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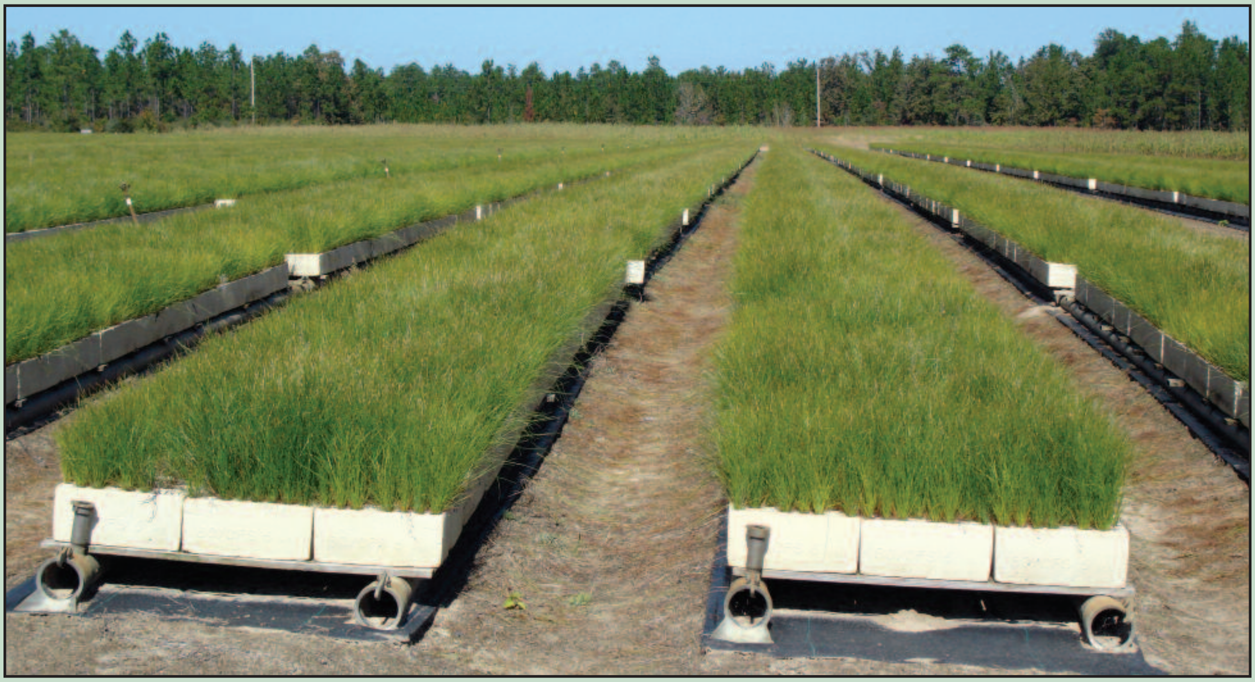
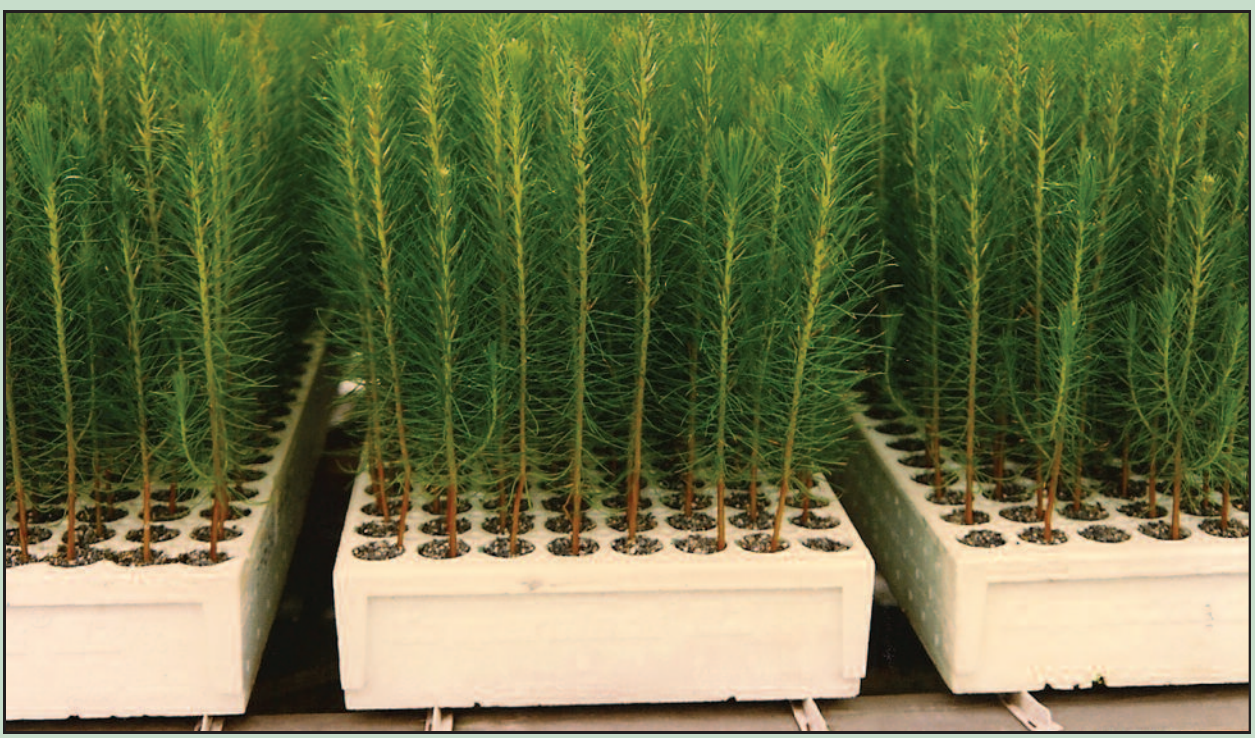
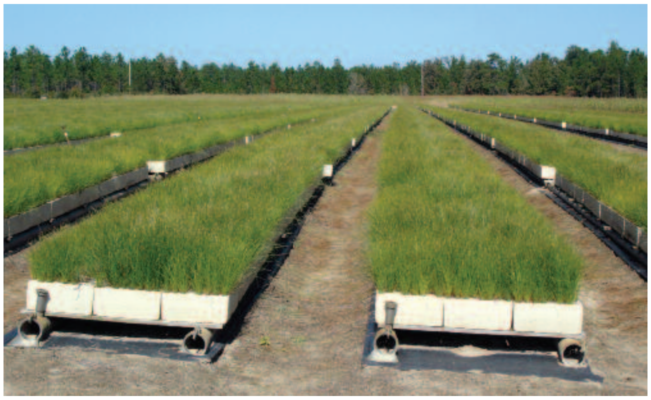
Growing pine seedlings in Copperblock containers in a bareroot nursery in the southeastern United States

by Jol Hodgson







Growing pine seedlings in Copperblock containers in a bareroot nursery in the southeastern United States

by Jol Hodgson

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Introduction

Restrictions on the use of soil fumigants (methyl bromide) in southeastern USA bare root nurseries will cause some bare root beds to become unutilized "buffer zones". This series of 8 bulletins is issued to assist the nursery manager to make full use of such space to meet or exceed seedling demand.

The bare-root nursery grower has the expertise for raising container seedlings and the basic infrastructure is in place. These bulletins bring together facts, figures, hints and tips for installing and operating a container seedling nursery – how to start small and how to expand.

This is a guide for a Copperblock nursery – favored for the stabilizing root form of the planted seedling – but with minor changes is useful for all container types. It is intended for the culture of loblolly pine (Pinus taeda) in the southeastern United States – but has useful information for growers of other species in other locations throughout the world.

Citation:

Hodgson J. 2010. Growing pine seedlings in Copperblock containers in a bare root nursery in the southeastern USA. Acheson, AB: Beaver Plastics. 21 p.

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Copies of this publications can be downloaded from the USDA Forest Service Reforestation, Nurseries, and Genetic Resources website:
http://www.rngr.net

Beaver Plastics

Technical Bulletin

Buffer Zone
Copperblock Nursery : Infrastructure

INTRODUCTION

A bare-root nursery and a container nursery have many of the same infrastructure needs and can be operated as a combined system to produce loblolly seedlings for a wide planting window.

In the case of a Buffer Zone Nursery most of the 'heavy lifting' has been done by the bare-root nursery. Critical aspects such as water quality and quantity; accessible land; buildings and services are in place (and silvicultural expertise). Developing a Copperblock container nursery in the buffer zone of a bare-root nursery should be safer and faster than opening a new site.

> **Problem:**
>
> The buffer zone may not be accessible for a short period in the Fall if fumigation is happening. Therefore the Buffer Zone Nursery must have a dedicated water supply line controlled from **outside the buffer zone.**

This Technical Bulletin, first in a series, discusses the infrastructure needs of a container nursery that uses the Copperblock™ tray system.

Recognizing that new practices in new locations should be approached cautiously, this and future Bulletins address the "Start-Up" and the "End-Up" stages separately.

WATER

The water supply of a bare-root nursery will be perfectly suited to growing in containers.

A Copperblock nursery raising loblolly pine seedlings will need about 50,000 gallons/week per million trees in summer – a bare-root nursery generally applies 1" per irrigation 2 – 3 times per week = 50 - 75,000 gals/acre/week. As the Copperblock nursery has ~1.5 million trees per acre, the supply line should be adequate for a buffer zone nursery.

> **Additional thoughts:**
>
> Assured supply – Copperblock seedlings will require more frequent irrigation as each seedling has less soil volume available (~ 6 in^3 per plant *vs* ~ 35 in^3 per plant in a bed at 25/ft^2) – backup systems are essential.
>
> Filtration – common impact sprinklers are suitable, but if a microjet system is selected, filtration of particles may be needed.

Water quality is as critical for a container nursery as it is for bare-root. Greater control over fertility can be exercised in a container nursery so knowing the water analysis is essential.

> **EC:**
> 1 millimho/cm (mmho/cm)
> = 1,000 micromhos/cm (µmho/cm)
> = 1,000 microsiemens/cm (µS/cm)
>
> 0.05 mmho is very pure water
>
> 1290 µmho is very high, but can be used

Electrical conductivity is critical: **2,000 µmho** is the max for loblolly.

The more pure the water, the more easily the pH can be changed.

> pH Target range pH 5 to pH 6.5
> • Copperblock target pH5.5

The nutrient content of the water may be important and will be addressed in the Fertigation bulletin.

Water borne pests are controlled in the same way for a buffer zone nursery. As total water usage is about one-half, additional treatment may be economical.

STARTUP Install a (covered) reservoir to serve the startup nursery – this should hold sufficient water for at least one day.

Waste water collection, treatment or reuse can be introduced in a modern container nursery with some early planning.

POWER

A bare-root nursery usually has all the electrical supplies needed for a buffer zone Copperblock nursery. The most critical service is that supplying water extraction and irrigation pressure. A backup service must be available (this may be an alternative power source).

