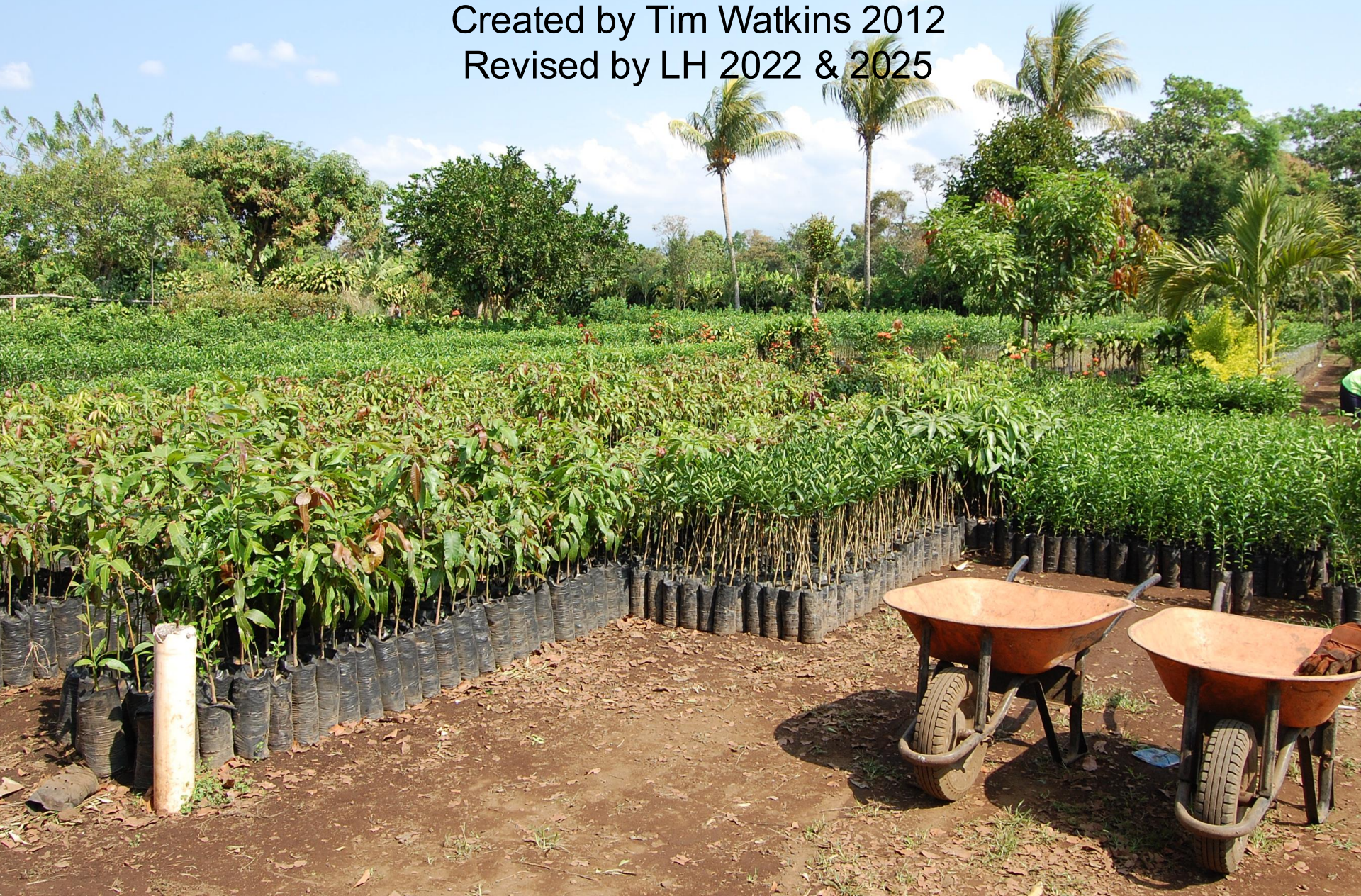
Small-Scale Tree Nurseries

Created by Tim Watkins 2012
Revised by LH 2022 & 2025



Overview

- Planning a Nursery
  - Purpose
  - Site Selection
  - Nursery Supplies
  - Water Management
  - Security and Protection
- Propagation
  - Seeds
  - Cuttings
  - Grafts



Types of Nurseries

- Large scale or Commercial
- Family business
- Research center
- School or community
- Reforestation/Agroforestry/Forestry Program
- Botanical Garden
- Germplasm Collections
- Small-scale farmer/ Farmer group/Cooperative
- Private Collection



Purpose of a Small-Scale Tree Nursery

- Provide an environment for the propagation and care for seedlings or plants until they are ready for permanent planting
- Produce quality plants that are adapted to the local climate and soil conditions



Goal of the Small-Scale Tree Nursery

- The production of quality seedlings for:
  - Planting, Distribution, or Sale
- Quality seedlings (ICRAF 2002)
  - Well-developed root system
  - Anchor in the ground quickly and start growing quickly after planting out
  - Sun-adapted foliage (hardening)
  - Balanced shoot/root ratio (1:1 or 1:2)
  - Adequate carbohydrate reserves
  - Are strengthened by inoculation with *Rhizobium* or mycorrhizae if needed.



Examples From Around the World



Church Nursery
Zomba, Malawi


Oil Palm Nursery, Congo

Commercial, Protea Nursery, Zimbabwe





World Vision, Haiti



Zomba, Malawi



Farmer Group Nursery, Haiti


Roadside Nursery, Tanzania


ECHO Florida 2006

Considerations When Planning a Nursery

- Location
  - Access to Markets/End Uses
  - Transportation
  - Climate
- Layout
- Size-Area Requirements
- Soil Media Availability
- Slope/Terrain
- Shelter
- Security
- Room for Expansion

- Accessibility
- Water Supply and Irrigation
- Potting Media
- Pest Management
- Hygiene
- Staff
- Fertility
- Costs
- Power Requirements

Sites to Avoid

- Very exposed sites
- Low areas, prone to flooding
- Rocky soils
- Heavy soils
- Extremely acid or alkaline soils
- Saline soils



