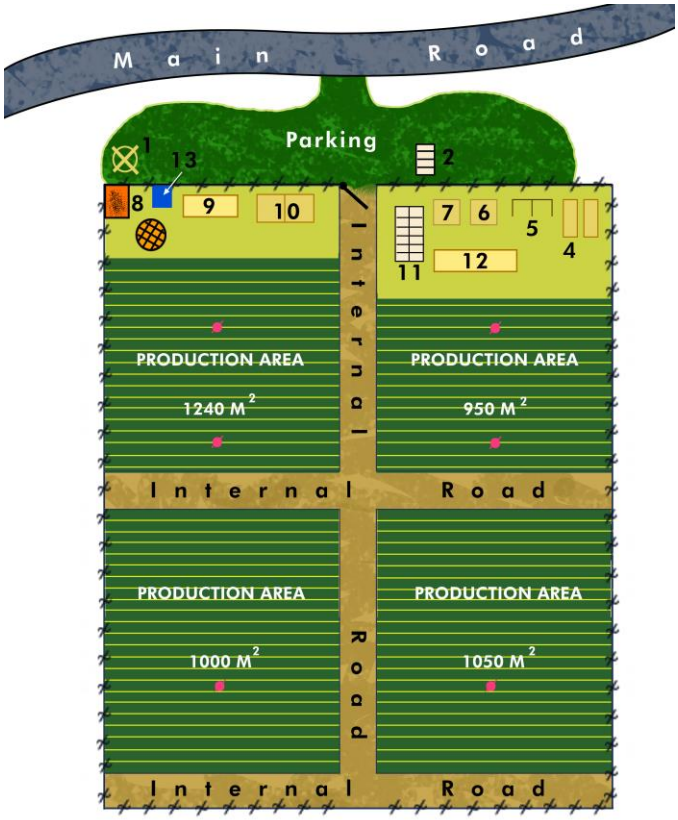
West Bengal Forestry and Biodiversity Conservation Project

Central Nursery Manual
Volume II

Nursery Site Selections, Layout and Development



West Bengal Forest and Biodiversity Conservation Project

Directorate of Forests
Government of West Bengal

Foreword

This volume of the Nursery Manual on Nursery Site Selections, Layout and Development techniques is an attempt to standardize the Central Nurseries Management and tree planting efforts within the State.

The West Bengal Forest Department (WBFD) has decades of experience on the subject, both empirical and through research findings and is very advanced in know-how. This volume intends to standardize procedures for production of Quality Planting Material (QPM) in the State.

This volume has been prepared by the Project Management Consultant in consultation with the Project Management Unit of JICA assisted West Bengal Forest and Biodiversity Conservation Project. A high level Technical Committee constituted by the Principal Chief Conservator of Forests, HoFF has edited & approved the Manual.

The technologies recommended have been decided upon during a series of meetings with the Addl. Chief Secretary Forest Department, Government of West Bengal, Principal Chief Conservator of Forests and Head of Forest Force, Principal Chief Conservator of Forests Research, Monitoring and Development, and a number of senior and field officers of the Directorate of Forests.

Recommendations regarding materials and techniques have been liberally taken from past research records of the Research wing of the Forest Directorate and other sources and adapted for present use.

Acknowledgements and thanks

The consultant would like to use this place to express his thanks and appreciation for the cordial reception, patience and efforts made by Dr. Subesh Das, ex-Addl. Chief Secretary Forest Department, Govt of West Bengal, Shri C. Sinha, Principal Secretary, Deptt. Of Forests, Govt. of West Bengal, Shri Azam Zaidi, Principal Chief Conservator of Forests , Head of Forest Force, West Bengal, Shri S.B. Mondal, ex-Principal Chief Conservator of Forests and Head of Forest Force, West Bengal, Shri N.C. Bahuguna, ex-Principal Chief Conservator of Forests and Head of Forest Force, Sri P. Shukla, Principal Chief Conservator of Forests, Wildlife & CWLW, Sri N.K. Pandey, Principal Chief Conservator of Forests, General, R.R. Pandey Principal Chief Conservator of Forests Research, Monitoring and Development, West Bengal, Sri S. Dhaundyal, Managing Director, WBFDC Ltd., Sri S. Barari, Chief Project Director, WBFBC Project, Dr. P.T. Bhutia, Addl Principal Conservator of Forests, North, Sri V.K. Yadav Spl Addl PCCF Chief Conservator of Forests, Central Circle, , Sri S. Chaudhuri Project Director, M&E, WBFBC Project and the forest officers of the districts of Bankura, Burdwan, Paschim Medinipur and Jalpaiguri. Together they succeeded in providing the needed insights and directives for the production of this volume making this exercise well organized, efficient, pleasant and enlightening.

Thank you again for your hospitality, patience and support.

J.P. van Kooijk,
Team Leader and
Forestry Specialist PMC
November, 2015

WBFBCP Central Nursery Manual Volume II
Central Nursery Site Selections, Layout and Development.
Container Nursery set-up for Improved Tree Seedling Production

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2.1 Introduction

In the following chapters, criteria and prescriptions have been given for site selection, layout and development for the new Central Nurseries for the state of West Bengal. Most of these recommendations can also be followed for the planned increase of existing nurseries' production capacity and their improvement.

Since most of the potential nursery sites are not perfect, site selection inevitably requires suitable adjustments. Since the Quality Planting Material (QPM) will be grown in containers in the Central Nurseries, local soil characteristics are less relevant and the following selection criteria may be adhered to:-

1) Proximity of the potential site to Range office, Beat office, Forest Rest House or any other forest establishment.
2) Proximity to (center of) future out-planting areas.
3) Accessibility.
4) Proximity to services.
5) Good water supply (both quantity and of reasonable quality).
6) Reasonably flat topography providing natural drainage.
7) No flooding risk.
8) No erosion risk (protect with grassed waterways up-slope or build terraces in hill areas).
9) Space for future expansion.

Potential sites should be visited and evaluated and the best site chosen. A development team should then lay out the nursery, formulate an action plan, and document current development and possible future expansion in a comprehensive master plan. Careful site selection and planning plus proper management are essential to the economical production of high quality nursery stock.

Ideally a several member strong team should be designated to select a nursery site.

- The team should develop site-selection criteria and establish priorities, then visit and evaluate possible sites on the basis of the chosen criteria, and finally select the best site.
- A development team should lay out the nursery, formulate an action plan, and then document nursery-site development in a flexible but clearly defined master plan.
- Possible future expansion of facilities and staff must always be considered.
- A perfect nursery site does not exist; tradeoffs are inevitable, but nursery efficiency and quality of seedlings produced should not be compromised.
- Wise planning and thoughtful decision-making, plus proper management, are essential for the economical production of high-quality nursery stock for reforestation.