> **Additional thoughts:**
>
> These days all irrigation and fertigation can be monitored and controlled remotely (even from off site) during a buffer zone exclusion period. This should be part of the planning process.

The electrical service should be extended to the buffer zone where the container nursery is to be located – to power nutrient injectors and monitoring equipment.

STARTUP Use a flow-powered ratio injector at startup Locate the startup nursery near the power supply.

BUILDINGS

A buffer zone Copperblock nursery needs no more buildings than are normally present at a bare-root nursery. Growing medium can be stored outside, fertilizers and chemicals should be protected and contained as usual. Copperblock trays are stored outside.

CONTINUED ON THE NEXT PAGE

A sheltered work area is needed for the seeding and harvesting operations – this can be the existing packhouse.

A large-scale container nursery will have a sizeable soil mixing, filling and seeding line occupying as much as 2,000 sq.ft. for a loblolly production of 30 million This will need 3-phase electrical service, water and compressed air.

And a harvest area of 4,000 sq.ft will be needed for this nursery if Copperblock loblolly seedlings are shipped over a 4 month window.

INFORMATION TECHNOLOGY

This infrastructure element is already in place in a bare-root operation. Crop record systems, from seed acquisition to seedling shipping are essentially identical for a Copperblock nursery. Some additional records will be suggested but the current system can be adapted.

The communications system of a bare-root nursery will serve the needs of the Buffer Zone Copperblock nursery. With more advanced automation a more advanced communication and control system may be developed.

SITE

A Copperblock nursery has less demanding needs for quality of site than does a bare-root nursery. Therefore a Buffer Zone nursery site is more than adequate.

For any bare-root nursery:

- **Aspect** has been proven suitable
- **Slope** has been shown to be sufficient
- **Clearing** has been completed
- **Flatness** has been provided
- **Soil** has been selected for mechanized equipment

ROADS

Copperblock containers have to be transported from the covered work area, after filling with growing medium and seeding, to the nursery area. For seedling harvest the Copperblocks have to be moved back to the covered work area.

Fortunately the roads serving the buffer zones are normally adequate for the vehicles serving a Copperblock nursery, both in smoothness and strength. Regular maintenance is important.

New roads may be required within the Buffer Zone Nursery to serve Copperblock layout, machine spraying, and Copperblock removal for seedling harvest. The impact would be similar to equipment entering the bare-root fields.

STRUCTURES

A Copperblock loblolly Buffer Zone Nursery in the Southeast USA can be an "open-compound" and greenhouse structures are not necessary.

An open-compound Copperblock nursery may be exposed to heavy rainfall causing nutrient leaching (see the Bulletin on Fertigation). Storm damage to seedlings would be similar to that experienced in bare-root beds.

WASTE MANAGEMENT

A Copperblock nursery will generate waste from familiar sources:

- rainfall runoff
- hazardous materials and fuel spillage – and their containers
- non-hazardous containers (polyethylene bags)
- seedling culls
- fossil fuel emissions

unfamiliar sources:

- damaged, discarded and retired Copperblock trays (see the Bulletin on Containers)
- leachate – from irrigation and fertigation (see the Bulletin on Fertigation): leachate can be collected and recycled, or treated, in the container nursery if an impermeable layer is installed.
- growing medium from non-germinant cavities (see the Bulletin on Growing Medium.

A bare-root operation has systems in place to manage the familiar forms of waste while the unfamiliar forms are not hazardous and easily managed.

TRANSPORTATION

The infrastructure of transportation ensures supplies reach the nursery and product is delivered to clients. There is no difference between the transportation system required for a bare-root nursery and that required for a Copperblock nursery:

- materials are delivered by suppliers, usually by commercial trucking companies.
- seedlings are shipped in cartons, usually in refrigerated transport.

Transportation timing may be different if Copperblock loblolly seedlings are "hot lifted" and shipped over a wider planting window. (See the Bulletin on Harvest).

Transportation load size will be different, depending on Copperblock stocktype an average full reefer load will be:

PCT 410 : 240,000 per load

PCT 415 : 210,000 per load

(adequate space for cold air circulation must be provided inside the packed trailer).

SECURITY

The Copperblock Nursery will be located within the security system of the bare-root nursery. As it will be located in a buffer zone it will have to be marked as an exclusion zone during fumigation of the bare-root beds.

A Copperblock nursery is less prone to damage from wildlife or livestock as the containers are usually raised above the ground.

Bird damage can be prevented with bird netting – with protected seed/seedlings often at 50/ft^2 in Copperblock trays vs 25/ft^2 in bare-root.

Vandalism and theft of equipment may be a consideration in a Buffer Zone Nursery if the buffer zone is remote from the center of operations or near the property boundary.

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Beaver Plastics

Technical Bulletin

Buffer Zone
Copperblock Nursery : Containers

WHY COPPERBLOCK™?

For the landowner:

- tree stability from the Copperblock rootform – avoid toppling
- rapid root egress = rapid establishment of Copperblock loblolly seedlings and
- no 'potbound' seedlings if planting is delayed

See the Technical Bulletin: Copperblock trays

For the nursery:

- EPA registered, factory coated
- resistant to fungal pathogens, easily pasteurized
- rigid, lightweight, non-abrasive for easy manual and automated handling
- stackable – after filling – for bulk transport in the nursery
- reusable, recyclable, small carbon footprint, economical
- wide selection – for a range of stocktypes (see the Copperblock specification sheet)

WHAT – IS THE PLASTIC?

Polystyrene was discovered by distilling the resin of *Liquidamber orientalis* but today is synthesized from benzene (petroleum byproduct) and ethylene (natural gas byproduct). The plastic is a hydrocarbon (hydrogen, oxygen and carbon). To make Expandable Polystyrene (EPS) a volatile blowing agent is added – this is pentane.

COPPERBLOCK LOBLOLLY 100 DAYS AFTER PLANTING. (LOWER COASTAL PLAIN, GEORGIA

Shrinkage:

EPS containers shrink to the specified dimensions soon after manufacture. A 'fresh' Copperblock tray could be ¼" (6mm) over length and 1/8" (3mm) over width.

Layout spacing and conveyor width should be designed to tolerate this variation.

Thermal conductivity:

- EPS = 0.033 W/mK
- ice = 1.6 W/mK

Expanded polystyrene has excellent insulation properties – it is 98% air.

Albedo (reflection):
Copperblocks (white) reflect short wave radiation and emit less long wave (heat) radiation that could stress seedling foliage.

WHERE – CAN YOU GET COPPERBLOCKS?

Beaver Plastics' Copperblock trays are distributed throughout the USA by Stuewe & Sons of Corvallis, Oregon (Ph: 1-800-553-5331). They hold a small inventory of popular models and can supply samples – FTL orders require a lead time.
See the current Stuewe & Sons catalogue.

FINANCING COPPERBLOCK TRAYS

Copperblock™ trays can be financed by agricultural equipment financing companies in the USA. Adopting a Copperblock tray lease program allows:

- use of operating expenses, preservation of capital
- predictable annual expense, extended terms
- determination of seedling cost input for the life of the container (cost per cavity)

Further details can be obtained from Stuewe & Sons or directly from the finance companies.

TESTING & TRIALING

STARTUP

Variations in climate and weather between nursery sites make it wise to start with a Test Buffer Zone Nursery and carefully monitor seedling growth. A test nursery should study only one Copperblock model.

Trials of different Copperblock trays may require a sophisticated irrigation system to accommodate the different cavity volumes and their different needs. Trials with a statistical design can provide a measure of assurance that the observed result is due to the treatment applied (Copperblock model) and not to irrigation inadequacies.

CONTINUED ON THE NEXT PAGE

STORAGE & HANDLING

COPPERBLOCK STORAGE – NOTE PALLET ON TOP.

All plastic seedling containers will degrade in intense sunlight. The addition of ultraviolet light blockers, like carbon black, will slow the process but will also absorb and re-radiate heat. Therefore, Copperblock trays should be stored under cover or stacked to minimize exposure and be secured from wind forces. Do not return empty Copperblock trays to the growing area for storage between uses.

EPS containers are 'user friendly': soft on the hands with optimal dimensions for lifting and lightweight. Compressive strength is high (>200kPa [>30psi]) – very stackable – while the tensile strength is just 10% of that – therefore the practice of carrying a Copperblock tray by inserting fingers in cavities can snap out a sidewall and should be discouraged.

SUPPORT SYSTEM

There are two Copperblock tray formats that may be used in a loblolly Buffer Zone Nursery:

- **Format 600** Measures 23 ⅝" long (600mm) X 13 ⅞" wide (352mm)
- **Southern Format** Measures 26 ½" long (673mm) X 13 ½" wide (343mm)

There is, at present, a much wider range of models in Format 600. The Southern Format is compatible with benching designed for the Hortiblock series of containers used for vegetable seedling production.

Caution: The format chosen will impact support design.

Copperblock trays need to be raised above the ground to allow air pruning of roots that would emerge from the drainage hole at the base of each cavity. Air movement desiccates the growing tip and stops root elongation (just as root-pruning in a bare-root bed severs the downward extending roots).

Raising the Copperblock trays a few inches is effective if air movement is not restricted. Raising the crop to working height (42" = 1075mm [ISO 14738]) will be ergonomically efficient. The height should be just below elbow height for the taller workers.

The container rigidity allows the Copperblock trays to be supported only at each end. The popular aluminum T-bar support is spaced on the long dimension of the container.

STARTUP A test nursery in a buffer zone can utilize a simple support system – e.g. 4" irrigation pipes laid 12" apart on the bare-root beds.

Support systems vary widely e.g. wires, pipes, T-bar, pallets and even old hospital beds! The design of a support system must consider:

- access (for manual tasks)
- underblock airflow (for hygiene and pruning)
- Copperblock tray handling (for layout, tasks and harvest)
- mechanization (of tasks e.g. topping)

ENDUP The support system must permit mechanization – of layout, topping and lifting for harvest.

MECHANIZATION & AUTOMATION

Northern species growing in containers are frequently moved between cultural zones in the nursery – handling systems have been developed to meet this need. Copperblock trays in Buffer Zone loblolly nurseries take only 2 steps:

A layout rate up to 10,000 Copperblock trays per double-shift can be achieved with current mechanization (~ 1 million seedlings per day)

1. From seeding to layout

The first move is made with Copperblock trays stacked (on a trailer or pallet) and moved to the final location manually or by moveable conveyor and positioned by hand.

A harvest rate of 7,500 Copperblock trays per shift can be achieved with current mechanization (~ w million seedlings per day)

2. From layout to harvest

The second move handles Copperblock trays with mature seedlings, lifted manually to a trailer and later unloaded manually at the harvest line.

Palletized growing systems lend themselves to mechanization and automation but add cost to an otherwise simple infrastructure. Common pallets hold 20 Copperblock trays each.

CLEANING & PASTEURIZING

Immediately after harvest remaining growing medium is dislodged by directed impact followed by washing with water jets – the water is often filtered and re-used in the "block-washer".