Close and Reliable Water Supply



Good Source of Topsoil for Soil Mixtures



Don Ramon Ailon

El Campesino Nursery
Reu, Guatemala





Shelter From Wind



Shade



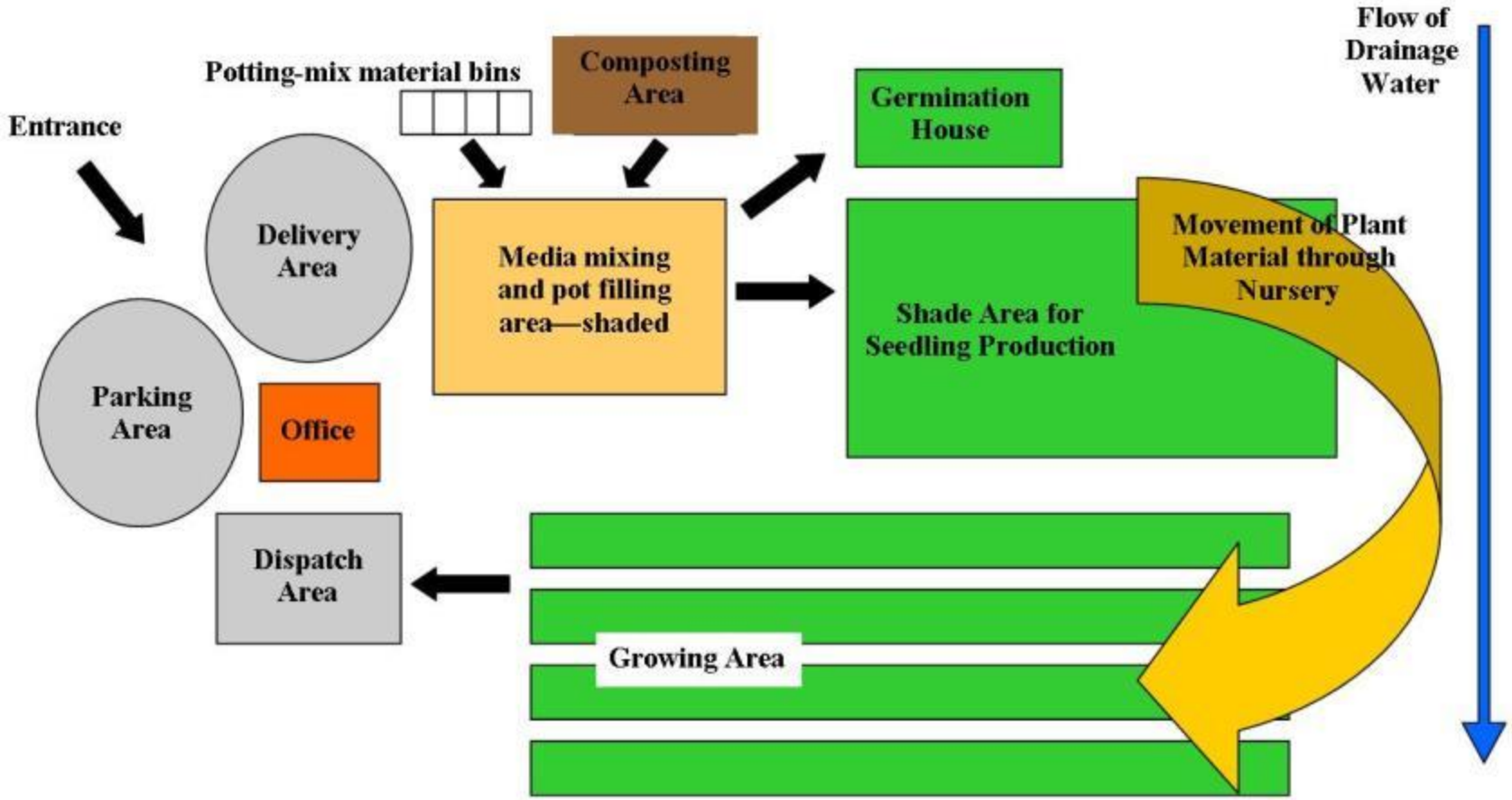
Protection



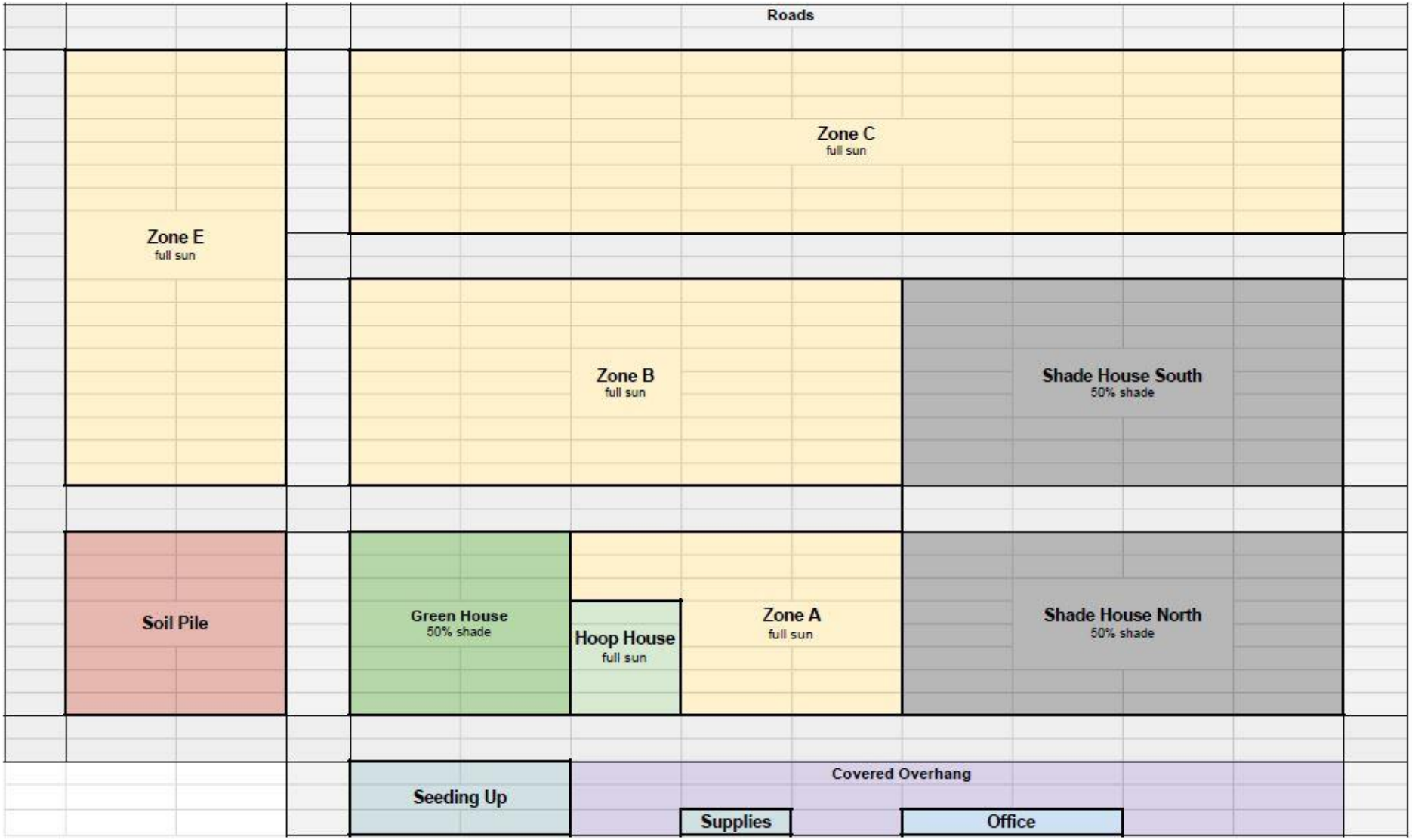
Work Flow/Site Plan Activity

- Each person gets an element/area of a nursery
- Arrange yourselves based on what you think would make sense to be nearer or further from each other in order to have an efficient work flow/site plan

