperature and this is achieved by the soil spread out as a flat layer outdoors for several weeks while covering it with a transparent plastic sheet with the edges buried in the soil to trap the heat to the maximum inside. Alternatively, the nursery may have steam-sterilization system with boilers.

4.7 Potting shed

Another essential requirement in a high-tech nursery is the potting shed. Potting shed should be a roofed partially open shed with a lot of free air circulation. Easy access for vehicles and storage space for soil, sand, polybags, trays etc should be available in the potting shed. The potting shed should essentially have protection from rain and sun and should have provision for work benches. Though the side walls are partially open in a potting shed, there should be adequate protection from rodents and stray animals. Some amount of mechanization will be ideal for sieving, preparation of the soil mixture and filling of the bags. Soil filling hoppers are available which saves time and labour costs and brings some uniformity in filling. Proper blending and mixing of different ingredients in potting mix should be ensured while mixing a combination of fertilizers, growth regulatory substances etc. in the potting mixture.

4.8 Net house

Bamboo seedlings/propagules require partial shade initially in the germination bed and soon after potting in to poly bags or larger containers. Plastic woven shade-nets are available in

different colors (Fig.2) in the market and are capable of cutting the light intensity in different intensities (shade percentage of 25%, 50%, 75% etc.). The installation of the shade nets will require fabricated structures with angle iron and GI pipes or bamboo for support. These structures, though costly during the establishment phase are reusable, hygienic and will last a minimum of eight to ten years without any interim investments. The recommended color for shade net to be used in a bamboo high-tech nursery is “black” and the light intensity to be cut is 50%. Mechanical devices are available for rolling on and off of the nets as and when required, the use of which will enhance the life span of the plastic shade nets considerably. Planting material is placed under the shade net nursery in batches labeled clearly and in a manner that avoids any inadvertent mixing during handling. Sufficient space should be left between rows of plants to permit removal of containers without damaging the adjacent plants.

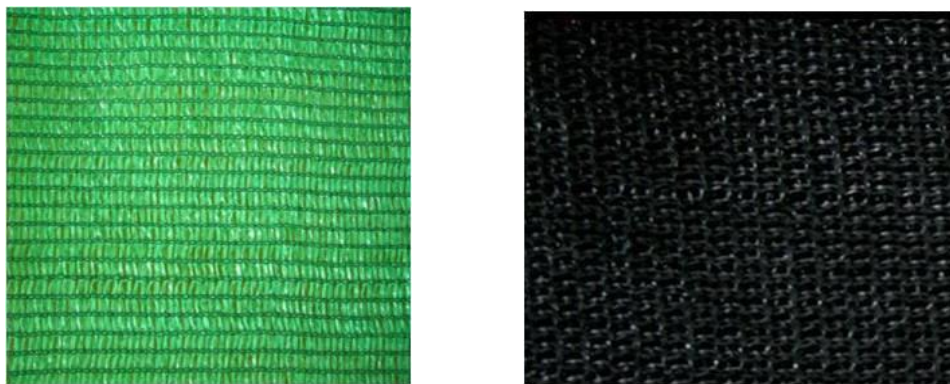


Fig.2. Shade nets available in different colors and shade percentage.

4.9 Irrigation system

Developing seedlings/propagules of bamboo requires intermittent watering to ensure higher survival rate and faster establishment. An effective and water saving irrigation system is desirable in the High Tech Nursery. A modern irrigation system consisting of sprinklers, drip systems and fogging equipment, polyethene hose/ pipes, valves and nozzles are available from various manufacturers for dispensing water in desired volume and frequency exactly at the root zone/aerial part of the developing propagule (Fig 3). Modern agricultural nurseries administer fertilizers along with the irrigation water and the process is called “Fertigation” and specially designed equipments are available in the market. The same system can be made use of in bamboo nursery also. Since the bamboo gets the nutrition with water exactly at the root/rhizome zone the survival and growth rate will be much faster.



Fig.3. Sprinkler irrigation system in a shade net nursery.

4.10 High-tech green house

Green-house with automated misting equipments and temperature control are desirable but low cost polytunnels can also be an alternative. Polytunnels are fabricated structures which can be set above the raised beds with the dome covered with UV resistant polythene sheets and sprinklers/misting units fitted inside to maintain desired humidity to encourage sprouting of buds.

