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MEMORANDUM

FOR : The Regional Directors
Regions 2, 3, 4A, 5, 6, 9, 12, 13, NCR and NIR

FROM : The Director

SUBJECT : **FMB TECHNICAL BULLETIN NO.22-C, DESIGN AND LAYOUT OF A MECHANIZED CONTAINER TREE NURSERY**

DATE : JUN 16 2016

I. This Technical Bulletin

This Technical Bulletin is to introduce some design and lay-out of a mechanized container tree nursery that should have both flexibility and integrated flow. Flexibility means the readiness to incorporate new machinery and procedures as needed to increase production. Integrated flow means arranging buildings, structures, walkways, roadways, etc., to complement each other. Space is saved by purposely designing certain areas to accommodate several activities.

II. Users of the Technical Bulletin

The users of the Technical Bulletin are the Nursery Managers, Growers, Assistant Growers and readers who plan to start and operate a nursery for native plants as well as exotic plants in the tropics.

III. Introduction

A perfect nursery site will never exist. The goal is to develop an efficient operation that optimizes plant growth and expedites harvesting and shipping. In general, the average permanent nursery should be designed to accommodate the administration, operations and the production areas. There should be no space wasted although unused land has to be included if expansion is planned.

A permanent nursery is a long-term commitment and investment. Care, caution and lot of thoughts should be used in designing a nursery site. Good design and layout

will increase efficiency in growing seedlings and in minimizing unnecessary time and cost.

Nursery developers must give careful attention to planning and design of the seedling growing area to ensure the production of uniform, healthy plants in quantities that will meet quality demands.

IV. Nursery Design and lay-out

A well designed forest nursery should have proper roads, office, growing media sheds, seed germination, growing areas, water supply, telecommunication, water or irrigation system, fencing, etc. Consideration should also be given to the construction of storage facilities for nursery equipment, tools, fertilizers, pesticides and other materials. The design of the nursery should include defined areas of operation, such as:

1. Access roads - It is advisable for the nursery to have a proper road system with a minimum width of 3 m to allow accessibility. Access roads should be properly paved with gravel and compacted or concreted to allow for proper passage throughout the year, especially to the forklift and trucks.

2. Infrastructure and Facilities
    a. Multi-purpose building – This building should have sufficient floor space that can be taken up as office space, a room with good ventilation to store seeds, and a separate room for storing chemicals and fertilisers.

    b. Preparation area – This area should have enough space for preparing and storing growing media.

    c. Seeding house - The seeder building will house the seeding line that includes the media mixer, soil elevator, tray filler, seeder, tray topper, and watering channel, and trays. It should be made of permanent materials such as concrete, steel and galvanized iron sheets to protect the seeder from typhoons and strong winds. The roof ceiling can be fitted with insulator to reduce heat inside the building. It should have four large doors on four sides for ventilation, and ease in the movement of equipment, materials and personnel.

    d. Germination house

        The germination and propagation houses should be a semi-controlled and modified free-standing greenhouse with a permanent transparent roof and wall. An option is half the walls could be covered with plastic that can be rolled up or opened. This design permits considerable flexibility in environmental control. During germination, the sidewalls are kept lowered to maintain temperature and humidity inside the greenhouse. When ambient temperature is needed, the plastic cover at the sides can be raised to permit natural ventilation by allowing dry air to enter the greenhouse. Aside from these structural modifications, the greenhouses can be outfitted with shade cloth to reduce heat and fitted with foggers and sprinklers to control humidity inside the greenhouse.

3. Growing areas – If possible, the growing and hardening areas should be laid out in a north-south direction. This direction provides maximum sunlight to all the seedlings. The width of the growing bench (pallets) depends on the nursery planner. The spacing between the growing benches should be between 0.5-1 m.

    a. Shade houses

    Providing shade to young plants by suspending shade fabric over the plants to protect them from excessive sunlight is an important consideration in nursery operation. Traditionally, shadehouses are covered with shadecloth in a variety of densities, materials, and colors. Shadehouses are equipped with irrigation and fertilization systems but climate remains at ambient levels.

    For forest and conservation species, 50-70% lock-stiched polypropylene woven black shadecloth are normally used which is strong and durable and will shrink only 1%.