Commercial Nursery Layout



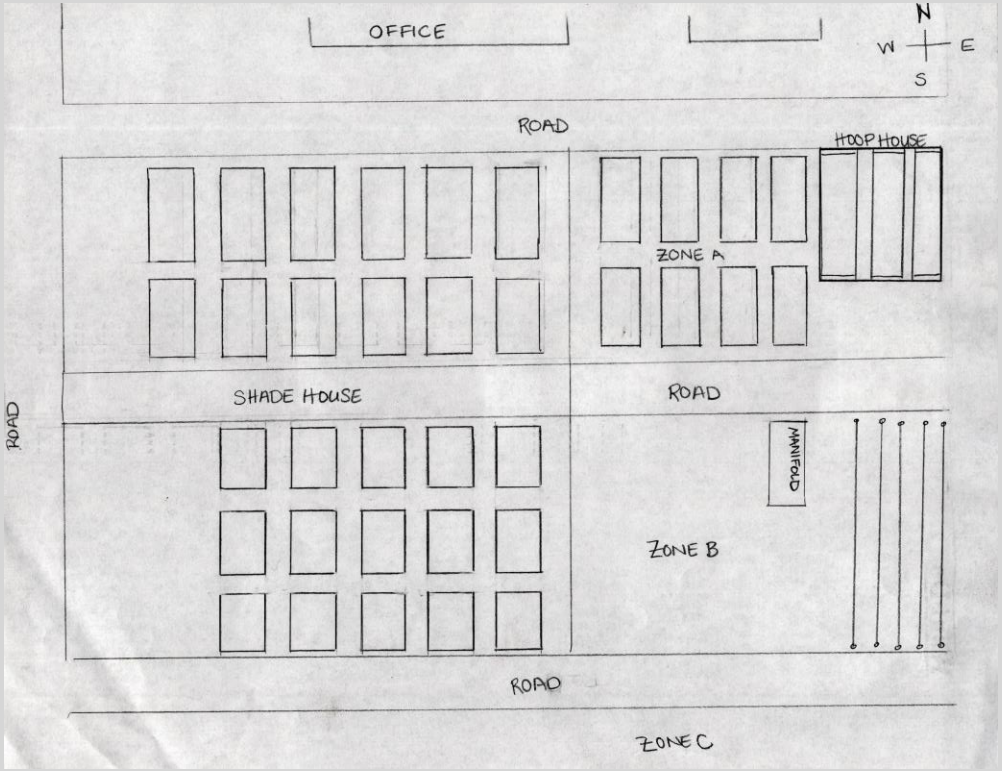
ECHO's Propagation Nursery Layout



Microclimate Activity

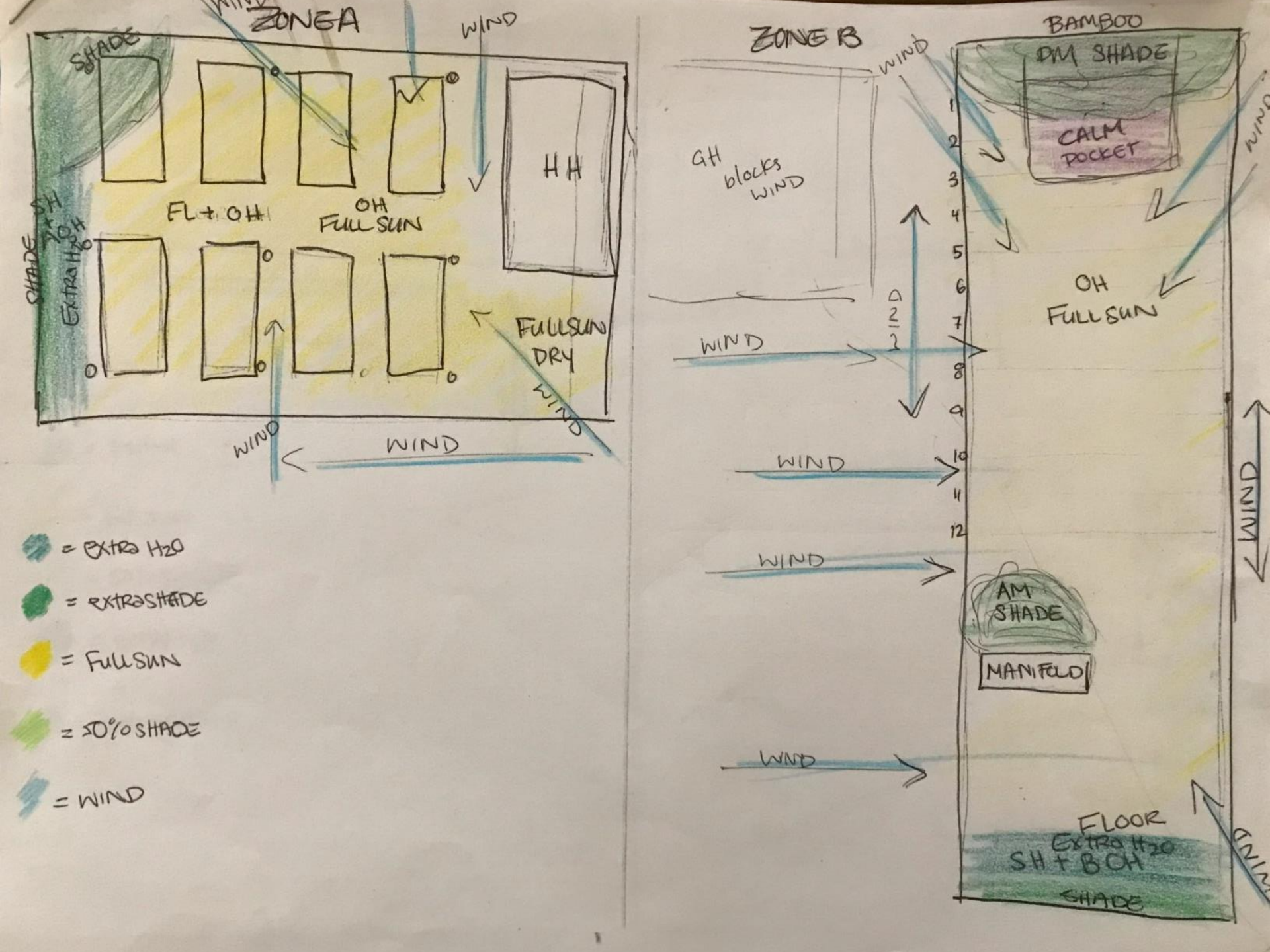
Sector Analysis

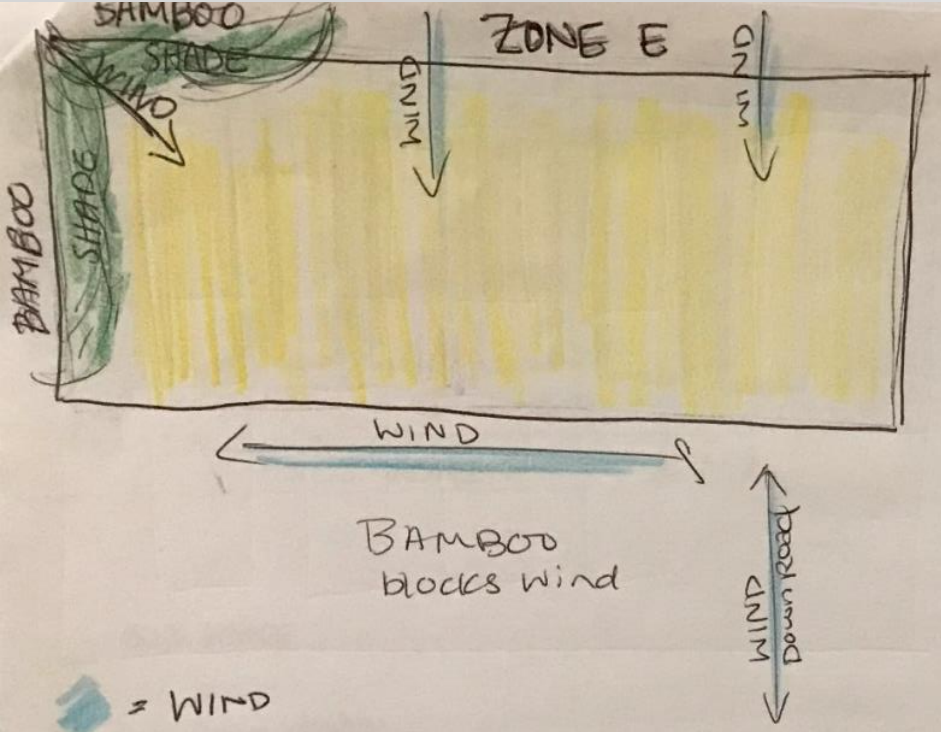
- Walk around Pre-sale and the Shade House and observe:
  - Sun/Shade
  - Wind/Calm
  - Water/Extra/Dry



Why? Different plants in different growth stages need different things.