Hot Water Soak:
batch wise – 30 mins @145ºF
high temperature short time (HTST) – 2 min @ 165ºF
– 1 min @ 170ºF

Pasteurization is achieved with steam or, more commonly, with a hot water soak.

REUSE & RECYCLING

Copperblock trays will modify root form (root pruning) for 4 to 5 crops if the growing medium pH has remained in the range 5 - 6. Useful life can be extended at the higher pH but at pH7 no active ingredient is released.

At the end of their useful life Copperblock trays can be recycled – in the nursery – into a soil amendment (Styrolite™) or a seed cover material (Styrogrit™). Retired Copperblock trays can be marketed for reuse as "Terrafill" in landscaping – particularly in Green Roof landscaping.

Carbon Footprint (Copperblock 112/105ml):

Cradle-to-gate = 20tCO_2eq/million cavities

Use 5 times = 4tCO_2eq/million cavities

WHY USE COPPERBLOCK TRAYS?

Value-added Features:

A Copperblock loblolly pine or longleaf pine may cost ½¢ more than a container seedling without this treatment. Is it worth it?

The nursery manager will not benefit greatly from using Copperblock trays but the landowner may benefit greatly. The Copperblock seedling choice should be regarded as insurance.

• for as little as $3/acre.

Do you have life insurance? Sure. You have never claimed on your life insurance – is it worth it?

Tree stability:

The Copperblock trays seedling root form is not distorted by the container. The rootform is more natural with multiple root tips in suspended elongation on all faces of the root plug.

When removed from the Copperblock tray and planted in the field these root tips can resume elongation and roots will radiate in all directions naturally.

Roots radiating in all directions will provide stability for a tree subjected to wind pressure. This is critical in the first six to eight years – while top growth presents increasing resistance to wind.

Toppling effects are being experienced in the SE USA many miles from the path of hurricanes. Toppling may be the extreme of windfall or the less obvious sinuosity with attendant compression wood formation – leading to the loss of the basal log at harvest.

• $3 per acre – is it worth it?

Rapid Root Egress:

Container seedlings permit the extension of the planting window (early and late) and the planting of non-dormant seedlings. These conditioned seedlings can grow immediately but may also experience transplanting shock (a delay before root and shoot extension).

Copperblock trays seedlings, correctly conditioned, can rapidly establish moisture relations with the soil as root elongation can resume immediately on planting – the root tip is not pruned nor is it desiccated.

Rapid root egress leads to faster establishment, earlier and greater growth. Increased growth can benefit the landowner by shortening the rotation (similar to the benefit of planting larger stocktypes). Increased growth should also lead to earlier canopy closure and reduced weed control treatments.

• $3 per acre – is it worth it?

Raised planting:

Containerized longleaf pine seedlings can be planted with as much as two inches of the plug above ground (Longleaf Alliance advisory). This planting technique ensures that the bud is not covered by soil after a heavy rainfall and can improve survival.

The tap root is protected by the growing medium in the exposed portion of the plug but lateral roots will be desiccated if exposed.

Copperblock longleaf seedlings can lose upper lateral roots but mid and lower laterals will not be affected. Standard longleaf seedlings with a majority of lateral roots originating in the top part of the plug may experience greater transplant shock.

• $3 per acre – is it worth it?

Deep planting:

Bare root and container seedlings are often deep planted to ensure roots meet moist soil (sometimes to reduce transpirational moisture loss). This is usually limited by the cost of deep planting.

The Copperblock tray seedling rootform presents moisture absorbing root tips from top to bottom of the plug. Lower roots can take advantage of residual moisture in the soil and upper roots can absorb moisture from light rainfall that may not penetrate deeply. **• $3 per acre – is it worth it?**

Normal Planting:

Root growth is minimal when soil temperature in the root zone is lower than about 46º F. Seedlings planted in the normal window (January-February) do not show active root growth at this time.

Copperblock tray seedlings, with viable root tips at the top of the rootplug can begin root growth as soon as suitable soil temperatures reach the top of the plug.

• $3 per acre – is it worth it?

IN THE NURSERY:

Rootbinding:

Root deformity (potbinding/rootbinding) can be severe in standard containers if seedlings are not harvested on schedule (and most loblolly container seedlings are not cool stored). Rootbinding increases transplanting shock (Auburn Coop) and reflects reduced seedling quality.

Copperblock trays seedlings retain the same rootform if harvest is delayed.

• ½¢ per seedling – is it worth it?

Fungicidal:

The Copperblock trays treatment includes copper oxychloride as active ingredient. This is a common fungicide and these properties are not lost in the treatment, though Beaver Plastics makes no claims of efficacy.

The Copperblock trays has received EPA registration and is licensed for sale.

• ½¢ per seedling – is it worth it?

What does the Copperblock tray do?

The coating on the cavity wall releases copper ions into the water film that covers the sidewall. When a root tip grows into this area these ions are absorbed and biosynthesis of cytokinins is suspended. Cytokinin is a growth hormone produced only in the root tip and has the function of stimulating cell division in the root tip and suppressing lateral root initiation. Auxin, on the other hand (produced in leaves and in root tips) stimulates cell elongation.

With cytokinin production suspended, no new cells form – so auxins have no cells to elongate – and root growth is suspended.

Also, with cytokinin production suspended, lateral roots are initiated – and their root tips do produce cytokinins – which stimulate cell division in their root tips – and auxins then cause the elongation of these cells – and the lateral root grows… until this root tip reaches the Copperblock tray wall.

The result is a proliferation of higher order lateral roots, the fine root system. Active root tips are distributed throughout the root plug, in a state of "suspended elongation" – until removed from the Copperblock tray.

Beaver Plastics

Technical Bulletin

Buffer Zone
Copperblock Nursery : Growing Medium

INTRODUCTION

The purpose of the growing medium in a Copperblock container is to

(a) provide support for the seedling and

(b) hold the nutrient solution for uptake by the roots

We have to appreciate plant growth and physiology when selecting and using a growing medium for raising loblolly in Copperblock trays.

The grower's objective is to have the seedling roots grow evenly throughout the plug. A healthy, dispersed root system will take up adequate moisture for transpiration and absorb mineral nutrients dissolved in the soil water and essential for growth.

• Water uptake is passive but mineral accumulation – where the concentration of nutrient ions in the root cells is greater than in the soil solution – requires the expenditure of metabolic energy i.e. respiration.

• For plant roots to respire they need oxygen – which they absorb from the air in the soil. Respiration releases carbon dioxide. If the oxygen content of the soil air reduces, anaerobic respiration begins and no energy is available for nutrient uptake.

• Respiration provides the energy for cell division and cell elongation in the root tips – by this growth the roots can disperse throughout the plug. Oxygen is required wherever there is a root tip. (you can change most other aspects after you start a crop, but not the air-filled porosity)

A buffer zone Copperblock loblolly nursery can be thought of as a hydroponic growing system – seedling growth controlled by fertigation depending on the nature of the growing medium.

> The single most important feature of growing medium management is AIR FILLED POROSITY **AFP**

COMPONENTS

Soilless growing media may have a very low CEC (cation exchange capacity) and require continuous fertigation or may have a high CEC requiring only intermittent fertigation alternating with irrigation.

STARTUP Fertigation with every irrigation is safe and CEC is not an important aspect of the growing medium.

Alternating fertigation, with a high CEC growing medium, is influenced by pH. Cation availability is optimum in the range pH 5 – 6.

> **The target for Copperblock loblolly growing media is 30% AFP v/v (range limits: 25% to 40%)**

Peat moss – Peat is the largely organic residues of plants, incompletely decomposed through lack of oxygen. Peat moss is usually partly decomposed Sphagnum moss species (others are Hypnum peat moss; reed peat; sedge peat).

On a volume basis sphagnum peat moss can hold 48% water after draining (WHC) and still have 25% AFP. Sedge peat has 20% AFP and 32% WHC. Sphagnum peat moss is hydrophobic when dry and becomes increasingly difficult to rewet – a wetting agent is usually added to irrigation.

Sphagnum peat moss CEC range : 100 – 180 meq/100g

Peat moss is classified as Light or Dark: Light peat moss has the higher AFP but lower CEC, dark peat moss has the higher CEC but lower AFP.

EC (electrical conductivity) of sphagnum peat moss 0.85 mS/cm ; sedge peat 0.35 mS/cm (see the Tech.Bull. on Fertilizers).

C:N ratio ~45:1 – high lignin content – decomposes slowly with little nitrogen drawdown.

Sphagnum peat moss pH ranges from 3 to 4 and is calcium deficient. Hypnum peat moss pH ranges from 5 to 7 and is usually calcium sufficient.

Peat is graded :
- coarse (all particles > 2.38mm)
- medium (all particles between 2.38 and 0.84mm)
- fine (all particles < 0.84mm)

Copperblock growers use fine grade to ensure sticks are removed ("stick" = anything > ¼ x 1 ins or longer than 2¾ ins)

> A 1½" stick can bridge halfway down a 415 cavity.

Weed seeds – sphagnum peatmoss is virtually free of weed seed. But know the history of the shipment – peatmoss is usually vacuumed off the exposed surface of a bog, a few inches per year, over several years. A newly opened peat bog may be contaminated with weed seed.

Peat moss is compressed during packaging to half its normal volume. When bales are opened the peatmoss expands in the mixing and filling process.

Pine Bark with a resinous smell should not be used before composting. Pine bark may be aged (will draw down more N) or composted, management is easier with composted bark.

CONTINUED ON THE NEXT PAGE

Pine Bark Compost (PBC)

Pine barks are typically composted 5 weeks to 5 months reducing the C:N ratio from 300 down to 45:1 – there will be a continuing need for nitrogen as decomposition continues in the mix.

AFP 30 - 40%
WHC 25 - 35%v/v BD <12lbs/ft^3
pH 3.9 – 5.9
EC 0.22 - 0.96 mS/cm
CEC 53 meq/100g

Pine Tree Substrate (PTS) manufactured from chipped and hammermilled (¼" screen) freshly harvested loblolly pine logs. The C:N ratio is high and an additional 100 ppm N is advised.

> Testing AFP
> Fill one Copperblock tray with soilless medium as usual. Select one cavity and close the drain hole with your thumb. Add water until the surface glistens. Remove your thumb and collect the water that drains.
> Fill an empty cavity with water to the same level as the growing medium to determine the volume of growing medium.
>
> **Vol drained water ÷ vol growing medium X 100 = AFP%**

AFP 31%v/v
WHC 48%   pH 5.8   EC 1.45 mS/cm

Coir dust. The coir fiber pith or coir dust produced as a by-product when coconut husks are processed for the extraction of long fibers (there are no sticks!). Hydrophilic (wets easily) – and can hold up to 9 times its dry weight (5½ lbs/ft^3) in water. (a ⅓ ft^3 brick uses 1 gallon of water to expand to 1.5 ft^3. Add coir dust to the mix to improve wettability. The capillarity of coir dust aids in redistribution of moisture added by irrigation.

pH 5.0 – 6.8 less lime required than with sphagnum peat moss.