2.2 Site selection

The basic objective of any nursery operation is to modify the natural environment so that plants can be produced quickly, efficiently, and economically. Container nurseries offer the potential for considerable environmental modification, but both development and operating costs increase with the degree of modification. A successful container nursery must therefore be carefully matched to the environmental conditions on the site; a nursery designed for one site will not necessarily be best for another. As the nurseries will be Target oriented (out-planting survival rate and post planting tree development) nursery developers must analyze the climatic environment at each potential site by critically evaluating both short-term and long- term weather records as well as through direct observation and compare these with climate data of future planting sites. Nursery developers should be prepared to devote a substantial amount of time to site selection because many biological and operational problems that develop later in nurseries can be traced back to problems with the selected site. Nursery sites that are selected mainly for economic or political reasons frequently fail to meet some of the more critical criteria, and these deficiencies limit the success of the nursery. Biological site selection criteria should always be paramount, but potential nursery developers must also consider out-planting realities. The things to look for in a potential container nursery site can be divided into critical factors and desirable factors (table 1). Critical site selection criteria are those factors that are essential to a successful nursery operation. Desirable attributes include those site factors that are not absolutely necessary but will increase the economy and efficiency of the nursery operation.

Table 1 Site selection criteria for container tree nurseries

Critical factors	Secondary factors
Close to forest establishments	Protected microclimate
Solar access	Gentle topography
Good water supply	Seasonal labor supply
Reliable energy	Accessibility
Adequate land area	Distance to out-plant area

2.2.1 Critical Site Selection Criteria

2.2.1.1 Climate

Climate should be the same as the Target Area for out planting.

2.2.1.1.1 Precipitation

High rainfall areas are best avoided and if this proves impossible should be taken into account during the nursery design phase regarding roads, foot paths, nursery platforms and drainage lay out. However, the season in which the precipitation occurs is important. Heavy spring rains can delay spring operations such as adding soil amendments or sowing tree seed. Summer rains tend to be a problem only when they occur as cloudbursts and result in flooding, erosion, or seedling wash-out. Frequent summer rains may be detrimental, because rains may disrupt stock hardening processes already induced by withholding irrigation. Areas with heavy winter rains will result in saturated nursery soil to the point of hindering movement of materials, lifting, movement of personnel and causing flooding and erosion.

2.2.1.1.2 Wind

Areas with frequent, long-lasting, high-velocity winds, particularly where humidity is low should be avoided. Winds will affect irrigation application and uniformity and may result in soil movement. High winds can desiccate seedlings, and soil carried by winds can blast stems and foliage. Wind can restrict spraying of pesticides, cause tree-seed cover to be blown away, and displace or scatter seedbed mulches. In sites with a risk of high wind velocities, double semi- permeable wind breaks should be planted along the nursery's entire length (or all around the nursery) outside the nursery grounds and perpendicular to the predominant high velocity wind direction.

2.2.1.1.3 Unobstructed solar access

It cannot be stressed enough that nursery sites must be selected in areas with the same climate as the targeted out-plant areas. Similarly it should go without saying; container tree nurseries must be located on sites with good solar access, both throughout the day and during the growing season. It is usually considered uneconomical to supply enough light energy for photosynthesis, and so container nurseries must be located where they receive full sunlight for almost all of the solar day. Any amount of shading will decrease productivity and increase costs and, if or when necessary, can be easily supplied with agro-netting during the short periods of plant development before the hardening off. This is most critical in perennially cloudy climates of our hill divisions but also applies to tropical sunnier locations; because it is relatively easy to provide the shading if it is required. Growing areas must not be affected by shade from surrounding trees or buildings. If crops are to be grown year-round, the solar angle should be determined for all seasons to ensure that the growing area will always receive full sunlight. To this end it is recommended that, as a general rule, nurseries should be located at a distance that is at least 2.5 times the height of any object to the east, west, or south. Shelterbelts on the north side can be relatively close as long as falling leaves and litter are not a

problem.

2.2.1.2 Soil

Soil characteristics or quality are not a critical site selection criterion as long as it is firm or can be made firm after removing the topsoil and compacting. Containers are typically filled with a growth medium consisting of a mix of sand, vermiculite or perlite and organic materials such as compost, composted coir, dry cow dung etc. and not grown in the ground as is the case with bare root production. (*Potting media has been dealt with in volume III)*

2.2.1.3 Supply of water

Next to sunlight, a reliable supply of quality irrigation water is the most important site selection factor. Relatively large amounts of water are needed by the seedlings themselves and also for regulating the temperature of the growing environment. Container seedlings have very low moisture reserves, which are limited by the volume of the container and the moisture holding properties of the growing medium, so seedlings must be irrigated frequently. In hot climates, water is also essential for evaporative cooling. In cooler climates, growers may need to use irrigation water during the early spring or late fall for frost protection of seedlings in open growing compounds.

2.2.1.3.1 Water quality

For nursery site evaluation purposes, irrigation water quality is determined by two factors: suspended particles (sediments or pests) and dissolved salts.

2.2.1.3.1.1 Suspended sediments

Inorganic materials such as clay, silt and even very fine sand particles are small enough to remain suspended and must be mechanically filtered or removed by chemical treatments. Suspended sediments are abrasive and can quickly wear out water pumps, fertilizer injectors, and sprinklers.

2.2.1.3.1.2 Pests

Water from surface sources, especially ponds in agricultural areas can contain propagules of potential nursery pests, which may include weed seeds and spores of fungi, algae, mosses and liverworts. Specially designed filters can remove the larger pests, including weed seeds, algae, and some fungal spores, but the cost of the filters increases as the minimum pore size decreases.

2.2.1.3.1.3 Dissolved salts

Many different mineral ions can be dissolved in potential irrigation water, and even perfectly clear water can contain harmful salts. In coastal areas, potential nursery sites can have its groundwater contaminated by saltwater intrusion during water extraction from tube wells. In such areas adequate supply of sweet water has to be ensured.

2.2.1.3.1.4 Testing water quality

On-site observations Although a complete water-quality analysis is always necessary, some basic observations will give the nursery developer some important clues to irrigation water quality. Water containing high levels of salts often tastes heavy and flat; if it tastes salty, chloride is probably greater than 250 ppm. Whitish crusts or scale deposits on faucets indicate high concentrations of calcium and magnesium bicarbonates in the water supply. Note the effort and amount of soap required to work up a lather; if little soap or effort is required and the soap is difficult to rinse off, the water is relatively "soft" and the water contains a high concentration of sodium compared to calcium or magnesium. Brown or orange-brown staining indicates high iron concentrations.