KEY
FULL SUN
SHADE
WIND + DIRECTION
CALM POCKET
EXTRA H2O | DOUBLE H2O
OFFICE
N
W
E
S
ROAD
HOOP HOUSE
ZONE A
SHADE HOUSE
ROAD
ROAD
MANIFOLD
ZONE B
ROAD
ROAD


ZONE A
SHADE
WIND
HH
FL + OH
OH
FULL SUN
SH + OH
EXTRA H2O
SHADE
FULLSUN
DRY
WIND
WIND
WIND
ZONE B
GH
blocks
WIND
WIND
WIND
WIND
WIND
WIND
BAMBOO
DM SHADE
CALM
POCKET
OH
FULL SUN
AM
SHADE
MANIFOLD
FLOOR
EXTRA H2O
SH + OH
SHADE
WIND
= EXTRA H2O
= EXTRA SHADE
= FULL SUN
= 50% SHADE
= WIND



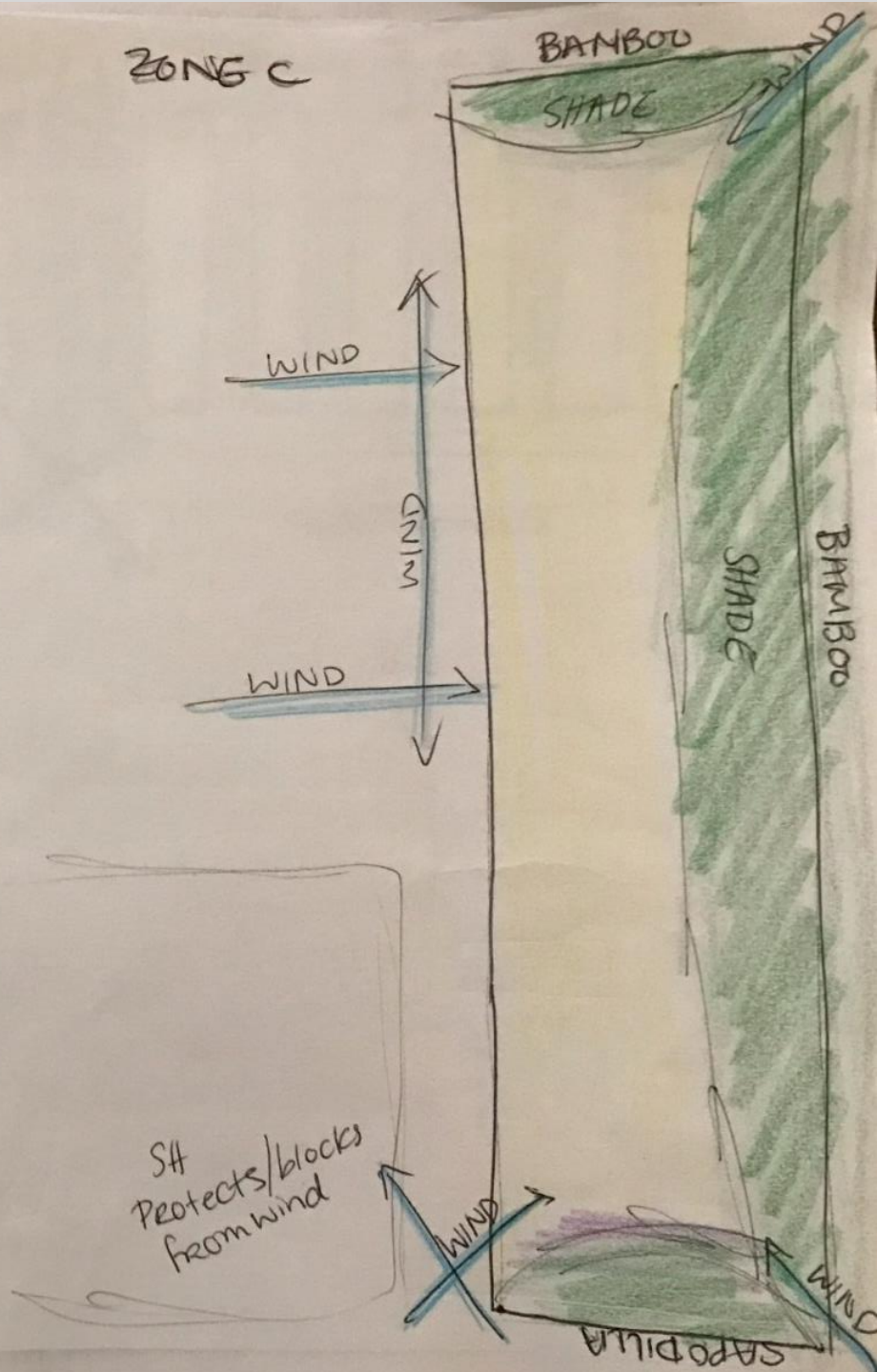
= WIND

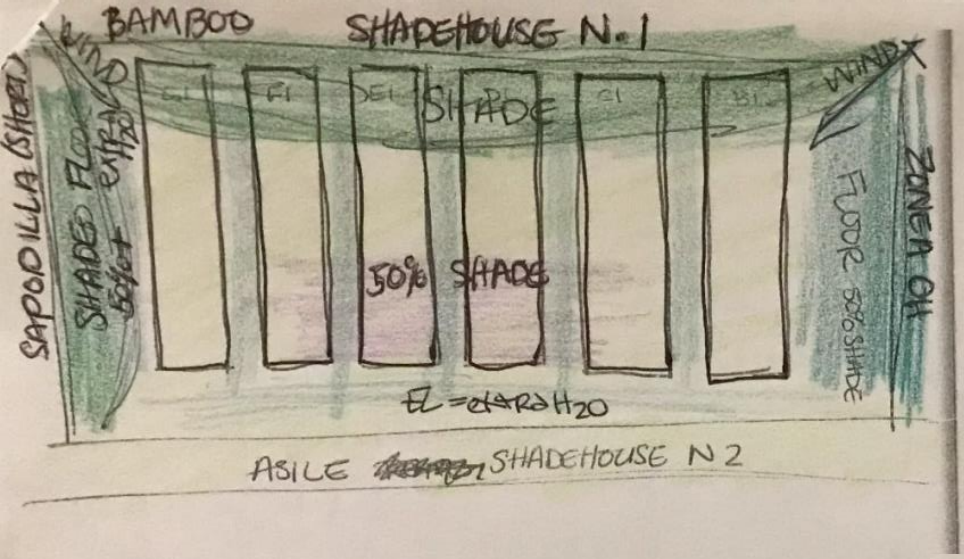
= full SUN

= 50% SHADE

= extra H_2O

= extra SHADE

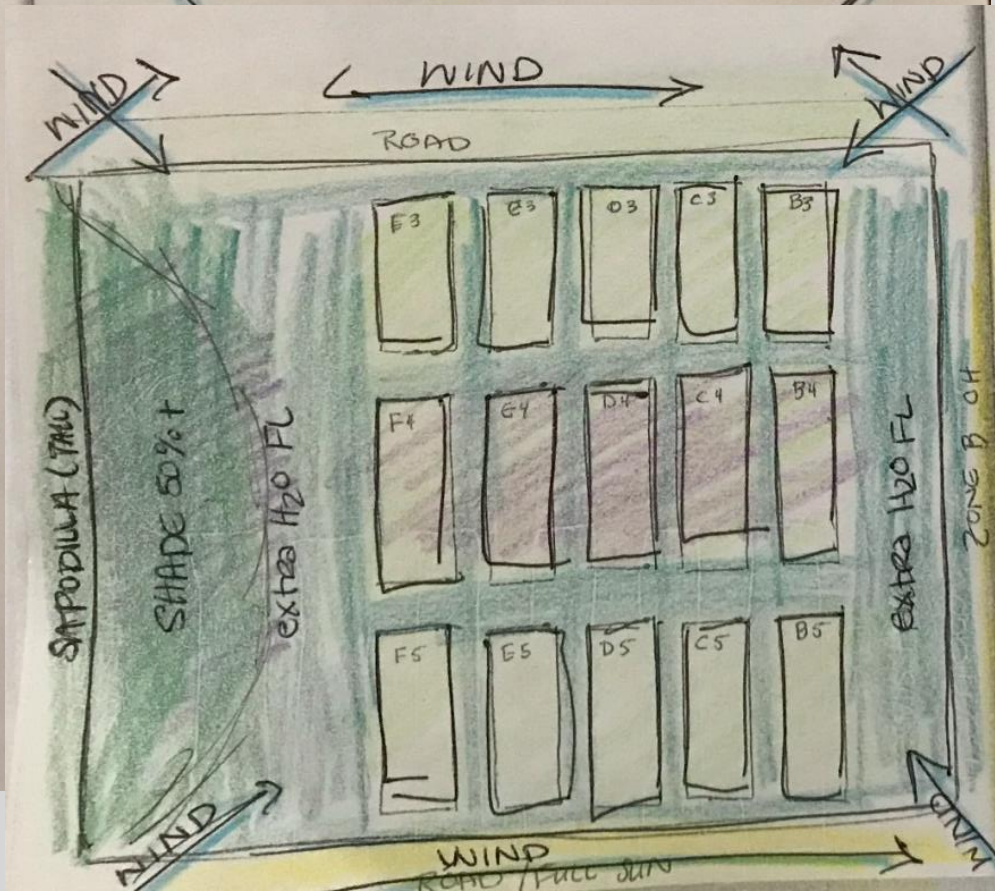






SHADEHOUSE SOUTH

- = Full sun
- = WIND
- = 50% SHADE
- = extra SHADE
- = extra H_2O
- = CALM pocket



Basic Nursery Supplies



Supplies

- Construction Materials
  - Poles
  - Shading materials
  - Fencing materials
- Storage and security
  - Secure shed
  - Locks
- Tools
  - Shovels
  - Wheelbarrow
  - Watering cans
  - Buckets
- Disinfectant
- Plastic (UV resistant)
- Work benches/tables
- Containers/Pots



Nursery Containers

- Many options available:
  - Plastic or Clay Pots
  - Root-trainers
  - Polyethylene/polystyrene plastic sacks
  - Tins, Cans, and Plastic Bottles
  - Bamboo pots
  - Banana leaf pots
  - Clear Plastic Water Bags

Polyethylene Nursery Bags

- Polyethylene bags are the most commonly used in the tropics (ICRAF 2002)
- Advantages:
  - Easy to use, compact, widely available
- Drawbacks:
  - Expense, poor root development, durability, waste,
  - Cost: 1 Gallon Black Case of 500 Bags $90 USD (2010)



Polyethylene Nursery Bags/Sleeves

- **Polybags** are the containers most commonly used in tree nurseries in developing countries. They are usually made of black polyethylene and have several drainage holes at the bottom.
- A common problem with polybags is that plant roots tend to grow in spirals once they hit the smooth inner surface. This will inevitably lead to plants with restricted growth, poor resistance to stress and wind-throw and even early dieback due to ensnarled root masses or pathogens. This is a major drawback in the use of the conventional polybags.