C:N ratio 100:1 = more N drawdown than sphagnum peat moss but less than composted bark or sawdust. The high lignin (31%) makes it slow to decompose.

AFP 15%
WHC 52% CEC 60–130 meq/100g EC 0.5–0.8 mS/cm

It contains significant potassium (0.4% DWt). If EC > 1.0 mS/cm leach strongly with the first irrigation.

Coir dust can suppress Rhizoctonia – damping off disease.

AMENDMENTS:

Vermiculite - grades #1(coarse) - #4 (fine): Bulk density 7lbs/ft^3 has a high water-holding capacity, high CEC 82 – 150 meq/100g and neutral pH. Grade 3 is used to increase AFP and WHC of a mix.

Perlite has a low water holding capacity (19%), low CEC (1.5 – 3.5 meq/100g) and neutral pH. Perlite itself has 60% AFP so is used to improve aeration in a mix.

Styrolite™ growing media amendment is lightweight, large particle size – used to increase AFP, does not raise WHC. see the Beaver Plastics Bulletin on Styrolite

Sawdust has a high C:N ratio 1,000 - 310:1 and needs to be composted for at least 6 weeks, usually longer to reduce the ratio to ~100:1 and still requires additional nitrogen fertilization in the mix. depending on particle size sawdust has AFP 47% and WHC 39%.

Puffed rice hulls – (of recent interest) – Rice hulls are hydrophobic but Puffed rice hulls are hydrophilic. PRH are pH neutral, light and useful to increase drainage and aeration. Nitrogen draw-down must be avoided. Composted rice hulls will have a pH 5.7 – 6.2 and potassium will be significant. C:N 120:1

> The objective, for the Copperblock nursery, is to have air-filled pores to the bottom of each cavity, shortly after irrigation or rainfall.

> **AFP vs WHC**
>
> **Air Filled Porosity** is due to the **macropores** between particles in the growing medium – where the adsorption forces binding water to the surface of the particles cannot resist the force of gravity drawing the water down.
>
> **Water Holding Capacity** is mostly due to the **micropores** between and within particles in the growing medium – where water adsorbed to the surfaces fills the micropore.
>
> However, there is no fixed limit between micro- and macro-pores. Even large pores can form a capillary and hold water against the pull of gravity. The weight of the water column is proportional to the square of the tube diameter – so a narrow tube will support a higher column than a wide tube.
>
> A glass capillary tube 0.5mm in diameter will lift a ~2.8mm column of water.

MIXING

Mixes – are not essential – loblolly seedlings can be grown perfectly well in Copperblock trays with hammermilled (¼" screen) pine needle litter as the growing medium. A mix should target AFP, accommodate irrigation constraints and assist nutrient regimes. A growing medium mix for loblolly in Copperblock trays can be composed of one or more components, amendments and additives e.g. lime (add 3lbs/yd^3 dolomitic lime).

Common mixes:	
Peat/vermiculite	80:20
Peat/perlite	80:20
Peat/sawdust	80:20
Peat/PBC	75:25

STARTUP Start with a pre-mix (formulated for forestry). But ask for the details: AFP; WHC; EC; pH; CEC and all nutrients added. Know the components.

Ask for a warranty on sticks and on weed seeds.

Batch mixing – used for production up to 300 blks/hr (~100ft3/hr) Peat bales may need pre-breaking and fluffing, coir dust will need pre-hydration, sawdust may need pre-screening. The batch mixer should operate only long enough to achieve an even distribution of all materials including added moisture – longer mixing may cause damage e.g. compression of vermiculite, pulverizing peat fibres.

> The second most important feature of growing medium management is CONSISTENCY

ENDUP

Continuous mixing

For efficient operation at 900 blks/hr (11yd^3/hr) an automated continuous mixing line is essential and can be managed by a single operator.

CONTINUOUS MIXING LINE – DRUM MIXER TO THE LEFT.

> **Mix Moisture Test** – Squeeze a handful hard – no drop should fall, but your hand should be damp.

FILLING

The most difficult operation in a Copperblock nursery is block filling. All the close attention to media selection and mixing can be ruined by poor, inconsistent filling.

Target fill per cavity –
(a) no large air pockets
(b) target AFP
(c) target quantity nutrients (if added)

Copperblocks require careful filling as the coating can slow the filling process.

> **Check the AFP.** – Develop a mental relationship between compaction and target AFP. Conduct continuous finger tests of compaction and intermittent tests of AFP.

STARTUP

Manual fill – Copperblock trays can be manually filled by spreading an excess of growing medium over the block surface and then dropping the container a few inches onto a flat surface. Repeat to achieve target fill. Repeat, consistently, for every Copperblock tray.

Check the AFP.

Batch filling – A simple advance that can serve a demand for ~ 300blks/hr – a few Copperblock trays laid on a vibrator table with growing medium spread by hand. Vibration or drops (produced by off-set cams) are set to achieve target fill.

Check the AFP.

ENDUP

Continuous fill – for production rates up to 900 blks/hr. This can be fully automated, controlled by a precision seeder and limited by detectors on the mixing line. A single operator can manage the filling-seeding line.

CONTINUOUS FILLER

Caution – Loading the filler hopper by conveyor can lead to separation of controlled release fertilizer (CRF) prills (grain silo physics). If CRF is added to the mix, more moisture may be needed to hold the prills.

Photo Note: the power conveyor feeds Copperblock trays from the right.

The roller conveyor provides downwards pressure to maintain traction. Cavity filling and compaction of the growing medium is dictated by the time the container spends in the filler and the vibration intensity of that conveyor.

TAMPING (DIBBLING)

The final operation before seeding will:
(a) provide room for seed cover
(b) help the seed to be centered

Between filling and tamping the Copperblock trays must be brushed free of surplus growing medium – to improve hygiene in the nursery.

STARTUP

Manual dibbling – can be achieved with a simple dibble-board designed for the Copperblock model in use. The dibble-board pins should extend ½ in with a convex apex of ¼ in. The pin diameter should be 1/16 in less than the cavity top diameter.

Loblolly seed requires a target dibble depth of ½ in – for the seed + seed cover.

ENDUP

Roller dibbling – may be passive or powered – designed for the specific Copperblock tray – and the dibble depth can be adjusted.

A POWERED DRUM DIBBLER.

AFP is an average!
– the photo (below right) shows the increase in WHC lower down in a pot that was filled with a uniform mix, irrigated and allowed to drain. The AFP correspondingly reduces with depth.

This is due to the range of capillaries – with the narrowest (micropores) holding water to the top and the widest (macropores) supporting the shortest columns of water.

Evaporation from the drain hole of a Copperblock cavity provides aeration for root growth at the very bottom of the cavity.

A zone immediately above the drain is the most difficult to aerate and can result in poor root development in this zone.

Solution –

- Fill with the driest medium (that will still be retained)
- Use the least possible vibration (to get the greatest AFP at the base of the cavity)
- Tamp (dibble) to compress the upper layer.

Buffer Zone
Copperblock Nursery : Seeding

INTRODUCTION

Seeding loblolly pine in a buffer zone Copperblock nursery is a precision operation, which is not necessarily automated. Each unfilled cavity in a container forest nursery is a waste of resources and uniform seedling quality is achieved by providing equal resources (above- and below-ground) to seeds of equal potential.

The seed process technology developed for bareroot loblolly nurseries is essentially the same as needed for a buffer zone Copperblock nursery.

The seeding operation includes seed preparation, the mechanics of sowing and steps to provide some of the conditions conducive to rapid and uniform germination.

Seed preparation

Normal seed preparation steps are applied:

1. Cleaning – (99% purity) to remove non-seed particles
2. Sizing – to group germination classes
3. Separation – to remove empty seed (flotation in water)
4. Stratification – to enhance germinative energy.
5. Priming – to enhance germination capacity (H_2O_2)
6. Drying – to aid seeding mechanics (surface drying).
7. Testing – to determine seeding regime.

Seeding Regime

Loblolly seed <70% germination capacity should not be used in a container nursery

The nursery target is uniform seedlings in every container cavity meeting the order quantities and quality at the least cost.

Step 1: Determine the seedlot GC% (germination capacity)

Step 2: Deduct for field conditions – if the germination test was under controlled conditions (deduct ~5%).

Step 3: Estimate costs: per viable seed; per blank cavity; per cavity for thinning (@ 10,000 pppd); per cavity transplanting (@5,000 pppd).

Step 4: Calculate least cost sowing factor – single or multiple, within logistical limits, using the sowing tables below and the information from steps 1 to 3 above.

Step 5: Calculate Oversow (additional Copperblock trays sown) allowance:

- germination losses – see germination tables below "0 trees".
- culling : missed doubles (poor thinning); deformed; under spec. (5% – 25%)

See the Fractional Seeding Calculator at www.RNGR.net

Sowing rate: The sowing table examples below reflect cavity fill when sowing 1, 1.25, 1.5, 1.75 or 2 seeds per cavity. Tables can be calculated for sowing factors (SF) appropriate to specific Copperblock trays .e.g. the CB98/105 has 14 rows of 7 cavities –

SF 1.0 : all single sow
SF 1.2 : 3 double sow rows
SF 1.3 : 4 double sow rows
SF 1.5 : alternate rows single and double
SF 1.7 : 4 rows single sow
SF 1.8 : 3 rows single sow

Seeding Equipment

The objective is to place the seed/s in the center of the cavity –

- The loblolly seed should be released over the cavity center
- The seed should bounce as little as possible
- The dibbling (see Tech.Bull. Growing Medium) should provide a concave depression in the growing medium directing the seed to the center of the cavity.

STARTUP

Manual seeding:

- V-notch (handheld)~100 Copperblock trays pppd.
- vacuum bar,– single row, handheld.
- Shutterbox – full Copperblock tray ~ 800 pppd.

Machine Seeding: Many automated seeders are available, new and used. Loblolly seed is robust, large, clean and dry and suited to every machine.

- vibration seed separation – tube drop – row seeder
- vacuum seed selection – tube drop – row seeder
- vacuum seed selection – tube drop – whole tray
- vacuum seed selection – short drop – whole tray
- vacuum seed selection – short drop – drum seeder
- vacuum seed selection – water drop – drum seeder

The chief consideration will be production rate (ensuring that seed placement precision is not sacrificed for speed).

VACUUM DRUM SEEDER – SINGLE REVOLUTION PER COPPERBLOCK

ENDUP

Vacuum drum seeders will provide precision and accuracy at rates up to 1,000 Copperblock trays/hr.

CONTINUED ON THE NEXT PAGE

SEED COVER

As with bareroot nurseries the conditions needed for loblolly germination are:

heat : 71ºF to 77ºF (22ºC to 25ºC)

moisture : maintain the seed moisture content reached in stratification (~32%mc). As the testa splits the seed is subject to desiccation. Keep moisture stress less than -3 atm (-300 kPa). (e.g.Field capacity = -33 kPa; TWP = -1500 kPa)

oxygen : AFP seed cover should be ≥ AFP growing medium. Oxygen is absorbed through the moisture film on the seed – too much water creates anaerobic conditions.