4.11 Pump house with over head water storage

Ready availability of fresh water round the year and at any given point of time is very much important in a high tech nursery. Pumping water from a dug well or flowing river to an over head tank will ensure continuous water availability in the nursery. A water purification system attached to the pumping process will make available pure water round the year. Such an uninterrupted supply of quality water is essential when sprinklers/drip/misting units are in use in the nursery. Over head water tanks can be installed above one of the RCC buildings in Sector I itself so that extra space need not be provided for accommodating the over head water tanks. The nursery should have a pump house to provide sufficient irrigation water to plants and water storage tank to meet at least 2 days requirement.

5. Sector-2 Propagation Area

Mass production of seedlings/propagules will have to be carried out only in this area/sector and hence all the germination beds, container beds, raised beds and cubicles are to be set up here.

Quality planting stock of bamboo can be raised either through seeds or through vegetative methods in the high tech nursery. Since the management procedures are different in different category of the propagules, different types of beds will have to be prepared. Raised beds for rooting the culm/branch cuttings, cubicles for propagating the offset/rhizome cuttings, open space for periodic grading of the planting stock etc. are to be earmarked in this sector of the nursery for raising different type of bamboo propagules. The final product of the nursery - the

field-plantable propagules are to be dispatched from this sector/area of the nursery to the customers.

5.1 Germination beds

If large quantity of seedlings are to be raised through seeds, the sowing should be done in germination beds having a standard size of 12m X 1.2m X 0.15m. Each germination bed will accommodate approximately 3 to 4 kg fresh bamboo seeds (*Bambusa bamboos*) and the quantity of seeds to be sown depends on the seed size and germination percentage of the seed lot. Fresh seeds do not require any special pretreatment, however water soaking for 24 hours enhances the germination percentage and ensures uniform germination. The best potting mixture to be filled in the raised germination beds will be a combination of 2:2:1 fine sieved soil, sand and mixed weed compost. Well digested and dried cow dung can be used if sufficient quantity of compost is not available in the nursery.

5.2 Plastic crates for germinating bamboo seeds

In order to save space in the nursery and to cut down expenditure, seeds of common species (*Bambusa bamboos*, *Dendrocalamus strictus*) can be germinated in plastic crates (Fig.4 and 5) of size 55 X 35 X 30 cm or in plastic trays of 30 X 20 X 06 cm filled with the same combination of potting mixture as already mentioned up to a height of 20cm. Around 30 gm fresh seeds will be sufficient for a crate of the above size and , fresh seeds, after 24 hours water soaking, will give good germination. Potting can be initiated by the second week of germination or at the most after a month depending on the seedling growth. The crates are to be arranged in shade preferably in the potting shed where it will have to be protected from rain and rodents.



Fig.4. Seed germination in plastic crates.



Fig.5. Seed germination in plastic trays

5.3 Production through vegetative propagation

When seeds are not available, vegetative propagation methods are used for the production of planting stock. Two major types viz; macro and micro propagation methods are available for vegetative propagation in bamboos. In macro-propagation, conventional methods of rhizome/offset, rooted culm/branch cuttings are used while in micro-propagation tissue culture techniques are employed.

5.4 Macro-proliferation

Bamboo seedlings start producing tillers right from the third month of germination and the number will be more with better management practices. These tillers can be separated from each other from the 5th month of potting and the process is termed as macro-proliferation. This process enables the production of large number of propagules from a single seedling and also ensures the availability of a large number of planting stock.

The process of macro proliferation can be continued every two months, provided tiller formation is profuse as in the case of *Bambusa balcooa*, *B.tulda*, *B.bambos*, *Dendrocalamus hamiltonii* and *D. strictus*.

While carrying out macro proliferation, 50 % of the stock can be used for field planting and the remaining 50 % can be kept in the nursery as parent stock material for further proliferation. This will ensure a sustainable production of planting material every year. However beyond a certain extend (3 times in a year) there are chances of the propagules becoming weaker and less vigorous with poorer survival rate in the field. Macro proliferation can also be practiced in culm/branch cuttings and rhizome/offset cuttings however compared to seedlings only a lower level of multiplication need be expected.

5.5 Rooting of culm/branch cuttings

Though a standard forest nursery bed is 12 m long, 1.2 m broad and 0.30 m elevated from the ground level, these dimensions need not be closely adhered to in bamboo nurseries. The height of raised beds can be reduced to 15 cm as the bamboo propagules will have to be transplanted into poly bags or larger containers soon after approximately 3 months. However, it is better to keep to the standard length and breadth of forest nurseries as this will help in calculating the dosages of prophylactic treatments and fertilization on a per bed basis. The raised beds are to be filled with 3:2:1 clean sieved soil, sand and powdered compost/dried cow dung (Fig. 6). However in the North eastern region of India, sand is considered to be the best medium to be filled up in raised beds (Fig.7) for getting maximum rooting from culm/branch cuttings. Side wall partitions of the raised beds can be with Ferro-cement slabs held in position with iron/cement pegs. In case Ferro-cement slabs are not available good quality bricks or tiles can also be considered for the purpose.