Heavy metals Contamination of irrigation water with elements (known as heavy metals) such as lead, chromium, cadmium, and mercury can also be a problem because even low concentrations can be toxic to plants. Sites having known history of heavy metal contamination should be avoided.

Specific ions Measures the concentration of the three directly toxic ions (sodium, chloride, and boron), as well as the other accessory ions that can indirectly affect water quality .

2.2.1.3.1.5 Estimating amount of water use Once the quality of the irrigation source is verified, both the total amount of water per season and the rate at which the water can be supplied must be evaluated. Estimates of total annual water use and peak water use rate must be determined for assessing the irrigation pump capacity and the need for water storage ponds or tanks.

In addition to current water requirements, projected nursery expansion must also be considered when estimating total annual water demand. If the primary water source is unreliable, it may be wise to evaluate a potential backup source of irrigation water.

The total amount of water that a container tree nursery will require depends on many factors, including climate, type of nursery and irrigation system, container volume, and the water use patterns of the species. Total water demand can be given in many different units, but volume of water that must be supplied over some time interval per unit area of growing space or per thousand seedlings is most useful for planning purposes as is shown for example in table 3. Water may also be required for purposes other than seedling production, such as domestic uses, and estimates of these requirements can be developed with normal engineering calculations.

A nursery consisting of a 500 m^2 semi controlled shade area and a 3,500 m^2 open area would require about 9,000,000 litre of water per year on an average (table 2) including other nursery and domestic uses, or 6 mm per day per unit area (i.e. 6 mm X 4000 m^2).

Since the Central Nurseries will be irrigated by hand watering with knapsack, peak water demand becomes less important except for emergency water storage capacity.

Water Storage, water point, raised beds with knapsack sprayer.

Table 2 Total irrigation water demand for container tree nurseries. *

Nursery type	Container volume	Irrigation demand per Growing area	1,000 seedlings**
Fully shaded enclosed raised beds	75 cm^3	___	130 l/wk
Fully shade controlled raised beds	150cm^3	___	180 – 350 l/wk
Fully shade controlled raised beds	300 cm^3	___	380– 650 l/wk
Open raised beds	150 - 300 cm^3	1800– 2450 l/m^2/yr	570-780 l/wk

** Calculate 60 - 100 seedlings in root trainers per m^2

2.2.1.4 Availability of energy source. All container nurseries require electricity to operate irrigation pumps and other nursery equipment. Although the type of electrical service will vary with nursery design, three-phase 240-V service is most efficient for large motors and so is preferred if available. To determine the electrical demand, the number and size of electrical motors, lights, environmental control equipment, and other users of electricity must be estimated. Remember to allow for future expansion. If the proper type of service is not available at the potential site, then the cost of bringing in a new electrical line must be included in the site development cost estimate. All container nurseries should have a backup generator in case of short-term power failure; chronic problems with reliability of electrical power are unacceptable.

2.2.1.5 Adequate land area The amount of land selected for a container tree nursery must be large enough for the production areas and support buildings, and also allow for efficient movement of equipment and materials. The shape of the parcel may be more important than the actual area because production ranges tend to be elongated areas. In addition to immediate needs, the nursery developer should evaluate potential nursery sites on the basis of their space for possible expansion. In fact, it is to be recommended looking for a site that has at least twice the planned growing area. Sketching potential expansion areas on the existing site plans along with access roads and support buildings is strongly recommended. It is much easier to give it for a different use at some future date than to acquire some much-needed space for expansion or try to operate at two separated locations.

2.2.2 Secondary Site Selection Criteria

Although not as important as the criteria discussed in the previous section, the following factors should be considered during site evaluation. They can greatly increase the efficiency of a nursery operation and reduce operating costs.

2.2.2.1 Protected microclimate In addition to having unobstructed solar aspect, a potential nursery site should be located in a protected area with the most equitable climate in the local region. Within any geographic area, nurseries should be located in areas that are not subject to extremes in temperature or damaging winds. On the other hand, a moderate degree of air movement is necessary for ventilation during warm weather. As long as they do not shade the growing area, trees on the windward edge of the nursery site can act as a natural windbreak and protect against damaging winds. However, trees or other obstructions on the lower edge of the site can serve as barriers to cold air drainage, and valley bottoms or other low sites that collect cold air should be avoided. Obviously, potential nursery sites near industries or utilities that could generate possible pollutants should never be considered. Even in rural West Bengal air pollution can present problems in certain areas.

2.2.2.2 Gentle topography. The general topography of a potential nursery site is important for both biological and economical reason A relatively level site reduces

the cost of land leveling during construction and increases the ease of moving equipment, supplies, and vehicles after the site is developed.

2.2.2.3 Dry land free of flooding or erosion risks In all cases potential nursery sites should be risk free where flooding or erosion is concerned. Sites should be dry all year round and if necessary the nursery platform heightened to prevent even accidental flooding. If a remote chance exits the site might become damaged by erosion run off from higher up the slope (in Northern Hill Divisions) grassed waterways should be constructed up hill to deviate eventual run off deposits away from the nursery site. This will obviously greatly increase the nursery establishment costs.

2.2.2.4 Seasonal labour supply. The success of a container tree nursery depends on the quality of the available work force. In addition to a small permanent professional staff, a container tree nursery requires a reliable source of semiskilled labour for several peak work periods during the year, when tasks such as sowing or grading must be completed in a short time. During the site evaluation process this has to be taken into account. The number of employees required depends on the size and complexity of the operation. At least one technical supervisor for each central nursery may be engaged as a rule of thumb.

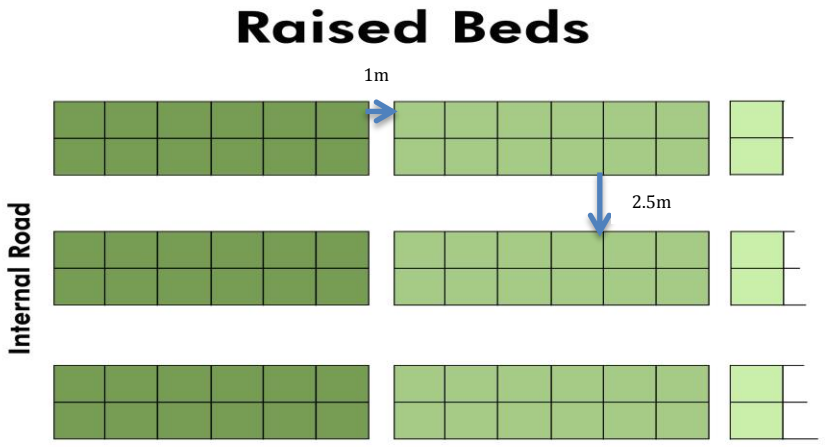
2.2.2.5 Accessibility A good nursery site must be accessible for regular delivery of nursery supplies and nursery stock. Most supplies are delivered by truck, making good all-weather roads and accessibility to regular routes important. Access roads should not have any steep slopes or sharp turns that would prohibit safe operation of delivery trucks. Essential supply and maintenance services should be available nearby. Remote locations may increase the cost of supplies, particularly in locations where fuel oil must be delivered regularly. Nurseries must also be easily accessible to workers, especially the key personnel who respond to emergencies. Regardless of how well a nursery is designed for reliable operation, there will be times when key nursery workers must be able to respond within an hour or less. If accessibility is a potential problem, then it may be necessary to provide a dwelling on the site, and this cost must be considered during site evaluation.