All of these conditions are supplied by placing the seed on top of the growing medium and covered with a suitable material that will also.

- provide resistance to assist the germinating radicle to penetrate the medium
- ensure extreme rainfall cannot wash the seed to the surface

This layer is necessarily shallow in depth (loblolly = ½ in) and rapidly dries in an exposed buffer zone nursery. Frequent irrigation to maintain moisture is also conducive to the growth of algae. In a container cavity this algae can form a seal (plug) on the top of the growing medium and prevent the penetration of irrigation.

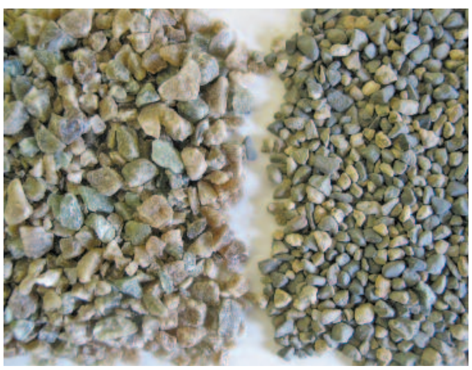
Solution – allow the seed cover to dry between irrigations OR inject an algaecide (e.g. Zerotol) together with the irrigation.

Seed cover materials

Granite grit : pH 6.9 : BD 92lbs/ft³ : EC 0.075 mS/cm

Styrogrit: manufactured from recycled Copperblock trays

pH 4.0 : BD 34lbs/ft³ (cooler than granite grit) : EC 0.05 mS/cm (Coverage ~50 Copperblock trays/ft³) AFP 40% : WHC 7.5%



STYROGRIT (LEFT) – FRASER RIVER GRANITE GRIT (RIGHT)

Other suitable seed cover materials are:

PBC (pine bark compost)

Local sand or gravel – check AFP and particle size (dust may cake)

Perlite

Vermiculite – lightweight and subject to windblow

Sawdust – conifer sawdust

Seed cover dispensing equipment (Topper)

The objective is to apply an equal depth of seed cover material (topping) to each cavity and not provide a link between cavities where roots could grow.

STARTUP **manual :** material can be dispensed through a handheld sieve and then the surface of the Copperblock tray is brushed clean.

ENDUP **mechanical :**

- Drum – dispenses a specific volume per cavity
- Belt – speed calibrated to the Copperblock travel. Some designs are limited to lightweight seed cover materials.

Layout

Pre-wet – immediately after topping with seed cover –

- prevents seed desiccation
- stabilizes the seed against vibration

Be alert for seed displacement by falling grit at high production rates.

Transport – of the Copperblock trays after seeding to the layout site in the nursery must be done with care not to further compress the growing medium or to vibrate the seed to the surface. Copperblock trays can be stacked for transport on trailers. Powered belt conveyors can provide a smooth ride. Or, if Copperblock trays are transported in a single layer, ensure that road surfaces are smooth.

PNEUMATIC TIRED TRAILERS, HOLD 100 COPPERBLOCK TRAYS EACH.

Handling – Copperblock trays should be handled with care during layout. Successive jolting can cause the seed to rise and become exposed.

First irrigation – begin with a clean water drench –

- leach excess salts and phytotoxic compounds.
- check all nozzles – ensure the system is fully functioning
- ensure complete wetting of peat moss growing medium.

The fundamental objective is to provide uniform conditions for every seed – to achieve uniform germination – the foundation for uniform growth.

Germination %	2 seeds/cavity: Probability of occurrence		
	0 trees	1 tree	2 trees
70	.0900	.4200	.4900
71	.0841	.4118	.5041
72	.0784	.4032	.5184
73	.0729	.3942	.5329
74	.0676	.3848	.5476
75	.0625	.3750	.5625
76	.0576	.3648	.5776
77	.0529	.3542	.5929
78	.0484	.3432	.6084
79	.0441	.3318	.6241
80	.0400	.3200	.6400
81	.0361	.3078	.6561
82	.0324	.2952	.6724
83	.0289	.2822	.6889
84	.0256	.2688	.7056
85	.0225	.2550	.7225
86	.0196	.2408	.7396
87	.0169	.2262	.7569
88	.0144	.2112	.7744
89	.0121	.1958	.7921
90	.0100	.1800	.8100
91	.0081	.1638	.8281
92	.0064	.1472	.8464
93	.0049	.1302	.8649
94	.0036	.1128	.8836
95	.0025	.0950	.9025
96	.0016	.0768	.9216
97	.0009	.0582	.9409
98	.0004	.0392	.9604
99	.0010	.0198	.9801

Germination %	1.5 seeds/cavity: Probability of occurrence		
	0 trees	1 tree	2 trees
70	0.1950	0.5600	0.2450
71	0.1871	0.5609	0.2521
72	0.1792	0.5616	0.2592
73	0.1715	0.5621	0.2665
74	0.1638	0.5624	0.2738
75	0.1563	0.5625	0.2813
76	0.1488	0.5624	0.2888
77	0.1415	0.5621	0.2965
78	0.1342	0.5616	0.3042
79	0.1271	0.5609	0.3121
80	0.1200	0.5600	0.3200
81	0.1131	0.5589	0.3281
82	0.1062	0.5576	0.3362
83	0.0995	0.5561	0.3445
84	0.0928	0.5544	0.3528
85	0.0863	0.5525	0.3613
86	0.0798	0.5504	0.3698
87	0.0735	0.5481	0.3785
88	0.0672	0.5456	0.3872
89	0.0611	0.5429	0.3961
90	0.0550	0.5400	0.4050
91	0.0491	0.5369	0.4141
92	0.0432	0.5336	0.4232
93	0.0375	0.5301	0.4325
94	0.0318	0.5264	0.4418
95	0.0263	0.5225	0.4513
96	0.0208	0.5184	0.4608
97	0.0155	0.5141	0.4705
98	0.0102	0.5096	0.4802
99	0.0055	0.5049	0.4901

Germination %	1.75 seeds/cavity: Probability of occurrence		
	0 trees	1 tree	2 trees
70	0.1425	0.4900	0.3675
71	0.1356	0.4864	0.3781
72	0.1288	0.4824	0.3888
73	0.1222	0.4782	0.3997
74	0.1157	0.4736	0.4107
75	0.1094	0.4688	0.4219
76	0.1032	0.4636	0.4332
77	0.0972	0.4582	0.4447
78	0.0913	0.4524	0.4563
79	0.0856	0.4464	0.4681
80	0.0800	0.4400	0.4800
81	0.0746	0.4334	0.4921
82	0.0693	0.4264	0.5043
83	0.0642	0.4192	0.5167
84	0.0592	0.4116	0.5292
85	0.0544	0.4038	0.5419
86	0.0497	0.3956	0.5547
87	0.0452	0.3872	0.5677
88	0.0408	0.3784	0.5808
89	0.0366	0.3694	0.5941
90	0.0325	0.3600	0.6075
91	0.0286	0.3504	0.6211
92	0.0248	0.3404	0.6348
93	0.0212	0.3302	0.6487
94	0.0177	0.3196	0.6627
95	0.0144	0.3088	0.6769
96	0.0112	0.2976	0.6912
97	0.0082	0.2862	0.7057
98	0.0053	0.2744	0.7203
99	0.0033	0.2624	0.7351

Germination %	1.25 seeds/cavity: Probability of occurrence		
	0 trees	1 tree	2 trees
70	0.2475	0.6300	0.1225
71	0.2385	0.6355	0.1260
72	0.2296	0.6408	0.1296
73	0.2207	0.6461	0.1332
74	0.2119	0.6512	0.1369
75	0.2031	0.6563	0.1406
76	0.1944	0.6612	0.1444
77	0.1857	0.6661	0.1482
78	0.1771	0.6708	0.1521
79	0.1685	0.6755	0.1560
80	0.1600	0.6800	0.1600
81	0.1515	0.6845	0.1640
82	0.1431	0.6888	0.1681
83	0.1347	0.6931	0.1722
84	0.1264	0.6972	0.1764
85	0.1181	0.7013	0.1806
86	0.1099	0.7052	0.1849
87	0.1017	0.7091	0.1892
88	0.0936	0.7128	0.1936
89	0.0855	0.7165	0.1980
90	0.0775	0.7200	0.2025
91	0.0695	0.7235	0.2070
92	0.0616	0.7268	0.2116
93	0.0537	0.7301	0.2162
94	0.0459	0.7332	0.2209
95	0.0381	0.7363	0.2256
96	0.0304	0.7392	0.2304
97	0.0227	0.7421	0.2352
98	0.0151	0.7448	0.2401
99	0.0078	0.7475	0.2450

Beaver Plastics

Technical Bulletin

Buffer Zone
Copperblock Nursery : Fertigation

INTRODUCTION

A Copperblock buffer zone nursery relies on fertigation for control of loblolly seedling growth – essentially an outdoor hydroponic system. Fertigation provides:

- water for germination and plant metabolism
- water for transpiration
- water for evaporative cooling
- nutrients for assimilation and growth
- mechanics for re-oxygenation of the growing medium
- a means for applying pesticides
- frost protection

There are two application categories:

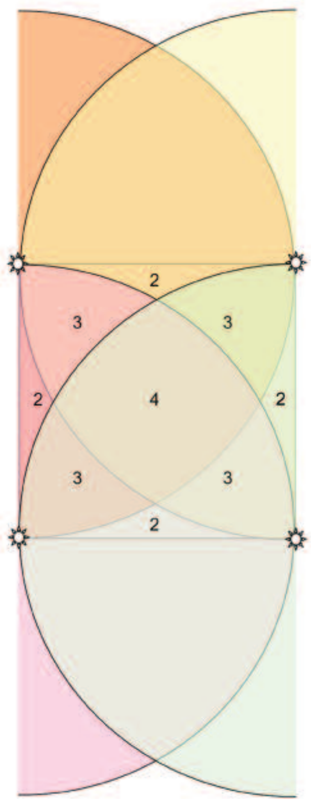
1. **Mist application** – to wet above the root collar
   - for frost protection
   - for heat alleviation

2. **Drench** – application – to wet the root plug
   - to replenish water and oxygen
   - to replenish the soil nutrients

Irrigation system

The objective of the irrigation system in a Copperblock buffer zone nursery is to:

- apply uniform watering to each individual cavity
- apply water in time to satisfy needs



A buffer zone Copperblock nursery irrigation system may be:

- static
  - impact sprinkler
  - micro sprays
- moving booms
  - linear
  - center pivot

Sprinklers and Micro sprays:

System design must consider:

- Irrigation pattern – this may have zones covered by 2, 3 or 4 sprinklers. (See diagram).
- Water pressure (in PSI) at the sprinkler must be greater than the sprinkler spacing (in feet)
- Max application rate 0.8gal/hr/ft² (1¼"hr) [4X coverage].