    Rigid frame shadehouses incorporates rigid steel framing instead of cables. Due to the spanning limitations of steel, the upright columns have to be spaced closer at 4-6 meters. Many rigid-frame systems employ diagonal "knee braces" to eliminate the need for the "dead man" assemblies in cable frame shadehouses. Rigid-frame systems are favored because they meet building codes.

    b. Hardening area

    The hardening areas are minimally-controlled area or open growing areas where the container seedling will be subjected to slow growth using moderate stress in order to acclimatize the seedlings to the out-planting environment. The areas shall be covered with gravel. They will be totally under ambient climate and will be equipped with permanent irrigation system such as ground or basal sprinklers for watering and injecting fertilizer.

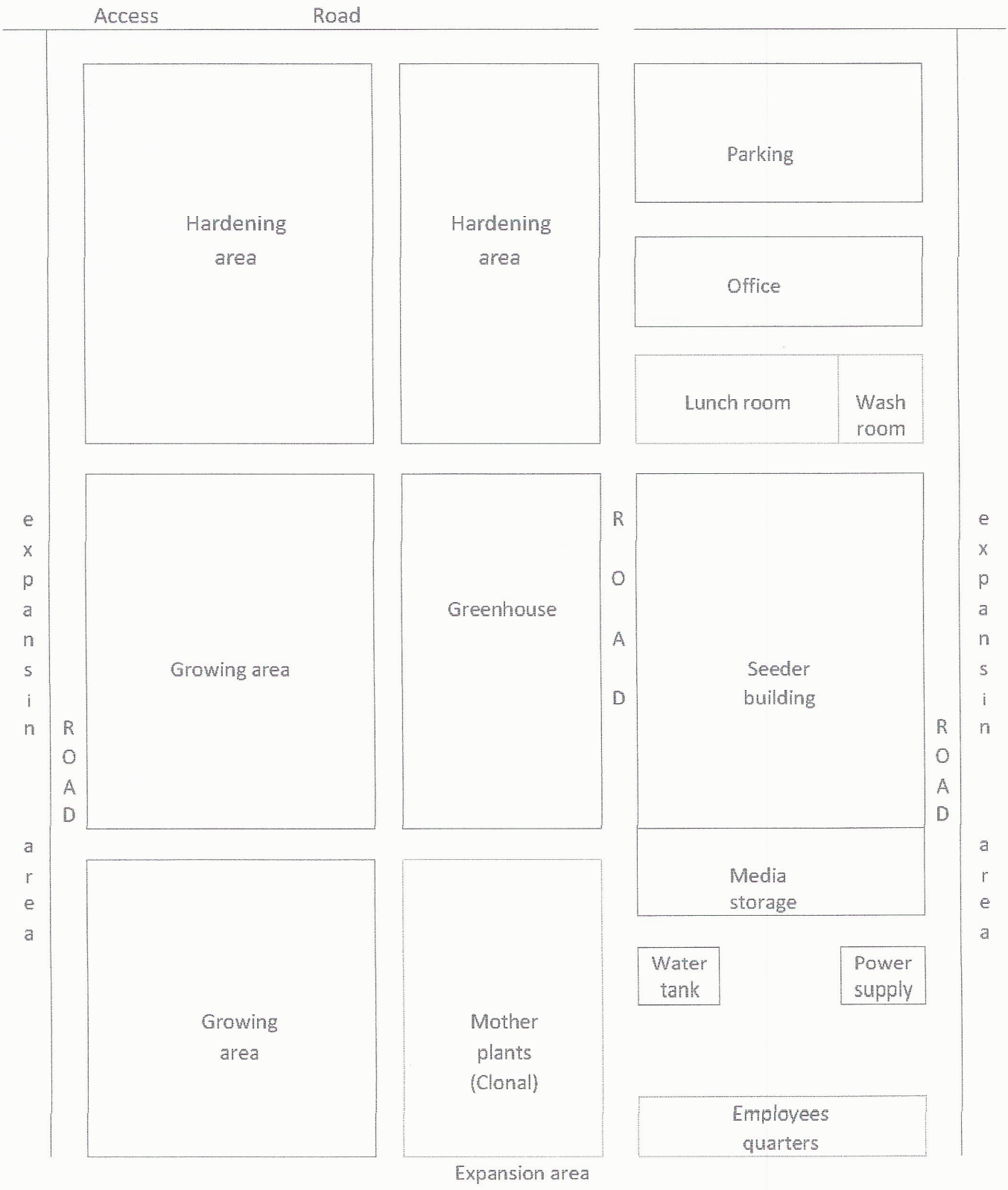
    Just like in the growing areas, the containers will be placed on pallets and the pallets with the containers placed on raised platform with rails.