- **Advantage** of Polybags: Usually widely available
- **Disadvantages** of Polybags: Roots grow in spirals (because of smooth inner surface)
- **Polysleeves** made from the same material are cut from a continuous roll and have no bottom.
- Because of their open bottom, polysleeves allow for air pruning when placed on raised propagation beds, for example on a thick layer of gravel. But they are less resilient in transport, because the potting substrate can easily fall out and damage the roots.
- Polysleeves should never be placed straight onto soil because roots will grow into the ground and the main roots break off when you lift the plants.
- **Advantage** of Polysleeves: Allow for air pruning of roots when placed on benches, gravel, or wire mesh table.
- **Disadvantage** of Polysleeves: Substrate falls out during transport



Plastic Cones, MCC - Haiti



Root Trainer, Haiti



Banana Leaf Pots

- Use fresh banana leaves
- Steam or Smoke leaves before forming pots (wilting)
  - Prevents splitting
  - Leaves take on shape of pot more readily
- Not viable for transport of plants




Nursery Potting Soil

Nursery Potting Mix

- Retain sufficient moisture, but drain well
- Allow good aeration
- Provide sufficient fertility
- Use locally available materials:
  - Good soil
  - Compost
  - Course sand
  - Composted rice hulls (charred rice hulls)
  - Composted coffee hulls
  - Coconut coir (coir dust)
  - Sugar cane bagasse
  - Worm castings



Forest Soil for Potting Mix, Guatemala

Potting Mixtures

- Depends on crop, soil composition, and climate
- Example mixes:
  - 3 parts topsoil, 1 part humus-rich soil (compost), 1 part sand (course sand)
  - 5 parts topsoil, 2 parts decomposed manure, 1 part course sand, 1 part decomposed straw or coir dust, 1 part 3/8” ballast
  - Mix 7 parts soil with 2 parts well-decomposed chicken manure, and 1 part fresh or charred rice hull. (IRRI)

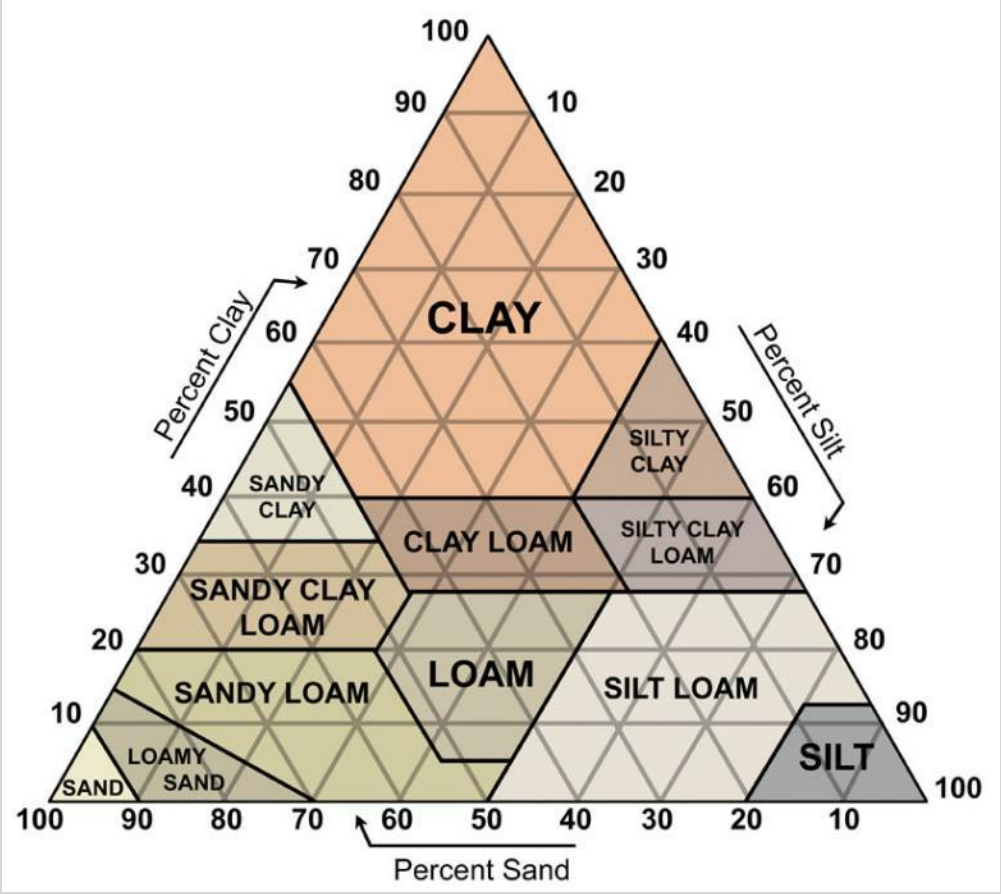
As a rule of thumb when soil is to be part of the growing medium, use the following mixtures (topsoil : fine gravel : well-decomposed organic matter such as manure or compost):