Set out a cup test to determine the irrigation pattern and locate critical zones (single coverage). Irrigation must be targeted to the critical zones.

Misting – a static irrigation system can treat the entire nursery at one time (depending on pumping capacity).

Drench – to return to field capacity (FC) :

Design the system to be able to deliver 30 - 60 minutes of irrigation throughout the nursery, in one day

Boom systems:

Must be capable of cycling once per hour

Linear booms apply the most uniform distribution. In a buffer zone nursery the power unit may travel on the ground dragging the water hose or may travel on a low rail with the water hose suspended from the rail.

The limiting factor in the design of a linear boom irrigator is the length of hose to haul. Common booms span 15 ft a side and run 200 ft.

Example: 40 plants/ft²; 6in³/cavity; 36% WHC; 40% dry down target.
This will require 40 x 6 x 0.36 x 0.4 in³/ft² irrigation to return to FC.
= 0.15 gals/ft².
Therefore if the application rate is 0.4 gals/hr/ft² (2X coverage) it will take 23 minutes of irrigation to reach FC (about ¼").

Linear booms may be fitted with misting nozzles (0.067 gpm at 40 psi) and drench nozzles (0.8 gpm at 40 psi) spaced 14" to 20" apart, and travel at variable speeds (6 ft/min for drenching).

A WET BOOM (SKDESIGN)

Center pivots are not restricted by a delivery hose, but by the edge application rate (max 0.8gal/hr/ft²) and the rotation limit of 1 hour. A common layout holds about 16,000 Copperblock trays per pivot (100ft) and can deliver 18,000 gph (= ¾" per rotation), traveling 5 ft/min at the edge. A double-span center pivot (200ft) would have to cover 10 ft/min at the outer edge – the average application rate (AAR), at the edge, would double and the instantaneous application rate (IAR) may exceed the infiltration rate (IR) of the growing medium. A rotator sprinkler provides the widest throw distance and reduces IAR.

Max infiltration rate (for a sand soil) = 1¼/hr

A Copperblock cavity may have a 2X catchment area – so the max IAR ≤ 0.5 x IR

CONTINUED ON THE NEXT PAGE

IRRIGATION REGIME

For germination

The objective is firstly to provide a continuously humid environment for the seed without depriving it of oxygen through extended saturation. Secondly to ensure the surface layer (where sunlight can penetrate) dries out between irrigations to prevent the growth and development of algae. (This objective can be met with algaecides).

The growing medium is thoroughly drenched in the initial irrigation so only misting irrigations are required during germination.

The seed cover material should be selected to have a high AFP and preferably a low WHC.

The frequency of misting will depend on the rate of evaporation, which is a function of relative humidity (RH), temperature, wind and … The best advice is to inspect

Example: ½" of Styrogrit covering the seed in a Copperblock 98/105ml will hold only 16 in3/ft2 H2O. Using the 2X catchment figure only 8 in3/ft2 should be applied. (1/16"). At a maximum application rate of 1¼"/hr (on a 4 X coverage zone) this would be a 6 minute misting for the 2X coverage zone.

For frost protection

The objective is to provide sufficient irrigation to maintain a covering of ice on the seedlings at 32ºF (0ºC) during a period when ambient temperature may fall below freezing (The technique is good to about 25ºF (-4ºC) with wind speeds below 5mph). Once the process is started the seedling and deeper layers of ice (at 32ºF) are prevented from getting colder due to the latent heat of fusion released by the continuing freezing of the following misting irrigations.

The latent heat of fusion releases 80 calories for every 1 gram of water that freezes. A misting rate of ⅓"/hr will be sufficient in winds up to 5mph. If misting is interrupted, the accumulated ice layers will begin to evaporate – and the latent heat of vaporization will draw 600 calories/g of water evaporated from the surroundings, including the crop. Misting must resume before the heat loss gradient reaches the seedling tissues. Non-misting periods should be limited to 60 seconds.

If the ice is cloudy or milky white the water application rate is not fast enough

Misting must be initiated at 33ºF (0.5ºC) [wet bulb] because RH will be low and evaporative cooling of the mist will immediately lower ambient temperature. Misting must continue after the ambient temperature rises above 32ºF until the ice is melting and loose, then the heat required to melt the ice will be drawn from sunlight.

For heat alleviation

Heat stress can adversely affect seedling growth. Extreme heat from seed cover materials can damage seedling stems. The objective of heat alleviation misting irrigation is to harness the latent heat of vaporization. The seedling will be utilizing this phenomenon in transpiration but needs help.

The **wet bulb temperature** of the air is the lowest temperature that can be reached by evaporative cooling.

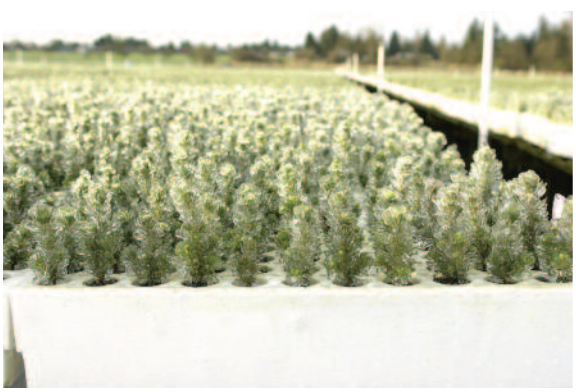
The evaporation of 1g water requires 600 calories. The heat absorbed by the seed cover is directly related to the density of the material. Light materials such as PBC(~12lbs/ft^3) will not become as hot as dense materials such as granite grit (92lbs/ft^3).To reduce the temperature of the material heat can be extracted by evaporative cooling.

For water replenishment

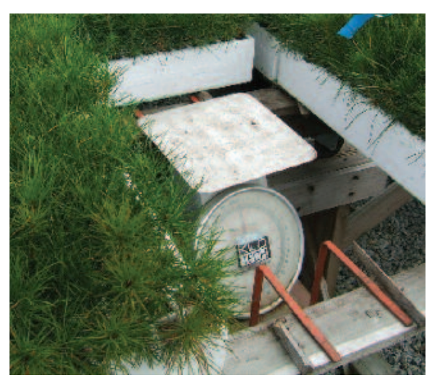
The objective is to provide sufficient moisture for plant growth at all stages of development. Water is required for transpiration and translocation of metabolites.

Block weight: Place top-loading scales under Copperblock trays at select locations throughout each irrigation area. Record block weight at FC. Irrigate at 20% to 40% weight loss – as per growing phase.

A drenching irrigation will return the growing medium to field capacity (FC). This must be monitored in the zone of lowest application rate – Copperblock trays in high application zones will receive more water but will drain to FC immediately after irrigation (with a well designed growing medium). The frequency of application will depend on the dry down regime (see Tech.Bull: Growing) and the weather.



FROST PROTECTION BY IRRIGATION



TOPLOADING SCALE

For nutrient replenishment

A drenching regime is applied to replenish oxygen and nutrients taken up by the roots from the soilless medium. The objective is to provide a uniform condition throughout the root plug.

It may be necessary to leach a buildup of salts due to high evaporation, or to replenish nutrients leached by rainfall. A full replacement requires a fertigation application equivalent to the WHC of the root plug.

FERTIGATION REGIME

Fertilizers for a Copperblock Buffer Zone nursery may be applied:

a) as solids – premixed in the growing medium.

- elemental or controlled release fertilizers (CRF)

b) as solubles – injected into the irrigation water.

- as concentrates or
- as a partially prediluted mix

c) a combination

The principles and processes for loblolly pine seedling nutrition are well known to experienced growers. Some points for Copperblock Buffer Zone nurseries are worth noting:

STARTUP Pre-mixed CRF is a simple approach, requiring no special equipment. The higher fertilizer cost is offset by equipment savings. CRF does not permit close control of seedling growth.

Loblolly fertilizer regimes are generally set in 4 phases:

1. **Germination**
Use only pure water – until cotyledon shed

2. **Starter**
High N (100ppm) – low EC

3. **Feeder** (exponential growth phase)High N (100ppm) – high EC (max 2,000µmho)

4. **Hardener**
Low N (50ppm) – high P

The selection of fertilizer sources and the formulation of mixes to achieve the desired nutrient solutions depend on water quality, growing medium and experience. The Copperblock Buffer Zone Nursery grower should be familiar with The Container Tree Nursery Manual Vol.4 Ch.1
USDA Hdbk 674.

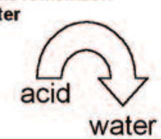
Note: Injection equipment may be required for other purposes e.g. pH adjustment

Refer to a compatibility table when formulating a stock solution for injection to avoid precipitation.

Two stock solutions are common. e.g. with calcium nitrate separate from magnesium sulphate, potassium sulphate or carbonate.

Iron chelate must be separate from sulphuric, nitric or phosphoric acid.

When diluting acid remember:
Add acid to water



The options for fertigation are:

- apply continuous feed of the target nutrient solution – ignore CEC : a simple, safe approach.
- apply alternately pure water or dilute fertilizer mix – rinse foliage – utilize CEC: requires storage tanks
- apply alternately pure water or inject fertilizer mix – rinse foliage – utilize CEC : monitor closely.

The Copperblock Buffer Zone Nursery must have the capacity to apply supplemental nutrition as a correctional treatment:

Loblolly pine seedlings grown in Copperblock trays may require increased iron nutrition – to avoid chlorosis due to iron deficiency. Apply Fe^{++} at 10ppm (Fe chelate) in the soil solution.

INJECTION

Copperblock Buffer Zone Nurseries may consist of widely separated sections – the primary concern will be delivery of clean water when necessary (leaching, misting). The nursery design will have to weigh up the advantages of central injection versus distributed injection.

STARTUP Water-powered injectors (e.g. Dosatron®) are suitable for positioning at independent buffer zone sections.

Injection rates should lie between 1:100 and 1:400 (it is more difficult to dissolve fertilizers in a more concentrated stock solution). Therefore, the flow rate of the system may govern the injector selection.

Example: a center pivot delivering 18,000 gph will need injectors capable of injecting 1 gpm of a 1:300 solution.

MONITORING

URGENT LEACH if:
$EC_{leachate}$ is > $EC_{applied}$ + 1,000 µmho/cm

The Copperblock nursery grower's constant companion should be an EC meter.

Fertigation solutions should be routinely tested. Leachate from Copperblock trays should be collected from select positions throughout the nursery (2X coverage zones) and tested on a regular schedule. (Tape over vent holes and position a clean flask below the Copperblock tray). Simple EC meters require immersion of an electrode in the solution to be measured.

Recently developed pin type meters can be inserted directly into the moist growing medium in a Copperblock cavity.