2.2.2.6 Distance to out-planting areas The distance from the potential nursery site to the delivery point must also be considered during the site evaluation process. The nursery site should be chosen at a central location to the main out-planting areas for years to come and delivery needs to be taken into account.

2.2.2.7 Site production potential To help determine the acreage needed for the seedling growing area, the required production capacity for seedlings by species is of course basic. The need for a particular container size for a specific species is described in details in Volume II. Considering the production with a species distribution according to needs for container sizes of 150 cc (50%) and for container sizes of 300 cc (50%), the following calculation can be made:

Each raised stand holds about 150 nos. containers of 150 cc size per m^2 and about 100 nos. containers of 300 cc size per m^2. The raised stands are built in segments of about 1 m^2 each. If 6 nos. stands are placed in double rows with a gap of 1 m for easy passage between double rows of stands, about 1150 m^2 space will be required for the 100,000 seedlings in 150 cc container and 1,750 m^2 for 100,000 seedlings in 300 cc containers, or a total of about 3,000 m^2 production area will be required to produce 2,00,000 seedlings with raised containers.

Banks (groups) of raised bed elements as nursery beds perpendicular to internal nursery road

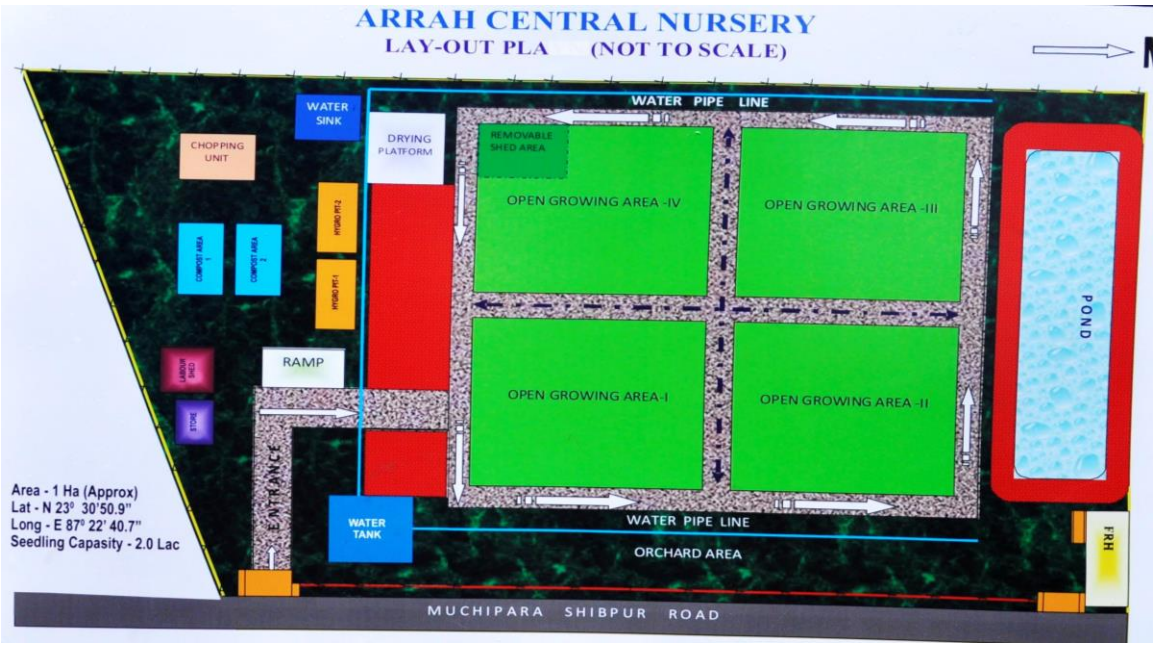


Central Nursery Raised Beds

2.2.3 Layout and Development

2.2.3.1 Access and traffic flow The nursery should be as compact as possible, nearly square or regular in shape, to minimize the length of the boundary fence and reduce the time loss in moving from one part of the nursery to another. Roads provide access to the site and to growing fields. When the site is developed, all access roads should be paved if possible; they must be capable of taking heavy "semi" truck and tractor traffic in all kinds of weather. Parking areas must be evaluated and particular attention given to the placing of a “loading ramp” to facilitate the loading of seedlings in vehicles outside the nursery. Connecting points (entries and exits) to existing road systems should be taken into account.

Central Nursery Layout Plan



2.2.3.2 Administrative site The administrative site could include administrative offices although in most cases the FD office space will be used, but certainly will need a storage area for equipment, seed, pesticides, other chemicals, and fuels; a water pump housing and seedling-processing facilities. The type, number, and location of required buildings must also be determined regarding production technologies used. Other than for administrative uses, the site development will include holding areas for irrigation water and a composting area, a protected divided shed for compost, sand and other potting media ingredients, root trainer cleaning and storage areas, a culled-seedling disposal area (compost heap), an area for holding scrap material and used equipment. In case where a clonal nursery has to be developed, an adjacent Clonal Multiplication Area (CMA) has to be established.

Although possible future expansion must always be kept in mind, the administrative complex must optimize the use of space to avoid being spread out.