- for heavy (clayey) soils 1 : 2 : 2
- for medium (loamy) soils 1 : 1 : 1
- for light (sandy) soils 1 : 0 : 1

Source: World Agroforestry Center

Potting Mix Guidelines

- Learn about your local topsoil!
  - Physical characteristics of available soil will determine your potting soil recipe
  - Clay, Silt, Sand, Organic matter



http:// http://www.soilsensor.com/soiltypes.aspx

Inoculate Potting mix with soil microorganisms

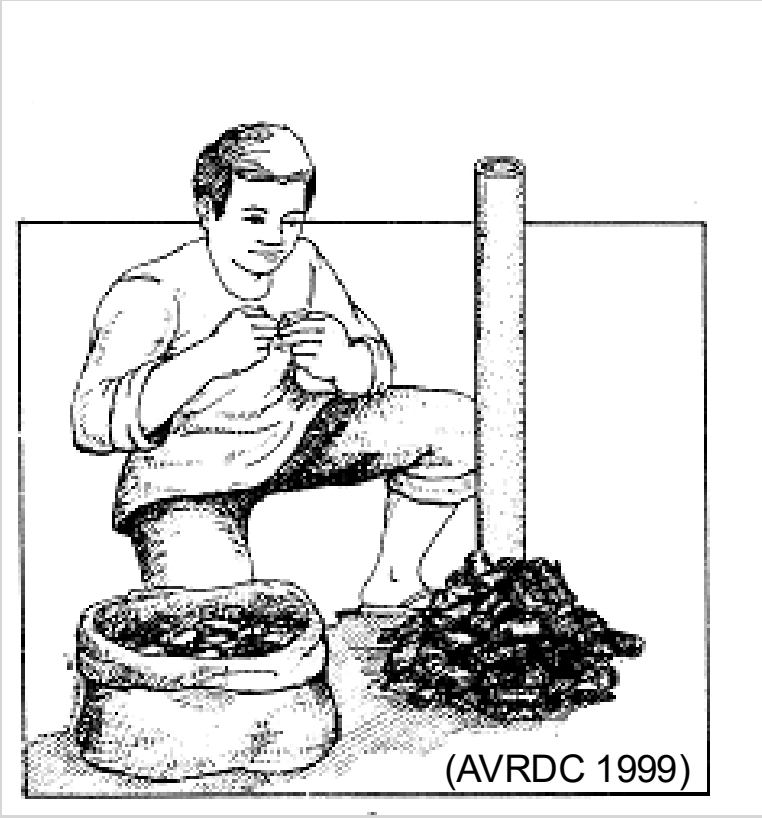
- Nitrogen Fixing Bacteria
- Mycorrhizae



Forest Soil for Potting Mix, Ethiopia

Charred Rice Hulls

- “smoked rice hulls” or “rice hull ash”
- Southeast Asia-used extensively in commercial potting mixes
- 38% carbon, 62% silicon
- Properties:
  - Disease-free medium
  - Good water-holding capacity
  - Good drainage
  - Adds soil structure
  - Some essential nutrients (Si)



http://www.echotech.org/network/modules.php?name=News&file=article&sid=201



Charring Rice Hulls, ECHO FL

Compost

- Create humus-rich material for potting mix
- Often an important component of a good mixture



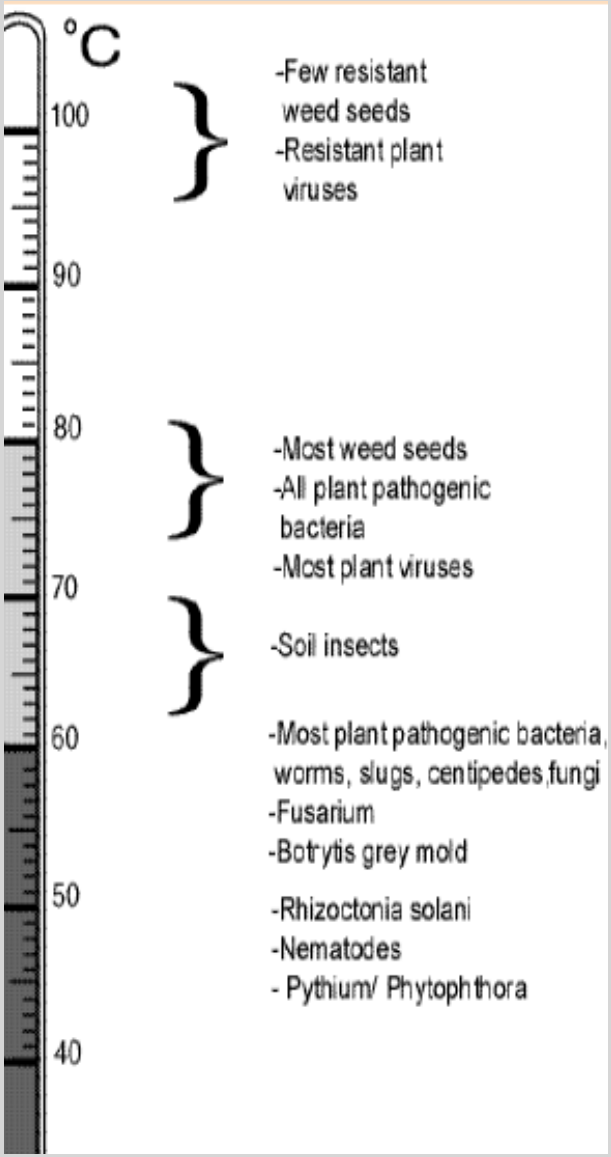
Sugar Cane Bagasse



- 'Haiti Mix'
  - 5 parts sugarcane bagasse
  - 1 part rice hulls
  - 1 part sandy loam soil
  - From Amaranth to Zai Holes, Chapter 6
- Must be well decomposed
- Color of bagasse should be dark red to brown
- Heat finely shredded bagasse by adding 1 pound per cubic meter of urea to mix
- Center of pile should reach 145°F (62°C)
- Turn pile inside out to heat evenly


Sugar Cane Bagasse
Potting Mixture

Creating Clean Potting Mix



- Use heat to prevent fungal diseases, weed seed, nematodes and bacteria
- Do this for germinating seeds that are sensitive to *damping off* or root diseases (*Pythium sp.* or *Phytophthora sp.*)
- Labor (and energy) intensive!

Pasteurization

- Fire box method
  - Cut a steel drum lengthwise or in half
  - Use stones or bricks to support drum
  - Fill with moist (not wet) potting mix
  - Start fire below drum
  - Stir mix constantly to heat evenly!
  - Heat to 60˚C (140˚ F) for 30min.
  - Allow to cool

Caution: Over-heating will kill beneficial organisms in soil!