(Right: Field Scout® EC Probe)

Technical Bulletin

Buffer Zone
Copperblock Nursery : Growing

INTRODUCTION

A Buffer Zone Copperblock Nursery will likely be managed by a grower with considerable experience in bare root culture, nevertheless, the basics are worth reviewing:

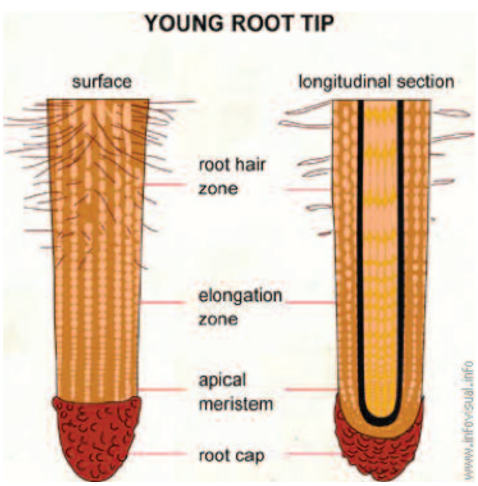
In a Copperblock Buffer Zone Nursery the grower is able to finely control the supply of water and nutrients to each seedling. The grower has limited control over oxygen supply to roots and sunlight to shoots. Temperature extremes can be reduced but the grower has to work with the climate of the location. The seedling does the growing, the grower controls the conditions.

The objective is to grow a seedling to target dimensions (Ø, Ht) with a well developed root plug and in good physiological condition.

MANAGING ROOT GROWTH

Roots do not grow towards water! Roots do need water to grow – water is required for respiration, which powers growth, so roots grow where there is moisture.

Roots grow at the tip. The diagram below shows the location of cell division – the apical meristem (which produces cells for the root cap and for the body of the root. The elongation zone is where cells are enlarged causing the root cap to be pushed forward.



The taproot of the loblolly seedling grows down under the influence of hormones (auxin) in the cotyledons and later produced in the needles. Auxin stimulates cell elongation and lateral root development. However, another hormone (cytokinin) produced in the root tip, suppresses lateral root development – so the tap root grows to the drain hole. Cytokinin is the hormone that stimulates cell division (without which, there can be no elongation) – so when the root tip emerges from the drain hole, a lack of moisture (air pruning) desiccates the tip, cytokinin cannot be synthesized, so growth stops but lateral root development is no longer suppressed.

COPPER-PRUNED LOBLOLLY ROOT PLUG.

Lateral roots grow under the influence of auxins, from the needles (for elongation) and cytokinins (for cell division) from their own root tips.

Once the lateral root reaches the Copperblock cavity wall it is the uptake of copper ions (Cu^{++}) that interrupts cytokinin biosynthesis – suspending cell division, so suspending root elongation – and taking the brake off further lateral root development. This cycle is repeated and the plug develops a fine root system.

Roots need oxygen – for metabolism and growth. This oxygen is absorbed at the root tip, through the moisture on the root surface. Oxygen moves very slowly through water so the root depends on oxygen movement in the air-filled macropores.

The grower controls air replacement in the plug through the irrigation regime – as a drench drains, so fresh air is drawn in to the growing medium. But too frequent irrigation, low AFP or impeded drainage can result in a saturated growing medium.

Roots work to take up nutrients – from the soil solution (low concentration) through the cell membrane – to the root cell (high concentration), water follows by osmosis.

> Normal air is 21% O_2. Water contains only about 0.8% O_2

The grower ensures that the concentration of salts in the soil solution does not rise above 3,000 μmho/cm. This can happen through successive light fertigation applications under conditions of high evapotranspiration.

Excessive salt levels will cause water to be drawn out of the root cells, by osmosis. The root cells then desiccate and die.

Temperature for root growth – the critical temperature for significant root growth is ~ 43ºF (6ºC) whilst the maximum growth rate of loblolly roots will be found at ~ 77ºF (25ºC), growth decreases at higher temps.

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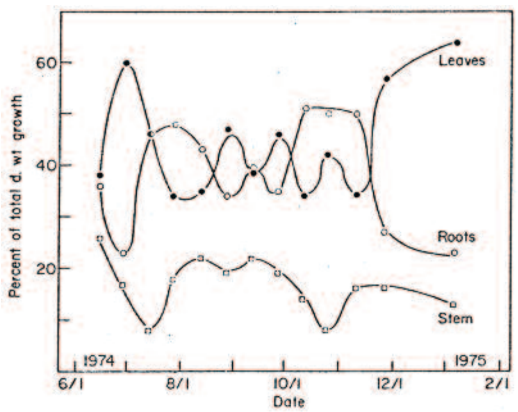
MANAGING SHOOT GROWTH

Shoot growth depends on nutrient uptake, photosynthesis and respiration – the grower can influence all these metabolic processes.

Shoot growth is periodic – the allocation of metabolites (dry mass) is not linear. From germination to the target Copperblock loblolly seedling, growth alternates between roots and shoots. The diagram below illustrates the periodicity of loblolly growth.



THE DISTRIBUTION OF DRY WT. INCREMENT IN LOBLOLLY SEEDLINGS.

In the 1st month root growth is significant (~35%), about equal to needle mass and higher than stem mass (~25%).

In the 2nd month needle growth dominates (~60%), root growth drops (~25%) as does stem mass (~15%).

Root growth increases in the 3rd month (~45%) while needle and stem mass drop (~45%, ~10% resp.).

In the 4th month root growth is maintained (~45%) while needle dry mass continues to drop (~35%) and stem dry mass accelerates (~20%).

For the next couple of months root growth slows (~40%) versus stem growth (maintained at ~20%) and needle mass fluctuates around 40%.

In the Fall stem growth drops (~10%) but root growth rises (~50%). This is followed in winter by a significant drop in root growth versus needle growth.

NB: The above refers to increment. Total dry mass accumulation follows a temperature dependant, seasonal exponential curve.

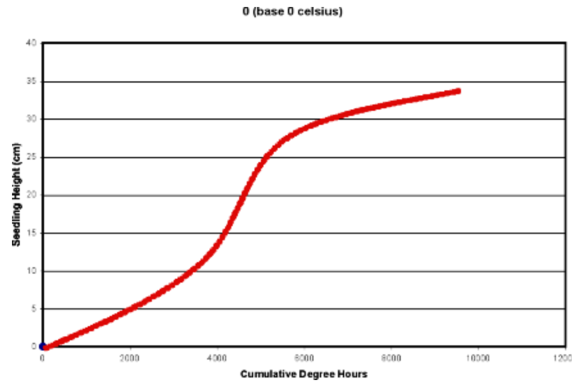
Simplify:

MTH 1	MTH 2	MTH 3	MTH 4	MTH 5
ROOTS	NEEDLES	ROOTS	STEM	BALANCED

Shoot growth is limited by temperature – the optimum temperature for photosynthesis is 68 – 95ºF (20 – 35ºC) with a peak at 77ºF (25ºC). Higher temperatures (>95ºF) induce photorespiration and the seedling is under stress. Photosynthesis proceeds at low temperatures in conifers if moisture is available (i.e. root plug not frozen).

Seedling growth accumulation – from seeding (April/May) to harvest (Oct.) – is closely correlated with temperature experienced. This can be tracked as Heat Units to be independent of calendar date.

Dry Mass of shoots and roots will accumulate in a similar curve as will collar diameter.



Shoot growth is limited – by growing space: Bareroot loblolly seedlings are grown at a density of 25/ft² and > 35in³ root volume. Copperblock Buffer Zone Nurseries will grow at a density of 40/ft² and 6in³ root volume.

> Degree Day = Daily mean temperature minus base temperature.
>
> e.g. daily mean temp (75F) - base temp (32F) = 43 degree days.
>
> This can be refined to:
> Degree Hours
> Daytime Degree Hours
> Photo Degree Hours

Shoot height – the primary objective is to limit loblolly seedling height to ensure that top growth after planting can be supported by the root system. A secondary objective is for convenience in shipping and planting.

6 in³ X 50/ft²	**Limits Ø < 5.0mm**	
6 in³ X 40/ft²		**Ø > 5.0mm**

TOP MOWING OF LOBLOLLY IN COPPERBLOCK TRAYS.

Topping
– shoot height in Copperblock trays can be controlled by topping as practiced in bare root nurseries. Most systems are simple, using domestic rotary lawn mowers drawn over the crop on a wheeled gantry.

CONDITIONING – HARDENING

Loblolly Copperblock seedlings will be shipped, stored and planted with growing medium protecting the roots and exposure of the shoots is limited between harvest and planting. However, on planting, the root system may not have the capacity to meet the evapotranspiration demand – until rainfall or root egress re-establishes the soil capillary connection. Until this time the seedling must survive on moisture resources in its tissues.

Hardening is a growth process requiring photosynthates and therefore requires normal growing conditions – this is alternated with simulated field conditions.

- In the first month seedlings should be under no moisture stress.
- For the following 2 months block weights should be allowed to drop by 20 – 25% from field capacity (FC) weight between fertigations.
- As the seedlings reach 8" tall (20cm) fertigation should be applied after a 40% drop in block weight from FC.

The first topping is typically conducted about August 1 (only about 10 – 20% of seedlings pruned). This should be preceded by fertigation but without cutting wet seedlings. The second topping cuts about 50% of the seedlings about 3 weeks later and a third cuts about 33% another 3 weeks later.

THE TARGET PLANT

Plant quality is determined by outplanting performance

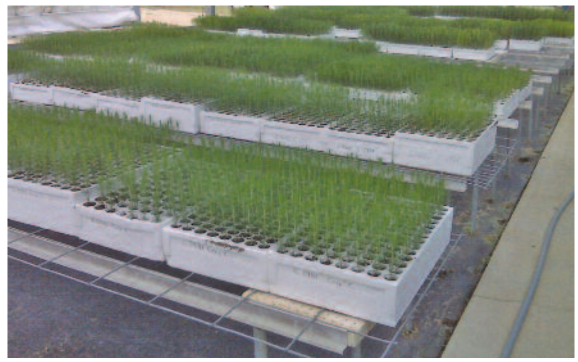
Growing is a balancing act of controlling or mediating moisture, oxygen, nutrients, temperature and light.

- Growing starts with Copperblock model choice and medium selection, followed by seed preparation and sowing.
- Then follows the balancing act of irrigation and fertigation with the need to mitigate temperature extremes.
- Finally the conditioning where the balance is between stress and repair.

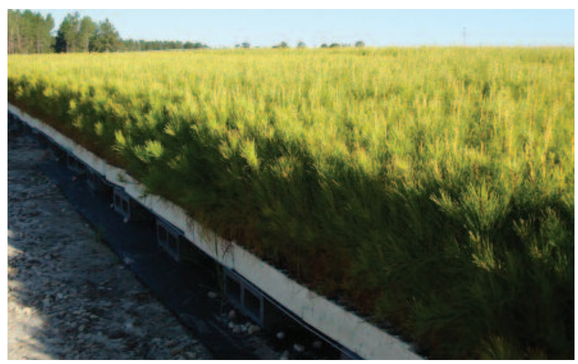
The tendency is to "kill with kindness" where the danger is hidden in the middle of the root plug. The grower must extract specimen seedlings to inspect root development in the lower plug – this is the hardest part to manage.