Treatment with rooting hormones like Indole Butyric Acid (IBA) or Naphthalene Acetic Acid (NAA) promotes rooting in most of the bamboo species. The treatment is given either through the dip method or by pouring the hormone solution it into the culm cavity (Fig,8 and 9). New

sprouts usually appear after about 10 days but it may take more time for the roots to sprout and establish. Under normal conditions the sprouted plantlet can be lifted out from the bed and potted in larger plastic bags (28 X 22 cm) after about 3 months growth in the nursery bed. (Figures 10 and 11)

5.6 Raised cubicle beds for rooting of rhizome/offset cuttings

The rhizome/offset cuttings are best raised in square cubicles of the dimension 1.2 or 1 m sq m. The height of the cubicle will be 30cm from the ground level, filled with the same combination of potting mixture as mentioned earlier. The side partitions can be of Ferro-cement slabs, bricks or tiles. Each of the cubicles can be made use of for accommodating at least 4 pieces of rhizome/offset cuttings which ultimately will be utilizing approximately 0.50 sq cm of space for their root growth (Fig. 12). The inside partition of the cubicles are made by smaller Ferro-cement slabs/bricks/tiles thus separating a cubicle in to 4 sub units. Since the side partition walls are removable, the rooted offset/rhizome cuttings can be taken out without causing any injury to the delicate developing rhizome/root system (Fig. 13). Raised cubicles are preferred for rooting of offset/rhizome cuttings.



Figure. 6. Raised bed with sieved soil, sand and FYM for vegetative propagation



Figure.7. Beds filled with sand for propagation



Figure 8. Preparation of cuttings for pouring hormone solution into culm cavity.



Figure 9. Culm cutting after hormone treatment placed in nursery bed for rooting



Figure 10. Sprouts from nodal cuttings in nursery bed



Figure 11. Rooted culm cuttings transplanted into polybags



Figure 12. Raised cubicles with a sprouted offset/ rhizome cutting.



Figure 13. Extraction of the sprouted rhizome cutting

6. Sector-3 -Rhizome/Clonal Bank

High-tech bamboo nursery should use only parent material from known source of origin so as to ensure/ascertain the correct species name, the quality and growth potential (like culm productivity, culm size, disease resistance, previous flowering cycle etc.) of the resultant propagule. In order to ensure this it is suggested to have a rhizome/clonal bank of identified clones in the nursery itself. This will enable the production of known superior planting stock which can be sold with an authentic quality/species assurance certification by any certified High-tech Nursery. The clonal bank will have to be developed ultimately into a production center of superior clonal planting stock of bamboo from identified parent clumps. The clonal bank can be developed either as a block plantation or as a boundary plantation along the boundary of the nursery, and the decision can be on the basis of space availability. Ultimately the clonal bank will contain selected, established, superior mother clumps of different bamboo species having superior traits of the mother plus clump, of known parentage/flowering cycle. It will be only through these mother clumps, certified planting stocks can be produced and sold for establishment of all future NBM plantation activities.

When bamboo is planted all along the boundary, care should be taken to see that the clumps are spaced at 5 X 5 m spacing so as to facilitate periodic cutting and cleaning of the mother clumps as part of routine clump management. A minimum of 2 m space should be left between the bamboo clump any other structures like the buildings/nursery beds.

In addition, propagules retained for further multiplication in the nursery during the next season will also form a part of rhizome/ clonal bank.

7. Records to be maintained in the nursery

1. Nursery Journal

The nursery journal must be maintained in every high-tech nursery and should be made available for inspection by officials from NBM/ Bamboo Nursery Certification Agency. The journal should essentially contain details as shown below.