Solarization

- Spread soil on concrete or plastic
- Thickness of 10cm
- Cover with clear plastic sheet
- Position in full sun

Temperature ˚C	Time to kill pathogens
40	2-6 weeks
50	6 hours
60	30 minutes



Flood Irrigation, Guatemala

Water Supply

- **Sufficient Quantity:** Potted plants are vulnerable to water stress Water plants according to their daily water needs
  - Factors: *Season, soil type, plant species*
  - Group plants according to watering needs
  - 0.5 inch of irrigation should wet 6” of potting media

- **Reliable Supply:** a dependable, year-round supply is critical (reduces need for reserve)

- **Close to Nursery:** Transporting water is labor intensive and costly

- **Water Quality:** Suspended particles, Pollutants, salt, oil or other chemicals (toxic to plants)

- **Reserve:** Store water for a reserve in cisterns, ferro-cement tanks, pond, etc

Water Management

Extremely important for plant health and quality

1. Overwatering:
   - Poor soil aeration
   - Root death
   - Fungal pathogens
   - Anaerobic bacteria

2. Soak pots top to bottom during irrigation events.

3. Allowed media to dry to near wilting point between waterings

4. Water in the morning, avoid evening waterings



Dryland Water Strategies



- Conserve water:
  - Heavier soil media
  - Sunken plant beds
  - Plastic liners
  - Windbreaks
  - Increase pot/bag size (increased media volume)
  - Use of shade



- Cloud forest fed fishponds on up hill
- Gravity fed, low infrastructure investment irrigation "trenches" down slope
- Rocks/low infrastructure investment directing irrigation to chosen rows of plants
- Down hill moist spots used for rooting coconuts and water hungry plants
- Back up PVC irrigation

Don Saul Larios

El Palmo Nursery

Pasabien, Guatemala










Japanese NGO, Malawi



Sunken Beds and Plastic Lining Conserve Water



Reservoirs for Water Storage



Greenhouse, CAR

Protecting the Nursery

Protecting From What?

- Drying winds
- Harsh Sun
- Torrential Rain
- Browsing animals
- Termites
- Thieves
- Flooding
- Freezing
- Other…

Theft Example
USAID Project, Mozambique

Situation:

- Food security program
- Improved planting material
  - Cashew and Citrus
- Training in nursery skills and grafting techniques
- Thieves stole high-value grafted fruit trees!

Solution:

- New planting method called *pe franco*
  - In-ground planting of rootstock
  - No longer required plastic planting bags
  - Required less water
  - Higher tree survival rate
- The method was not only effective but more sustainable!

Protection Against Browsing Animals

- Constructing fences
- Planting thick, spiny hedges
- Tethering animals





Euphorb sp. Live Fence



***Jatropha curcas* and *Agave* *sp.* Live fFnce**



Nursery Entrance, Haiti

Grafted Mango Trees




Shade


Shade


Shade

Regulation of Shade, etc…

- Protect newly sown seed from drying out by providing shade.
- Rootstocks: Remove or reduce shade to harden the plants and produce a sturdy stem for grafting.

(ICRAF 2003)

- Hardening Off: Gradually reduce water and shade over several weeks
- Root Pruning: Trees should be ‘shifted’ within nursery and root pruned weekly during hardening off
- Planting Out: Trees should be planted out at the start of the rains. Ideally on a wet or over-cast day

Hardening Off

- Remove shade gradually
- Reduce watering from 2x to 1x per day
- 4 to 6 weeks before planting out
- Reduce watering again to every other day until planting
- Plant out at the start of rains
- Plant out during the early morning or evening to avoid extreme heat

Small Scale Nursery Layout in Action

Beersheba Project, Senegal







Propagation Considerations

Seed Beds

- Method of raising seedling trees (or vegetables) in a seed bed or seed box
- Seedlings are later transplanted into bags or containers
- Advantages:
  - Use premium soil media (well-drained, sterilized, fertile)
  - Easy to protect (shade, wind, animals)
  - Better for monitoring water requirements, pests, etc.



Seed Beds cont'd



- Commonly recommended in nursery manuals
- Some nurseries germinate all seeds in seed beds
- Disadvantages:
  - 'pricking out' often deforms roots
  - Transplant shock
  - Too much time in seed bed results in long, twisted, and fragile roots

When to Use Seed Beds

- When using old seed
- When germination is low or unknown (filling containers is a waste of time)
- When planting recalcitrant seed (seed that losses viability quickly)
- When transport options are limited
  - Many seedlings may be transported in a single poly bag or other container and divided at destination



Direct Sowing

- Direct sowing in containers can save time, labor, and money (no need for seed beds)
- “In a well managed nursery, seedlings can almost always be directly sown!”
- Guidelines:
  - Prepare containers and shade in advance
  - Use only fresh and ripe seed
  - Test viability before sowing (if less than 70% sow more than 1 seed per bag) and later thin to a single strong seedling.



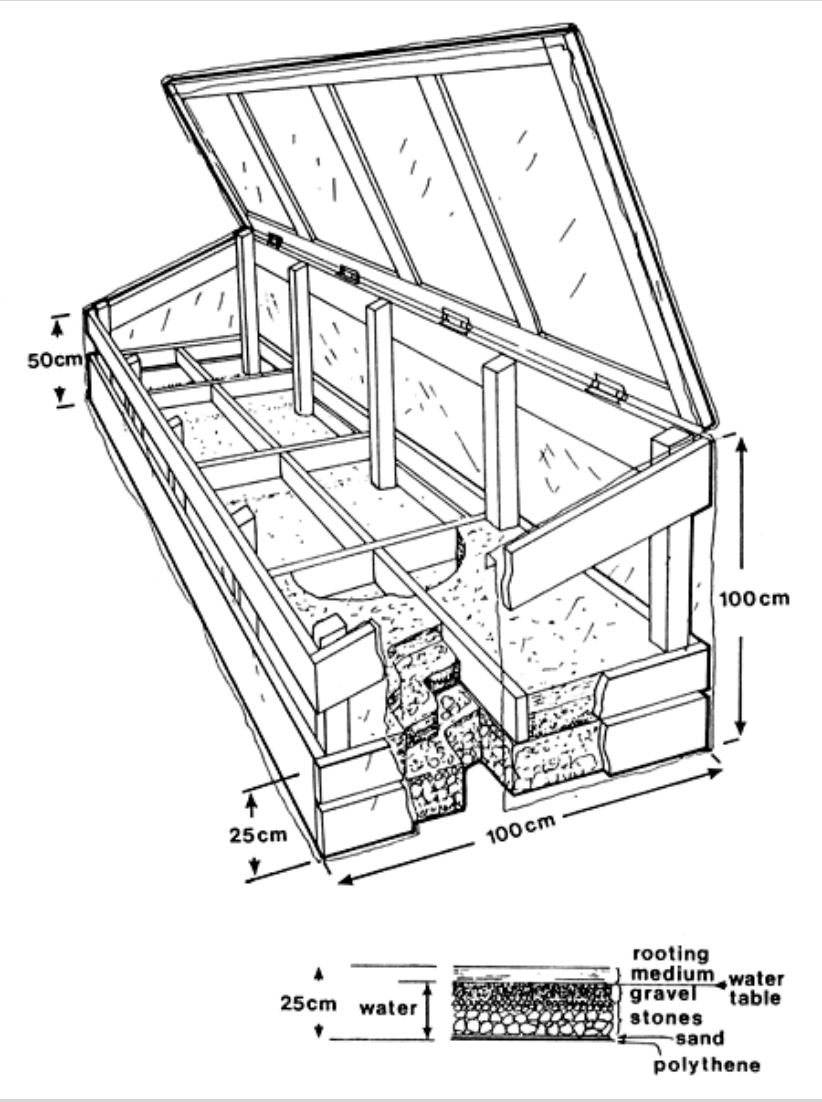
Vegetative Propagation

- Multiplying a particular plant individual using only vegetative tissues (not seeds)
- Preserves the genetic character of an individual (clonal material)
- Methods:
  - Cuttings
  - Layers
  - Grafting
  - Budding
  - Tissue culture