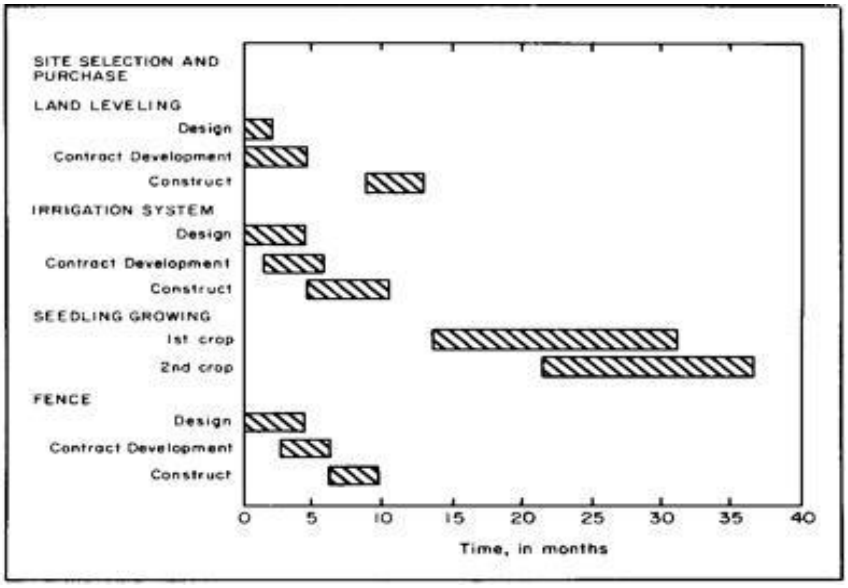
2.2.3.3 The master plan Once agreement has been reached on placement of all structures and development begins, a master plan—a dynamic tool—must be made to document the team decision. Once the selection process and the nursery design has been completed, this plan will stand as an illustrated document of site layout, indicating growing areas, roads, buildings, outdoor storage areas, reservoirs, streams, fences, neighbors, possible expansion areas for buildings, and other site development. The master plan is not cast in concrete, and can and must be up-dated as management needs change.

Example of a Nursery Master Plan

2.2.3.4 Development program To properly develop a site, an action plan must be prepared. One approach is to construct a critical-path chart that shows events and operations on a timeline. Seedling production scheduling must be coordinated with

site development. Structures that are needed first must be built first. For example, Figure 3 shows a partial nursery action plan, developed as a timeline. Throughout nursery development, the action plan is continuously reviewed and revised, as needed. Critical factors that may have been overlooked initially are identified and incorporated. It is important for everything to be viewed objectively and in a proper perspective.

Example of an Action Plan for a Nursery



2.2.3.5 Budgeting and accountability Budgeting is critical and must have highest priority in the development process. Budgets should be planned well in advance to ensure that funding, people, and facilities will be available when needed. The budget and the action plan must be developed together. If shortages of funds or people are anticipated, construction may have to be delayed or other alternatives sought.

2.2.4 Generic Central Nursery layout and brief infrastructure description

With the selection criteria as described in the previous paragraphs, a general recommendation for layout and infrastructure needs can be given for new Central Nurseries. Each new nursery will require adaptation to specific site characteristics regarding overall shape, internal roads, paths, length and compass direction of nursery beds. Ideally the site will be on gentle sloping land (slope less than 2%) to facilitate drainage without erosion risks, with beds along contour lines if necessary but preferably perpendicular to the central internal road. Most of the infrastructure described can be found on existing nurseries and most of the recommendations given can be used for the expansion of existing nurseries too. Sufficient and easily accessible water is a must and therefore where possible a water harvesting structure must be constructed outside the fence but at lowest foot of nursery area for eventualities.

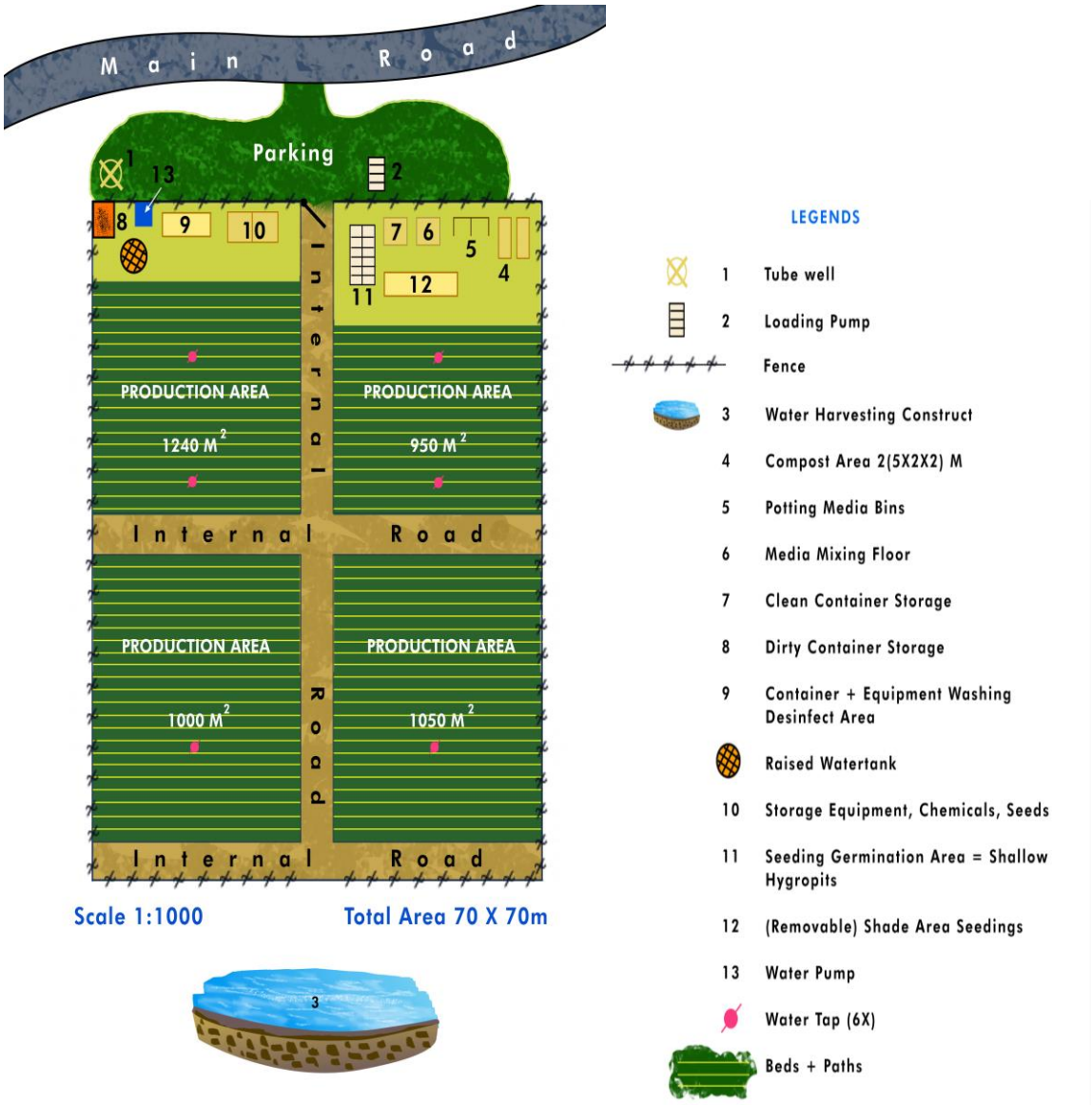
2.2.4.1 Total approximate surface area needs The initial production capacity target for the new nurseries will be 200,000 seedlings/yr. As mentioned above under 2.2.7, "Site production potential", approximately 3,000 m^2 area will be needed. While developing the central nursery additional areas as given below should also be taken in account :

i. About 1500 m^2 (50% of the area) for future expansion.
ii. About 500 m^2 (20% of the area) for all non-productive areas such as roads, administrative site, storage buildings, sand/compost bins and any area where seedlings will not be grown.
iii. About 3000 m^2 for spacing out the seedlings and accommodating the 2nd batch of seedlings prior to dispatching out to planting sites.