- The first page of the journal should mention owner ship details including full address, contact number and e mail ID
- A plot chart showing the location of different sectors and purpose for which they are being used.
- Types of bamboo planting stock being produced in the nursery.
- Annual target for production of each type of planting stock in the nursery
- Certificates showing the origin of all plant material used for propagation.
- Passport data of plant material used for propagation.
- Month and date of culm collection and hormone treatment.
- Name of the hormone used / concentration and details of application.
- Date of sprouting and details of prophylactic treatments administered during raising of the planting stock.
- Date and method of potting (container size & potting mix used) and shifting of the planting stock to larger containers.
- Dates and detail of fertilizers or pesticide applications.
- Whether macro - proliferation was carried out, if yes age at which it was done/potting mix used/size of bag to which potting was done.
- Dates of grading carried out.
- Date of dispatch of each batch of seedlings.
- Number of seedlings/propagules dispatched under each species
- Income generated through seedlings/propagule sale

2. Mazdoor attendance register

The register is essential to monitor the number of mazdoor attending to different works in the nursery. The register will be used to find out the employment potential of the nursery.

3. Stock register

The register should record all details regarding the production and sales of planting stock raised in the nursery so as to assist in the evaluation of the nursery regarding its achievements in meeting its annual targets.

4. Purchase register

The register will be used to monitor the total asset of the nursery and its appropriate running cost.

5. Instruments/equipments required in the laboratory

Electronic balance/ weighing balance/ seed purity board/ pH meter/ distillation unit/ oven/refrigerator

6. Growth hormones required in the nursery

Methyl alcohol/ Naphthyl acetic acid (NAA)/ Indole butyric acid (IBA).

7. Fertilizers/Pesticides/insecticides

Bavastin-Carbendazim 50%/ WP (Broad spectrum systemic fungicide)

Chlorpyrifos 20 % EC (Insecticide/termiticide)

Thimet 109 for white grub infestation.

Sumicidin 5 % (Insecticide)

Malathion 0.25 % (Pesticide)

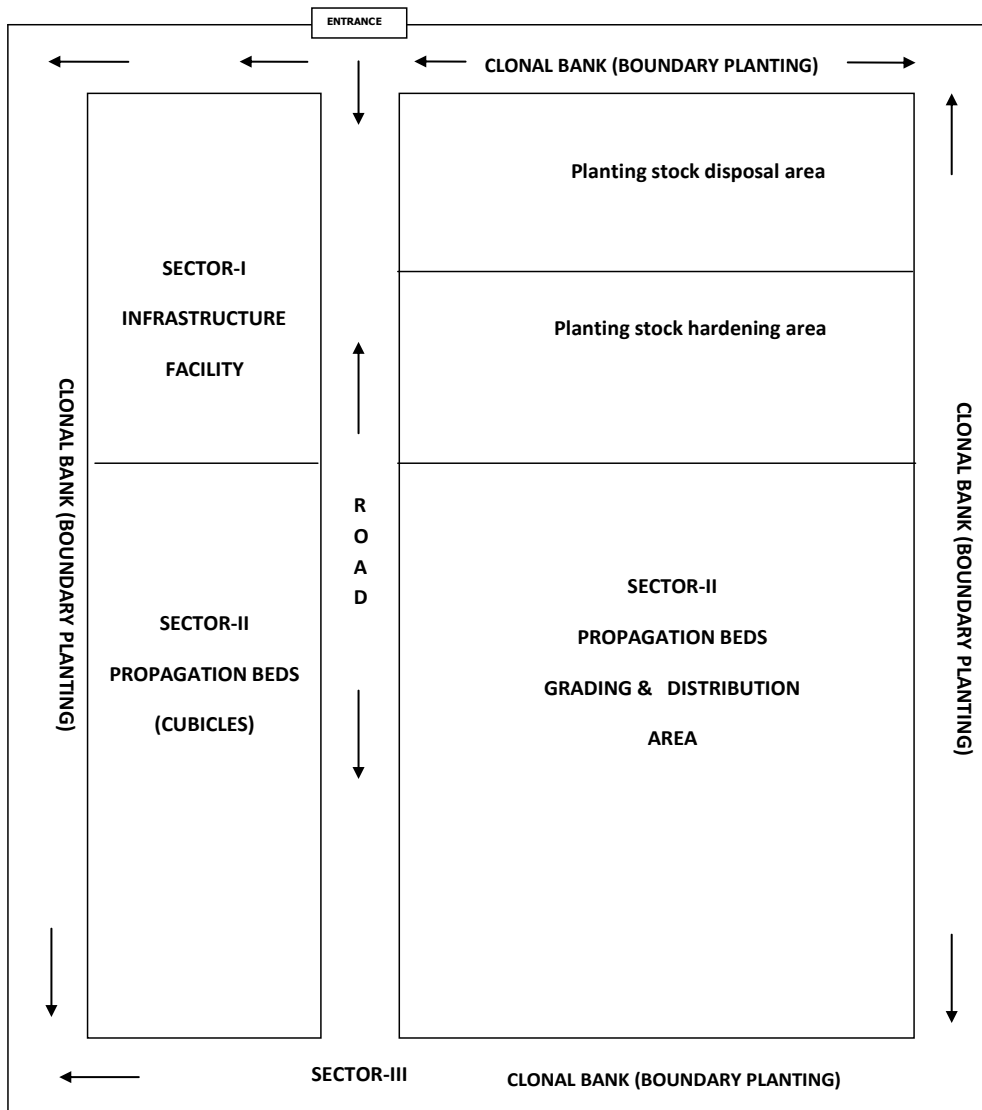
8. Other essential items:

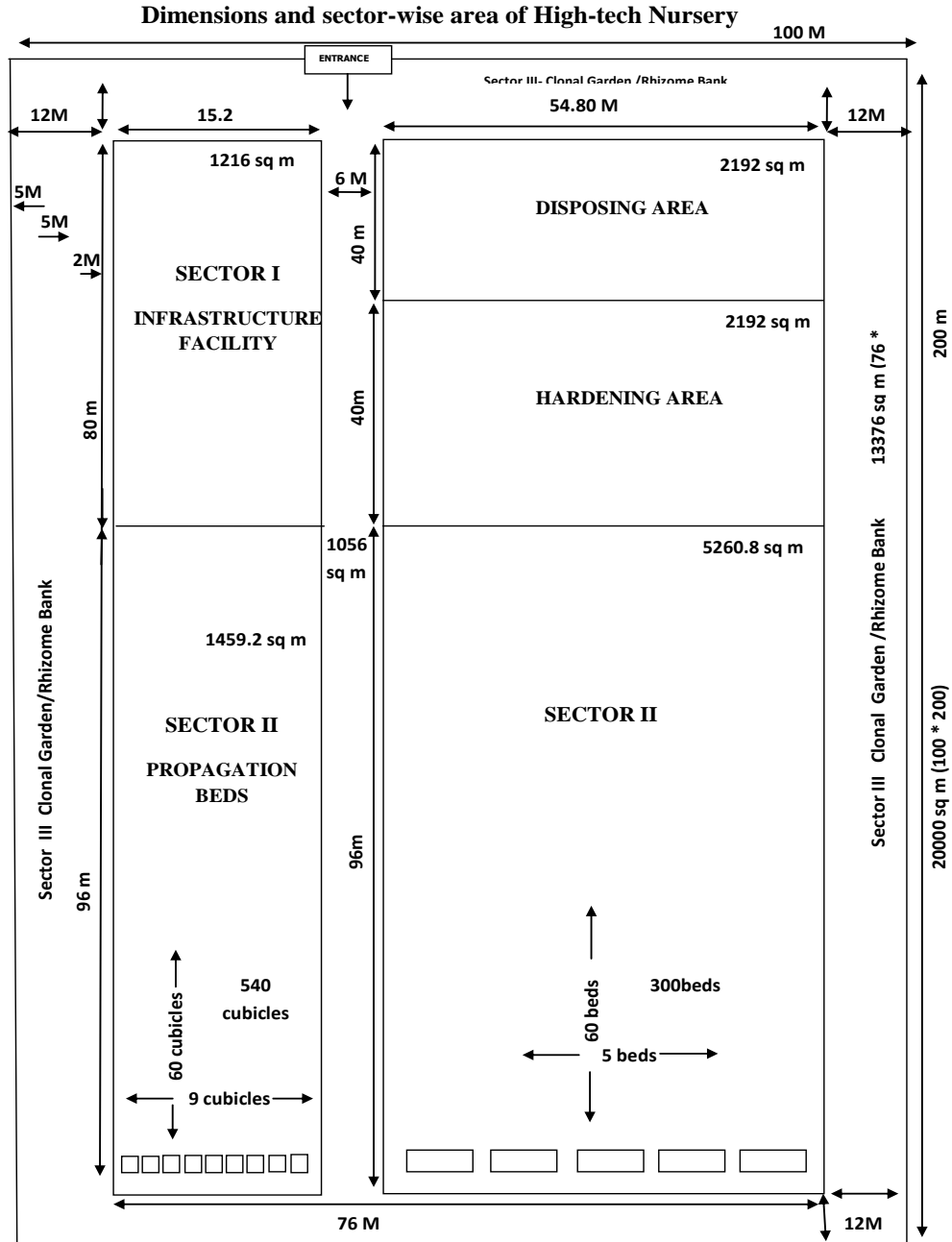
Nursery implements like bill hooks, crow bar, shovels, scoops, secateurs, plastic buckets, plastic mugs, water sprayers.