4. Power Supply - A forest nursery site should be accessible to electricity for the operation of nursery equipment, including irrigation pumps, chillers, potting machines, computers, lighting and so on. If electricity is not available, then generators will have to be used.

5. Water Supply - Adequate quality water supply are extremely essential for a containerized forest nursery. A pump house should be constructed within the forest nursery area or near the water source.

Typical Layout - Mechanized nursery

(not drawn to scale)



6. Water System - An overhead and basal water sprinkler system is the most common watering system used in container forest nurseries. The water system should be able to water the plants at a fairly rapid rate. It is relatively inexpensive to install and to operate.

7. Preparation and shipping – This can be an extension of the growing areas where planting stock are graded and prepared for delivery to planting site

8. Waste disposal area – This area should be isolated, secured, and well-separated from seedling houses. Good nursery hygiene is essential if disease free seedlings are to be produced for transplanting in the field.

9. Other Facilities - Very often washing and toilet facilities and a lunch room are overlooked when nurseries are being planned. These are essential to ensure high standards of personal hygiene as most workers are in daily contact with growing media and chemicals.

V. Types of growing environments

There are three types of tree nursery environments based on the relative amount of environmental modification: minimally-controlled environments, semi-controlled environments, and fully controlled environments. For the DENR, the first two types will be used.

1. **Semi-controlled environments**

   This type of propagation environment is designed to control only certain aspects of the ambient environment such as heat by opening the side vents or roll-up the plastic cover or opening the doors. In tropical and semi-tropical countries, crops can be propagated in semi-controlled structures all year round except in extreme weather conditions. For example, the side vents can be closed during seed germination and opened as needed to provide adequate ventilation. Semi- controlled environments are more economical to build and operate because they do not need additional equipment such as heater, fans and computer control.

2. **Minimally controlled environments (Open Growing Areas)**

   Open growing areas were developed to produce an inexpensive container seedling that was well acclimated to the environment. The areas can be graded for good drainage and covered with gravel. Although they offer little control of the ambient climate, these areas are equipped with semi- permanent irrigation lines that water and inject mineral nutrients. Containers should be placed on benches or pallets to encourage air pruning of roots. The pallets with the containers are arranged into elongated beds or bays, the dimensions of which are determined by the irrigation system.

   Although open growing areas are the least expensive way to produce container stock, seedling growth rates are slow and, depending on the climate, it may take at least 6 months to produce a shippable seedling or less

than 6 months for fast-growing species. Weather damage, such as torrential rain, is also a major concern and so the risk of crop loss is the highest in this type of propagation environments. To prevent heat injury to delicate plants, portions of this area can be equipped with a shade cloth to reduce sunlight from reaching the young plants.

3. **Fully-controlled environments**

Fully controlled environments are propagation structures like greenhouses in which all or most of the equipment to simulate favourable environmental factors are computer-controlled. Although fully-controlled environments have the advantage of year-round production, this may not be available yet in the Philippines because of higher costs of construction and operation where electrical power outages is common and the difficulty of obtaining specialized parts and repair services.

VI. Greenhouse structures

A greenhouse is a structure with a glass or plastic roof and side walls that is used for the production of plants and may be used seasonally or year round. The closed environment of a greenhouse has its own unique requirements, compared with outdoor production. Greenhouses for forest seedling production can be classified as free-standing or gutter-connected.

1. Free Standing Greenhouses

A free standing greenhouse as the name implies is a structure that is not attached to another structure. It may have side walls 2.4-3.0 meters high with roll-up sides which allow air to pass through the greenhouse. The free standing greenhouses are ideal for new nurseries because they offer the lowest investment per square meter. The nursery developer can start with one or two structures and then add more as the need arises. Individual greenhouses are popular in forest and conservation nurseries because many different crops can be grown in separate environments and offer better access.