Thus the total nursery area will be 8000 m^2 or around 1.0 ha. Many nursery sites have been selected and developed with little or no allowance made for future further expansion. Regardless of how remote it may seem, expansion should be considered.

2.2.4.2 Master Plan for Seed Origin Central Nursery A diagram representing a general Master Plan for a "seed origin nursery" for one of the new Central Nurseries is given below. Different aspects of the infra structure and production areas are explained in subsequent paragraphs.

Master Plan for new "Seed Origin" Central Nursery

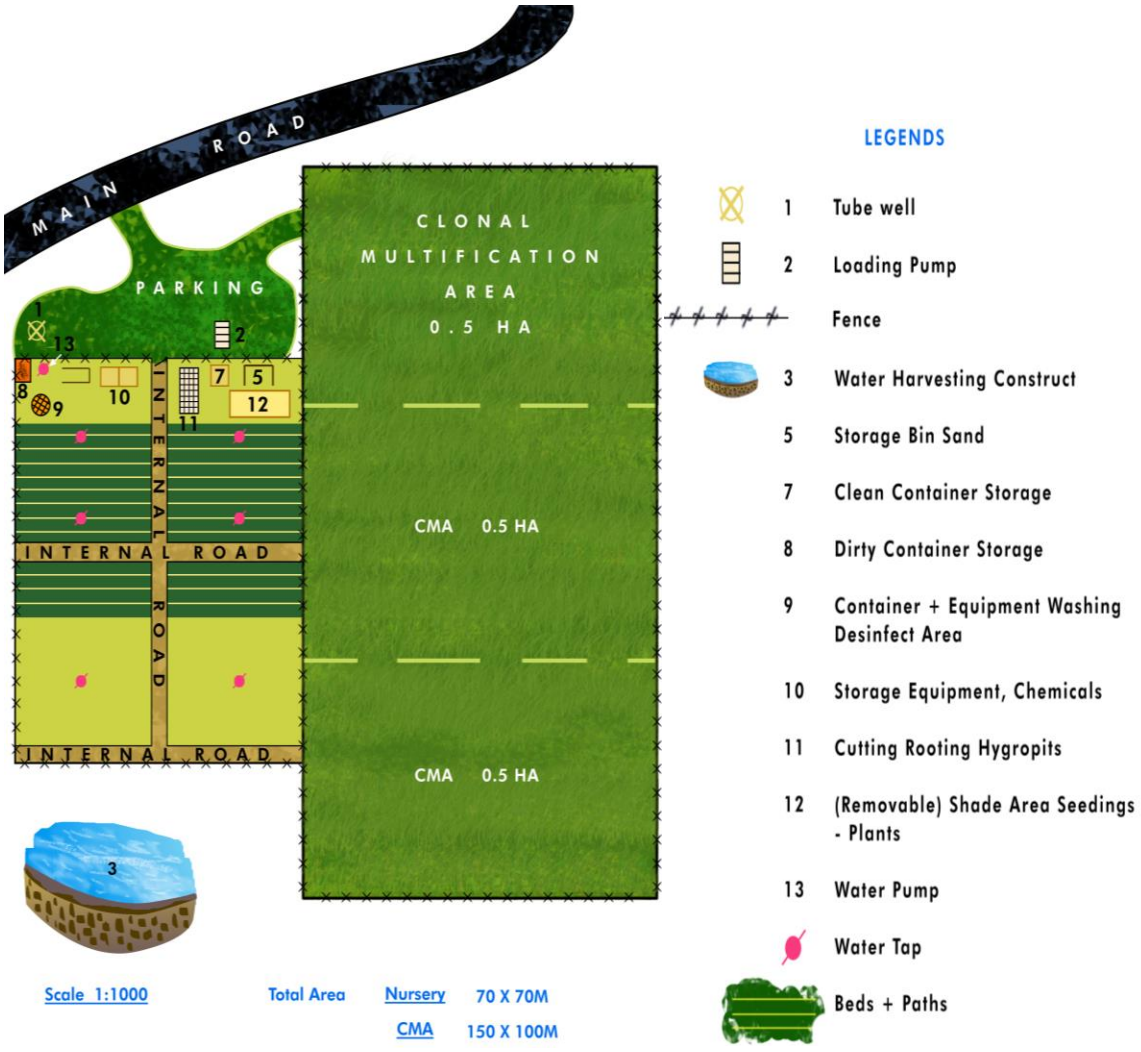


2.2.4.3 Master Plan Clonal Origin Central Nursery A diagram representing a general Master Plan for a "Clonal origin nursery" for one of the new Central Nurseries is given below. Pure Clonal Nurseries can be much smaller and only a few will be needed. Those already in existence can be put up to standard with little costs. Differences between pure Clonal Origin Nurseries and Seed Origin Nurseries are mainly found in

(i) adjacent Clonal Multiplication Area (needs a lot of water),
(ii) size of nursery (smaller),
(iii) no compost needed,
(iv) potting media bin can be smaller and will only hold coarse sand
(v) Hygro-pits have to be larger and deeper.

Different aspects of the infrastructure and production areas are explained in subsequent paragraphs.

Master Plan for new "Clonal Origin" Central Nursery

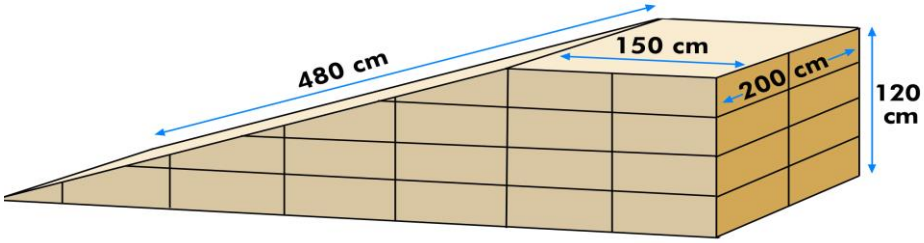


2.2.4.4 Initial development Before anything else the total nursery area will have to be graded in order to give it a smooth topography without depressions where water might accumulate. Construction areas and internal roadbeds will have to be scraped to remove organic topsoil and compacted.