Soil sieves, plastic crates/trays

First aid box.

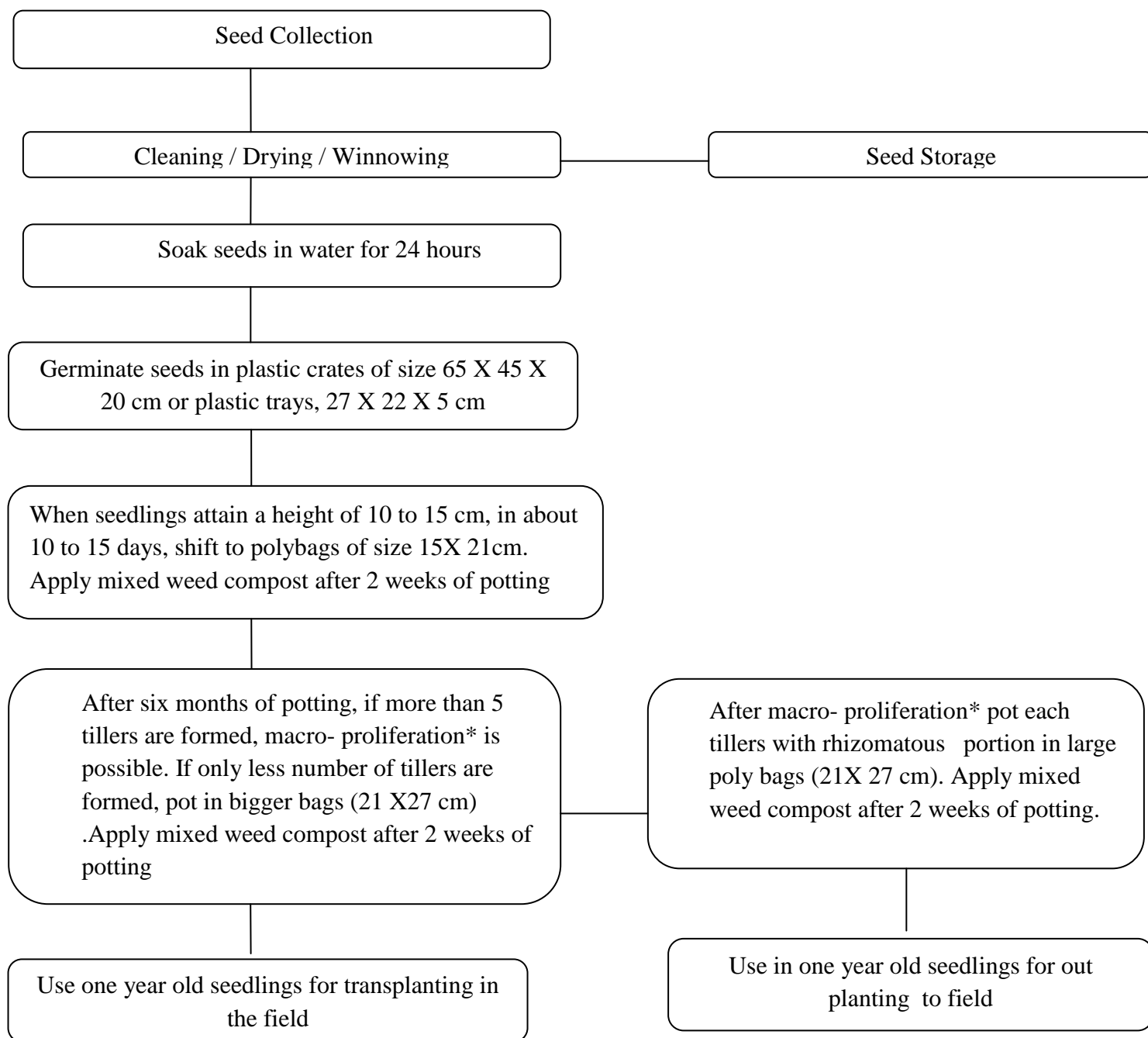
General layout of High –Tech Nursery





Dimensions	Area
Size of the raised bed 10m X 1m	6624 sq m Boundary planting
Distance between adjoining beds 60cm	6 sq m Sector I (Space for Office /Store/Compost & Potting sheds)
Distance at the far end of the raised beds 1.2m	1459.2 sq m Sector II (Cubicles for offset/Rhizome propagation)
Size of the cubicle 1 m sq	2192 sq m Planting stock disposal area
Distance between adjoining cubicles 60cm	2192 sq m Planting stock hardening area
	Raised nursery beds for vegetative propagation of culms/branches
	1056 sq m Nursery road