Propagation of Leafy Cuttings

- High humidity (>90%)
- Low light intensity
- Moderated temperatures
- Suitable rooting medium
- Protection from wind, heavy raindrops, pests and diseases



Poly Propagator



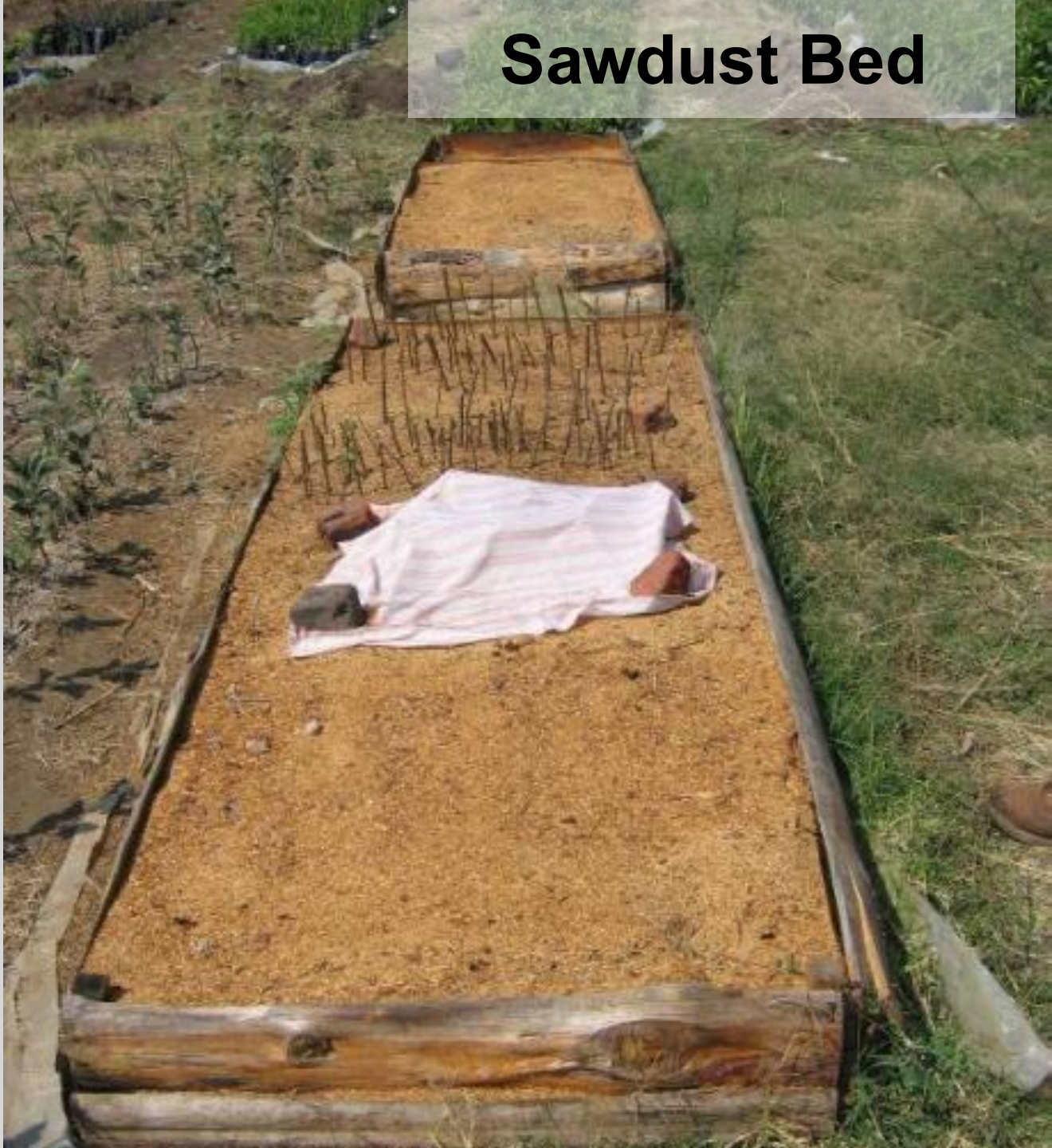
- Rooting tree cuttings
- Water reservoir
- High humidity
- Inexpensive alternative to mist house systems

Guidelines for Poly Propagator

- Shade the propagation area
- Construct with termite resistant wood
- Use durable plastic, double layer
- Mist cuttings with a hand-sprayer whenever the propagator lid is open
- Pot up and *wean* rooted cuttings carefully in shaded area
- Allow plants to ‘harden off’ before planting or exposure to harsh sun



- Rooting cuttings and germinating seeds



Grafting

- Joining compatible plant tissues together to form a new individual
- Scion: upper portion
- Rootstock: base/root system
- Principle Reasons for Grafting:
  - Clonal material
  - Earlier fruit production
  - Tree shape and height
  - Rootstock benefits



Guidelines for Grafting

- Goal: Produce healthy, vigorous grafted nursery trees
- Problem: Many grafted trees are not healthy and grow poorly after planting
- Why?
  - Unhealthy rootstock before grafting
  - Lack of nutrients while in nursery
  - Too much time in nursery
  - Poorly developed root system
- Solution:
  - Choose healthy, actively growing rootstock
  - Plant rootstock in larger nursery bags (1 litre)
  - Maintain fertility (manure, fertilizer, etc)
  - Root prune/shift plants during growth
  - Graft ON TIME!

- Graft at optimal time:
  - Mango: 3-4 months
  - Avocado: 3-4 months
  - Citrus: 5-6 months
- Avocado during cool season (January, February?)
- Mango during warm, humid season (June, July)
- Citrus…spray new growth with Cornell Spray (oil and soap in water)



Rootstocks

- Rootstock health is critical to the success of a grafted tree
- Successful graft + unhealthy rootstock = waste of time and effort
- Graft at the proper stage of rootstock growth and development
  - Select rootstocks that are actively and vigorously growing
  - Graft ‘on-time’ to ensure good root development (avoid encircling roots, *pot-bound* rootstocks)





Mother Trees/Parent Trees

- Trees used for propagation material
- Traits and characteristics of parent trees can be preserved by vegetative propagation
  - Rapid growth
  - Disease resistance
  - Fruit size and quality
  - Crown shape
- Combination of genetic influence and growing conditions of offspring
- Parent trees should be protected from animals, etc.
- Create map and update regularly
- Periodically remove rootstock suckers





Tree Pest control

- Goat manure slurry: A-Z p.210
  - Make a slurry of goat, chicken and cow dung. Paint on trunks and low branches of trees. 1 month of control during rainy season.
- Neem for termites: A-Z p. 222
  - Fill a barrel with leaves, cover with water and allow to sit for 4 days. 5-6 months of protection.
- *Tithonia diversifolia* for termites Ag Options p. 286
  - Soak in water half 55 gallon drum of chopped leaves and stems for 4 days. Pour into mounds and around base of tree. Do not allow slurry to pile up on base of trunk.



Resources

- Growing Trees and Gardens for Life: Practical tips for healthy tree nurseries and home gardens Edited by H van Houten
ICRAF/WOB/SII, 2007. 88 pp.
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ผักหวาน