Loblolly Seedling specifications are related to Copperblock model. Approximate attainable dimensions are suggested below:

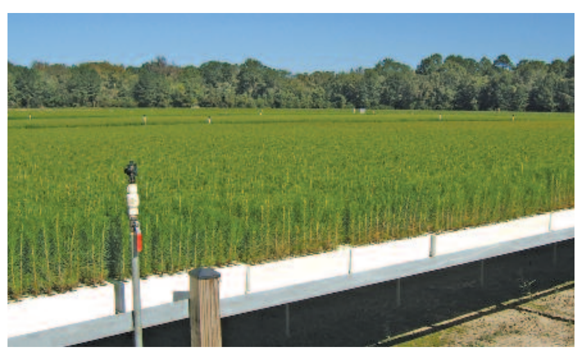
Copperblock Model	Height – Ht (cm)	Diameter – Ø (mm)
CB160/60ml	20	3.0
CB112/80ml	25	3.5
CB112/105ml	25	4.0
CB98/105ml SF	25	5.0
CB77/125ml	25	5.5
CB60/220ml	30	7.0
CB45/340ml	35	8.0



COPPERBLOCK MODEL TRIAL



COPPERBLOCK 60/220ML LOBLOLLY



COPPERBLOCK 112/105ml LOBLOLLY

Beaver Plastics

Technical Bulletin

Buffer Zone
Copperblock Nursery : Harvest

INTRODUCTION

Seedling harvest from a Copperblock Buffer Zone Nursery can be conducted as a “hot lift” to meet demand. Conditions in the container will not dictate harvest timing – in the Southeast USA.

The traditional planting season can be extended with Copperblock tray seedlings so there are good reasons not to overlap with the bareroot lift – e.g. to utilize the same harvest and packing building and the same labor force.

Copperblock loblolly can be dispatched in the container (sold as “bench-run”) with the Copperblock tray returned but this system is seldom used due to logistics.

The system common to bareroot nurseries is superior – i.e. extraction of seedlings, visual grading, packing and shipment.

EXTRACTION

CUSTOM BUILT TRAILERS FOR MOVING COPPERBLOCKS TRAYS ON CUSTOM PALLETS

Copperblock Trays are first moved from the growing area to the harvest building – where conditions for high productivity can be provided.

STARTUP

Plug moisture – dry plugs will not extract easily – and the seedling requires plug soil moisture for roots to grow to reach the field soil moisture after planting. Avoid wet foliage at harvest – this can promote *Botrytis spp.* mold in storage.

Manual extraction – is suitable for small operations and for irregular seedlots in larger operations. This is both an arduous task and a skilled task – the individual pulls the seedlings from the Copperblock tray, visually grades and wraps a bundle of plants.

Productivity = ~700 Copperblock trays/worker/hr

Workers should be rotated to avoid personal injury (e.g. carpal tunnel syndrome) – though use of a Plug Popper will loosen plugs before pulling.

A modular manual harvest line can utilize much of the bareroot handling equipment – and remain portable to not obstruct bareroot operations.

MANUAL EXTRACTION STATION (PULL & WRAP)

ENDUP

Machine extraction – automatic popping (pushing) of plugs will raise productivity 50% and eliminate repetitive action injuries. The machine operator conducts primary grading (which may be sufficient), followed by a wrapper, with two wrappers supplying one packer. The team can be as small as 3 (inside workers).

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VISUAL GRADING

Shoots – of Copperblock loblolly seedlings are graded the same as bareroot seedlings – to the specification selected.

COPPERBLOCK LOBLOLLY (LEFT), NON-COPPER LOBLOLLY (RIGHT)

Roots – of Copperblock seedlings are not the same as roots of non-copper treated containers:

- there is no cage of roots running down the outside of the plug.
- growing medium is easily brushed off the surface of the plug.
- the root plug will not be solid.
- there is no knot of roots ending at the drainhole.

But – the root plug should:

- have roots to the drainhole
- show live root tips throughout the plug
- retain most of the growing medium

PACKING

Copperblock loblolly seedlings are tallied in bundles after grading. The bundles are a convenient size for a worker to hold with two hands around the rootplugs.

Hot-lift for machine planting :

The bundles of seedlings can be placed, unwrapped, standing upright in a waxed box of appropriate dimensions.

Hot lift for manual planting : The rootplug bundle is stretch-wrapped (using a modified meat wrapper) – the wrapped bundles are placed standing upright in a waxed box of appropriate dimensions.

STORAGE

Cool storage of Copperblock loblolly seedlings is required if the harvest is a week or more ahead of planting. Seedlings can be held in coolers or refrigerated vans at 40° to 70ºF (4° to 21ºC) for a week. Non-dormant seedlings (tops and roots) will continue to respire and consume available oxygen.

Plug	Bundle size
310	15
410	10
415	10
512	6
615	3

Stretch-wrapped bundles are open top and bottom, and can be watered on site.

Copperblock loblolly seedlings can be held, under shade, for a week at the planting site – if the boxes are opened (within one day of arrival) and the plugs are kept moist.

SEEDLING WAXED BOX – NO STAPLES

Long term storage should be avoided as it requires close attention to seedling physiological condition and storage conditions. The reasons for long term storage of bareroot seedlings do not directly apply to Copperblock loblolly seedlings – unless the Buffer Zone Nursery location is prone to extended freezes.

Boxes require a plastic liner for long term storage and bundles can be laid flat. The temperature of the seedlings must be reduced to:

	Period	Temperature
Cooler storage	2 - 8 WKS	33 - 36ºF
Freezer storage	> 8 WKS	25 - 30ºF

Frozen seedlings must be thawed (± 50ºF) before planting.

BLOCK WASHING

Immediately after harvest the Copperblock trays should be cleaned (see Tech.Bull."Containers").

LAMINAR FILTER – PERMITS WATER REUSE IN BLOCKWASHING.

The objective is:

- to remove remaining growing medium while wet – to facilitate the next filling.
- to remove sources of disease contamination for the the next crop.
- to prepare for pasteurization.

Buffer Zone
Copperblock Nursery : Planting

INTRODUCTION

The grower is in direct control of seedling quality until the plants are shipped, but – as the dictum of the Target Seedling Concept is that plant quality is determined by outplanting performance – the grower must extend influence and interest through the shipping, handling and outplanting to an assessment of establishment success.

Plant quality is determined by outplanting performance.

SHIPPING

Seedlings can be transported in the Copperblock tray if physical damage to the container can be avoided:

- avoid desiccation – use covered vehicles
- Irrigate to FC before shipping
  - avoid temperature extremes
  - ventilate
- night time travel
- secure the load – avoid physical damage
- Copperblock trays can be cross-stacked on edge

Seedlings can be transported in the Copperblock tray in a box (e.g. per courier):

- use a waxed box of heavyweight board
- box markings to indicate “this side up”, “live plants” and “keep cool”
- hand-holds to be punched out to provide ventilation
- irrigate to FC and ensure drainage has ceased
- ensure foliage is dry

Seedlings can be transported as bundles (polywrapped or not) in waxed boxes:

- stack height limited by box strength – usually an 8 ft stack with a slip sheet at 4 ft.
- punch out hand holds for ventilation
- irrigate to FC and ensure drainage has ceased
- ensure foliage is dry
- overnight
  - in a closed vehicle
- daytime
  - in a refrigerated trailer (<50ºF)
  - insert a temperature recorder in one box

HANDLING

Copperblock loblolly seedlings can be stored on site in refrigerated trailers for a week.

On removal from the transport, boxes should be placed in shade and opened within 24hrs.

Irrigation must be applied as required, on inspection of root plugs. Copperblock loblolly seedlings can remain in the boxes for at least a week before planting.

PLANTING

The objective is to place the rootplug in close and complete contact with the undisturbed soil to establish a continuous moisture gradient.

- without compacting the rootplug – maintaining conditions for rapid root growth
- without distorting the root plug – maintaining the root form of the Copperblock seedling

Manual planting – there are two major considerations with manual planting of Copperblock loblolly seedlings:

1. Depth of planting – without rootplug distortion – is dictated by:
   - site preparation
   - planting depth desired
   - choice of planting tool
2. Soil contact – for rapid root egress – is dictated by:
   - choice of planting tool
   - planter’s skill

CONTINUED ON THE NEXT PAGE

Depth of planting – Copperblock loblolly seedlings can be planted deep – so that the root plug is in a horizon that does not dry out for more than 3 weeks in the first 3 months. Double-bedded sites must receive sufficient rain to penetrate to this layer before, or immediately after planting.

Planting depth desired – Copperblock loblolly seedlings may be planted deep to –

- place the rootplug in the permanently moist soil layer and/or
- reduce transpirational water loss

and this is balanced with the need to maximize photosynthetic area.

Roots grow with current photosynthate.

Choice of planting tool – will affect the depth of planting but will also have an effect on the interface between rootplug and soil:

- a solid plug dibble can compact the wall of a clay soil – affecting aeration, capillarity and root penetration.
- a planting spade can compact opposite walls of a clay soil – favoring two-directional root form.

Soil contact – is required for roots to acquire the moisture film that permits oxygen transfer needed for root respiration and growth.

Beware of J-rooting by deep planting in a shallow planting hole.

J-ROOTING OF A LOBLOLLY SEEDLING.

Large, airfilled cavities obstruct root growth.

Planter's skill – strikes a balance between compaction to avoid cavities and over-compaction that affects soil properties or damages roots. The planter ensures the Copperblock loblolly seedling plugs have sufficient moisture before removing the polywrap and inserting the bundles in the planting bag.

Machine planting

The same considerations of planting depth, equipment effect on hole walls, compaction of soil and plant apply to machine planting as to manual planting.

The operator should receive boxed – unwrapped – seedlings to achieve high planting rates (> 20 acres/day).

Puddle planting – is an innovation that can be used to extend and make the planting window continuous. The technique involves the injection of ± ½ pint (250ml) of water immediately on top of the root plug as it is firmed into the planting hole.

Puddle-planting re-establishes the soil capillaries at the plug/soil interface.

Equipment and controls are carried on the planting machine and the hauling tractor.

MONITORING

Performance should be assessed before genetic qualities are expressed.

Mortality – can be assessed within a few weeks of planting –

- use line plots – for rapid estimates
- expect planter differences
- investigate cause
  - planting quality – depth, J-root, air pockets
  - desiccation – handling, drought
  - storage – mold, duration, transport
- calculate survival percentage (% survival)

Establishment – can be assessed at the beginning of the spring growing season (~ May) –

- use randomly placed square plots of 5 X 5 trees
- measure only live trees
  - record ground-line diameter (GLD)
  - record height
- calculate mean diameter (GLD)
- calculate mean height (Ht)

Measuring the above parameters at the beginning of the growing season after planting will permit comparisons within Copperblock seedling stocktypes and between Copperblock and other stocktypes using common statistical procedures.

Plant quality is determined by outplanting performance.

COPPERBLOCK LOBLOLLY 3 YEAR OLD – LOWER COASTAL PLAIN.

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