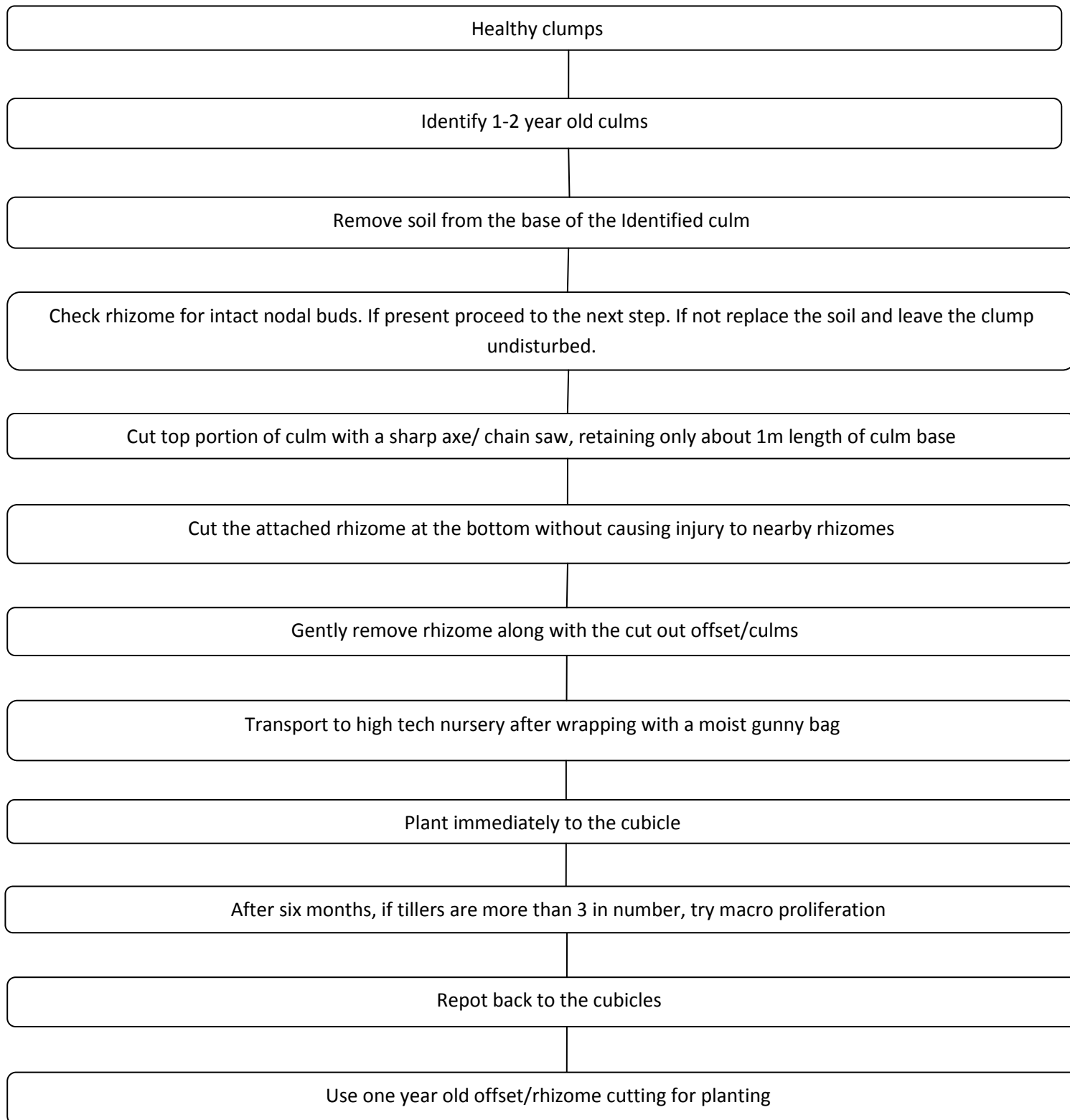
Road map for propagation using seeds



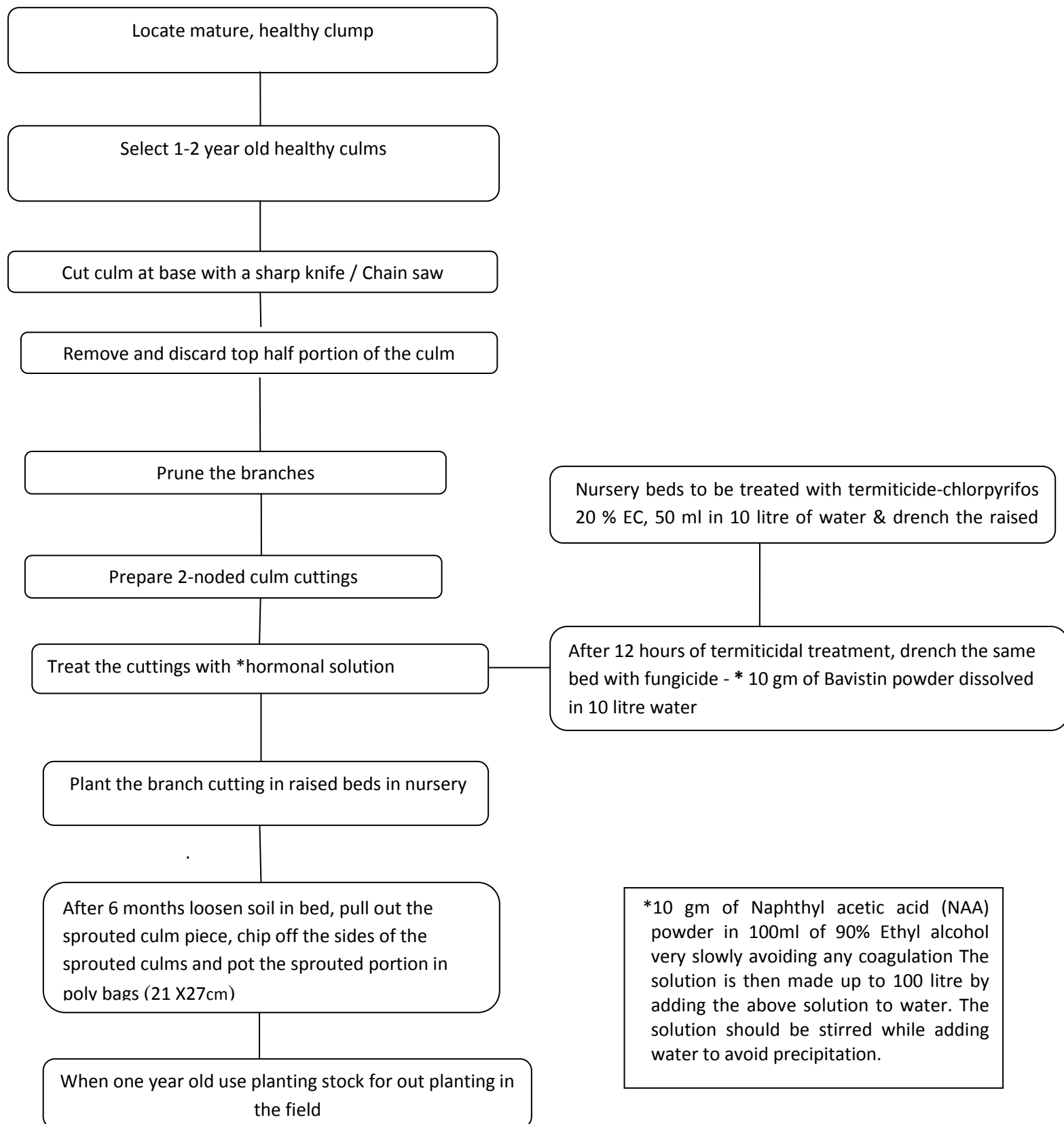
Foot note

***Macro proliferation is a process of splitting the bamboo (seedling) clump, depending on the number of tillers produced by the clump. The clump is gently uprooted from the container/medium, washed thoroughly in running water so as to clean the root system and the rhizome. Tillers along with a rhizomatous portion attached to the root system are separated out using a sharp knife and is potted in a larger container/polybag. By macro proliferation a single clump can be split into more number of individuals thus multiplying the number of planting stock in the nursery.**

Road map for propagation using offset/rhizome cuttings



Road map for propagation using culm cuttings



Road map for propagation using branch cuttings