A free-standing greenhouse can have a quonset (hoop), gothic or rigid shape. The Quonset is usually the least expensive and is available in widths up to 10 meters. Gothic designs have higher light transmission. The rigid designs may use trusses to span a width up to more than 20 meters.

2. Gutter-connected greenhouses

A gutter-connected greenhouse is a series of trusses connected together at the gutter level. Individual bays vary in width from 4m to 8m and have a clearance of 3m to 5m to the gutter. Bays can be put together to get any width of greenhouse desired.

Most greenhouses can be built with galvanized steel. Steel makes a strong frame to withstand strong wind and still allow about 80% of the light to enter.

3. Foundation and Floors

The most important function of the foundation is to tie the structure to the ground to prevent strong winds from lifting the structure and to counteract all the various loading forces, be able to keep the environment clean and pest free, and provide a solid base for the containers and other materials and ease in the handling system.

Foundations and floors should be made of poured concrete but asphalt or gravel paths between the structures are a less expensive option. Bare soil or even soil covered with plastic tarp or weed barrier is never recommended in propagation areas.

4. Design Loads

The different types of propagation structures are based on the following three functions:

a. Engineering – Should be able to safely support the design loads;
b. Biological – Should be able to capture maximum sunlight, and protect the crop from adverse weather conditions and pests;
c. Operational - Allow easy access and handling of seedlings and materials

5. Greenhouse coverings

The function of the propagation structure covering is to reduce sunlight while maintaining the desired or ambient temperature and humidity levels for the plants. In the Philippines where an average of 20 typhoons visits the country, rigid plastic or structured panels of fibreglass, acrylic and polycarbonate are recommended in favour of plastic film. These types of panels are lightweight and durable, and they have excellent light transmission properties. Structured plastic panels are available in both single layer corrugated sheets and chambered flat panels, which can be double or triple-layered.

The polycarbonate sheet for greenhouse industry is available as solid, multiwall and corrugated. Polycarbonate is unbreakable and offer high insulation values. It provides light transmission up to 90%, the same as glass. It has 200 times greater impact resistance that glass, 20 times greater impact resistance than fibreglass and ten times stronger than acrylic but its weight is just one-eighth of glass. Furthermore, the air between the sheets acts as an insulator which hinders heat transfer between the interior and the exterior of the room. Still, the internal structure adds some mechanical strength to the polycarbonate sheet.

6. Pallets

For container crops, they have to be grown on pallets and raised benches because container tree seedlings have aggressive root systems that quickly grow out at the bottom of the container. If they are allowed to grow on the ground, the roots will grow into the soil. These external roots must be air pruned to encourage the growth of fibrous roots. To cause roots to desiccate and air prune, an air space must be provided under the container.

Container nurseries are designed to maximize materials handling using wood, synthetic, or metal pallets that can be handled by forklifts. The dimensions of the pallets can be designed to fit the dimensions of the trays and easily moved by the forklift.

7. The propagation bench or rails

The cheapest way to grow plants is on the ground. However, air circulation and environmental control to encourage root pruning are difficult to achieve, and other problems may complicate growing, including, disease and rot. Benches, therefore, are recommended.

The basic needs are an open metal surface raised up off the ground, such as a steel mesh, that allows air to flow freely. It should be at least 75-100 centimeters high to allow air to circulate underneath. The frame can be constructed out of treated lumber or metal.

8. Transportation Carts

The transportation cart allows one person to move thousands of trays or seedlings easily and quickly within the nursery. The idea is to accommodate as many seeded trays as possible for germination eliminating any wasted space. Shelves can be adjustable to accommodate plants of different heights and come with wire mesh bottom. Carts are equipped with wheels for easy movement.

9. Conveyors

A very important consideration in the nursery is the movement of trays during seeding operation and seedlings during grading and shipping. Conveyors can be very simple, effective, efficient and flexible means of moving trays within the nursery. Conveyors are available in any width or length needed. They can be installed permanently or set-up temporarily. The conveyors should be installed in line so that the trays can be moved from one conveyor segment to the next. There are three kinds of conveyors: belt conveyors, modular conveyors and roller conveyors.

VII. Greenhouse equipment and logistics

1. Tray filler

Growing media filling is electronically controlled to ensure that trays are not over filled nor over compacted. The soil filling process will slow down before too much soil falls into the trays. This ensures perfect filling and compacting. The tray filler has an output of up to 800 trays per hour depending on the size of tray.