2.2.4.5 Lay out of roads and paths Internal central roads should be about 2.5 m wide and slightly higher then the surrounding areas with a shallow drain on each side. However, the internal arterial roads should not be more than 1 m width.

Material freed from levelling the area and excavating the foundations for the buildings can be used for filling up the roadbed, after which preferably a layer of gravel or morrum or "bajri" may be applied. In the new Central Nurseries the parking area will be provided with a ramp 120 cm high x 200 cm wide with a 150 cm x 200 cm platform and a sloping 480 cm long x 200 cm wide walkway to facilitate loading of trucks.

Diagram of loading ramp and platform for easy loading of seedling



LOADING RAMP

2.2.4.6 Layout and type of beds The beds are comprised of raised bed elements 85 cm x 85 cm x 60 cm, which can be stacked on top of each other for efficient transport of seedlings during out planting season

They are put together in repeating groups of 2 elements wide and 6 elements long, running perpendicular to the central internal nursery road with 1 m wide alleys (paths) in between. These alleys are needed for working the beds, but also provide easy access and drainage.

Raised bed elements 85x 85 x 60 cm and stacked for easy transport.

Pure Clonal Origin Nurseries in container size of 60-75 cc will require much less production space. A clonal nursery with a production capacity of 200,000 ramets/year will require about 0.25 ha of nursery area to cover production area, administrative area and area for future expansion.

2.2.4.7 Layout for watering system Since an irrigation system is costly, the nurseries, although labour intensive, will rely on watering with watering cans or knapsack sprayers. **Watering with hoses should never be done**. To facilitate the filling up of the watering cans or knapsack sprayers, adequate number of taps will be placed as recharging points at equidistance distributed over whole area connected with waterlines starting at raised water tank. Hydraulic pressure from raised water tank will be used to provide water throughout the nursery while a pump will recharge the water tank.

2.2.4.8 Tube well or other water supply A reliable and continuous supply of water should be available throughout the year. Since the need for water is greatest during the dry season, it is necessary to check the source during the most critical period to see if the flow of water at that time is adequate for the quantity of plants being produced. Regardless of the source, it is advisable to have adequate facilities for storage of at least 3 days supply. The quantity of water required depends on the size of the nursery, the species, container size, rooting media, the number of seedlings and the watering method employed. More frequent watering is needed for containers with sandy media, which have a low water holding capacity. In central nurseries with 200,000 seedlings production capacity using knapsack sprayers or watering cans an estimated amount of 24,000 liters of water per day will be the peak requirement during the dry season. This is equivalent to approx. 2.4 liters per second of water uptake for a three-hour effective water pumping.

2.2.4.9 Fence The entire nursery area should be surrounded by a durable fence, adequate to keep out animals and provide a measure of security. Where fence posts are used, they should be of concrete, durable hardwood or wood impregnated with a preservative. At the entrance the fence should have a sufficiently wide gate to facilitate easy movement of labour and material. It is advisable to maintain an open strip of land about 5 meters wide around the fenced perimeter, to serve as a roadway and buffer zone between the neighboring land and the nursery. This area should be kept weed free, or at the very least, weed species should be cut or mowed and not allowed to flower and produce seed for obvious reasons.

2.2.4.10 Office / Administration building It is not foreseen that a separate office/administration building is needed as all paper work will be done at the nearest forest establishment.

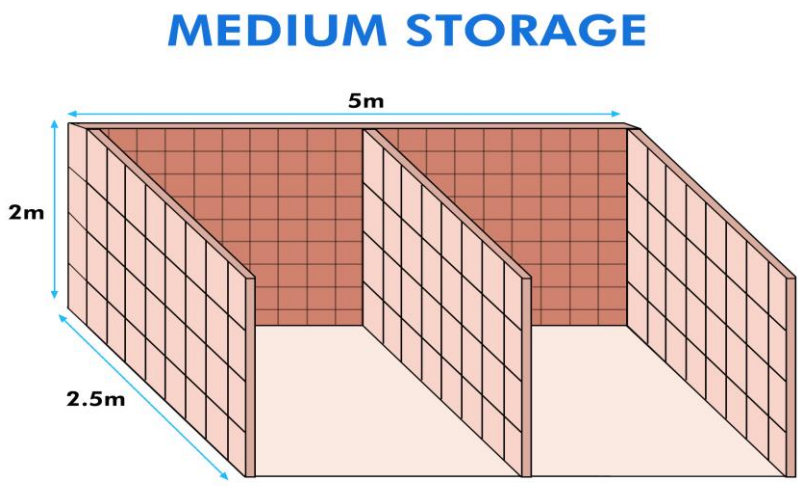
2.2.4.11 Washroom Separate washrooms of reasonable size for male and female laborers are required. The nursery water supply can be used for washroom cleanup.

2.2.4.12 Tools and chemicals shed Tools, equipment, chemicals, seeds etc should be stored in a simple shed of around 5 x 3 x 2.2 meter with separate lockable closets for chemicals and expensive equipment. Seeds can be stored for a short time in sealed well labeled containers on shelves.

2.2.4.13 Generator and pump Although the nursery should have access to 2 or 3-phase electricity, a back-up generator will be advisable to prevent damage to seedlings during prolonged periods of power cuts. A 2 KW generator will be sufficient in most cases, unless water is drawn from bore wells more than 20 m deep. Likewise a 3-5 HP submersible pump will be sufficient to raise water through a 5 cm diameter pipes to the overhead water tank (7-8 m height) from bore wells of depth up to 50 meters.

2.2.4.14 Raised water tank The height and capacity needs for the overhead water tank depend on the nursery topography, nursery water needs and watering system. With a watering system as recommended, gravity water pressure can be used if at least ¾" diameter water lines are used. To this end the tank has to be placed on the highest area of the nursery closest to the water source (well head) and raised to at least 7-8 meters above this point. With an estimated water need of 24,000 liters/day (peak requirement) the overhead tank should have a capacity of at least 8,000 liters. The overhead tank (PVC tanks) should be hoisted on a concrete platform of suitable thickness having area of 3 m (l) x 2.5 m (w) erected on pillars (7 m high). The space in between the pillars should be used to house pumps, generators and tools.

2.2.4.15 Potting media storage can be kept simple and inexpensive with a two chamber bin covered construction. Each bin of size 2.5 (l) x 3.0 (w) x 2.0 (h) meter, one for compost and one for coarse sand, will have a storage capacity of approximately 11 m^3 and is made of a concrete floor and cemented brick walls. Protective cover against rain and sun can be provided with a 3.0 m high roof (CGI sheets) supported on G.I. pipe structure.



2.2.4.16 Medium mixing area and Drying Platform It should be a clean area of 6 x 6 meters next to the potting medium storage and consists of a cement concrete floor on single brick flat soling. The cement concrete floor should have a brick edging all around. No cover is needed. Sterilized sand and compost out of the storage bins, or burnt rice husk, or leaf mould compost, or vermicompost will be mixed in a **cement mixer** at a standard ratio as described in volume III of Nursery Manual. The cement mixer should be installed adjacent to the Drying Platform.

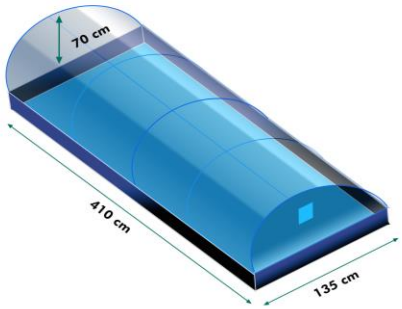
2.2.4.17 Composting area Total compost needs for standard central nursery will be about 32 m^3/yr, production of which (with the Berkeley method) will require 2 compost heaps of 5 x 2 x 2 meters each. In between (next) to these, at least an equal area is needed for turning the heaps with 1 meter extra each side for easy access and movement, giving a need for a total surface area of 5 x 11 meters. No extra provisions are needed as the soil underneath the compost heaps has to be loosened before starting and heaps can be protected against heavy rains with weighted heavy gauge agricultural plastic sheets. Weighting of plastic sheet covering against "blow off" can be achieved by e.g. tying a heavy stone as anchor at each corner with a rope. The heaps may be supported on all sides with split bamboo mats.

Chopping machine should be installed adjacent to the composting area.

2.2.4.18 Germination hygropits The tree species having large seeds will be dibbled directly in their end use containers. Small seeds will be germinated first in coarse sterilized sand filled hygro-pits covered with domed heavy (200 micron) gauge plastic. These pits will be 100 cm wide x 400 cm long and 10 cm deep, lined first with agricultural plastic and then filled with sterilized coarse sand. Hygro-pits will be covered with domes having dimensions of 410 x 135 x 70 cm made of PVC pipes and covered with 200 micron plastic with a 15 x 15 cm ventilation hole cut at top of each face. The germination hygro-pits will be situated at the edge of the removable shade area. After germination the plantlets will be pricked in 150 cc/300 cc root trainer containers filled with a rooting medium (potting mixture) as prescribed in volume III of the Nursery Manual. The containers with seedlings will

be placed in raised beds either under shade in a removable shade area or directly in the open field.

Hygro germination pit , lined with plastic, filled with course sand and either covered with thatch mulch or with a plastic dome

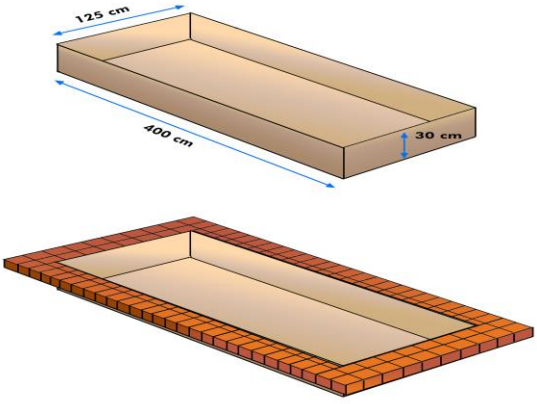


HYGROPIT with DOME

2.2.4.19 Hygro-pits for rooting of clonal cuttings. For clonal reproduction, cuttings dipped in a growth hormone in powder medium and directly placed in 60 - 75 cc root trainer containers filled with sterilized course sand, or vermiculite should be placed in trays in coarse sterilized sand filled hygro-pits

Hygro-pit for root cuttings

Trays for holding containers



HYGRO PIT

These pits will be 125 cm wide x 400 cm long and 30 cm deep, lined first with agricultural plastic and then filled with sterilized coarse sand. Each pit is surrounded by a double line of bricks to better support to the dome and will be covered after placement of trays with domes (similar to the germination hygro-pits) with dimensions 410 x 135 x 70 cms made of PVC pipes and covered with 200 micron plastic with a 15 x 15 cms ventilation hole cut at top of each face. After about 3 weeks the rooted cuttings will be placed directly with their 60 ml root trainer containers in raised beds after which the hygro-pits will become available for the next batch of cuttings. As is the case in the other nurseries with the germination hygro-pits, the rooting hygro-pits will be situated at the edge of the removable shade area. The containers with rooted cuttings in their raised beds can either be placed directly in the open growing area or preferably, first placed in a removable shade area (50% agronet shade).

2.2.4.20 Removable shade area. After the first culling, germinated seedlings or rooted cuttings, can either be placed directly with their raised beds in the open growing area or, preferably placed under light shade in the "Removable Shade Area" before being moved after about 3 weeks out to the open growing area. The removable shade area can be a simple structure of agronetting threaded over wires tensed between uprights either made of galvanized steel / M.S angle/ G.I pipe. The actual structure can be simple and inexpensive but must be sturdy enough to withstand heavy rains and winds. The required size of the area depends of course on the number of seedlings and cuttings being raised. Uprights can be placed East-West as 12 x 12 m grid as wide and long as needed and will accommodate raised beds in pairs between uprights in any direction desired. Agronetting with metal ring reinforced 3/4" perforated holes each meter can be threaded over galvanized steel wire or cable tensed between the uprights, which will permit netting to be spread out over area or recovered to provide direct sunlight.

Removable shade area with galvanized steel uprights

2.2.4.21 Storage for clean root trainers Should be a simple traditional roofing to provide shade and rain protection over a compacted earthen floor. To prevent containers from tumbling out of the storage area if not properly stacked it would be

advisable to surround the area with a 1 m high wall made of either bricks, wood or even hurricane fencing material.

2.2.4.22 Storage for dirty root trainers Should be a simple traditional roofing to provide shade and rain protection over a compacted earthen floor. To prevent containers from tumbling out of the storage area (if not properly stacked) it would be advisable to surround the area with a 1 m high wall made of either bricks, wood or even hurricane fencing material.

2.2.4.23 Washing, disinfecting trough for root trainers Two basic brick or concrete troughs adjacent to each other, with inner dimensions of 2.0 x 1.80 x 0.75 (depth) meters each will be able to hold enough water and containers at a time to permit efficient washing and soaking by several people at once. The troughs must have wide drains on each side to permit efficient draining and cleaning.

2.2.4.24 Resting and Training area A temporary structure 4 m x 3 m open on all sides should be set up at a convenient place within the nursery to be used by laborers for resting and also for training of small groups visiting the nursery. The area should be covered with G.I sheets on G.I pipe truss.