2. Roller Dibbler

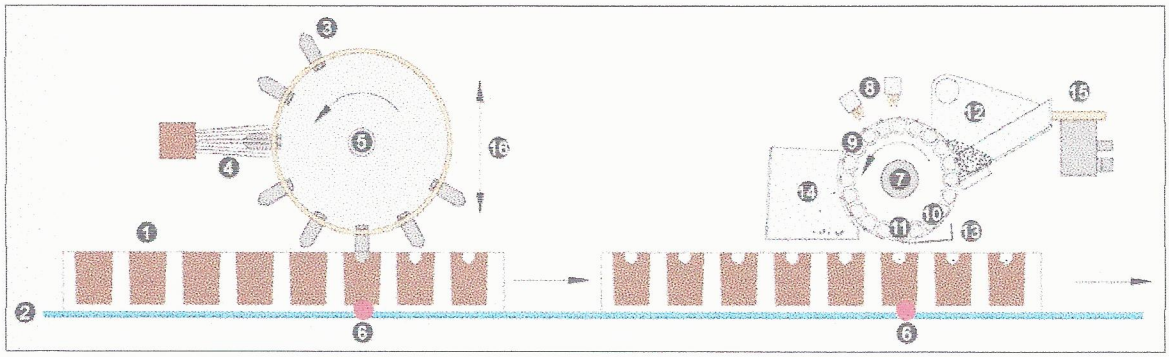
The roller dibbler is a simple but effective device for dibbling the cells of container trays prior to seeding. Mounted on a conveyor, the container trays are passed under a roller which has dibbler pegs protruding to produce neat, uniform depressions.

3. Seeder Machine

Sowing will be mainly done by the automatic seeder and sown on container trays where the seeds will germinate and establish until they are ready for planting. These automatic seeders are mechanically sophisticated and very efficient at delivering exact numbers of seed to each cavity, thus eliminating the need for thinning or transplanting. The fastest and most expensive among the automated seeders are the drum seeders. Sowing efficiencies can be as high as 98%.

How the drum seeder works

The diagram below shows how the seeder picks up seed out of the hopper, removes unwanted multiple seed using fine jets of air from the singulator bars, and places them in the tray.



1. Tray.
2. Belt conveyor.
3. Dibbles (Aluminium pins with different diameter and form according to the cell).
4. Polypropylene brush for the soil cleaning between the pins.
5. Driven dibbler synchronized with tray advancement.
6. Sensor for zero position.
7. Seeding drum.
8. Double blow bar with more holes for the seeding singulation.
9. Vacuum tunnel for seed suction.
10. High pressure tunnel for nozzle cleaning.
11. Low pressure chamber (0,2 bar) for seed drop.
12. Seed holding plate of transparent methacrylate, oscillating to distribute uniformly the seed.
13. Scraper blade.
14. Seed recover plate.

15. Vibrator which makes the sucking easier.
16. Drums with electronic height adjustment.

4. Tray Cover

After the containers are seeded, the seed is covered with a thin layer of growing media to hold the seed in place and prevent the seed to dry out.

5. Water Channel

After the trays have been topped, the trays will continue to pass through a watering channel that will give uniform watering before the trays are loaded to carts and brought to the propagation house. The fundamental objective is to provide a continuously humid environment conditions for every seed without depriving it of oxygen through extended saturation to achieve uniform germination which is the foundation for uniform growth.

6. Coconut Shredder
7. Media (Soil) Mixer
8. Media Elevator
9. Forklift

VIII. Nursery Expansion

In case seedling demand will outpace production, the nursery operator must consider whether to develop completely new facilities or expand the existing ones. Given the capability of the automatic seeder to produce, expansion of growing areas such as greenhouses, shade houses and open areas is often strongly favored rather than investing in the development of another site and new equipment. If there is no more area for expansion, another alternative is to develop satellite nurseries to accommodate production overflow.

The design and layout for containerized nurseries that use mechanized or semi-mechanized techniques should have large capacity area that can handle operation for forest, agro-forestry, food production and ornamental seedlings.

FOR THE REFERENCE AND GUIDANCE OF ALL CONCERNED.

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