Biologically based treatments for the production of loblolly pine.

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Biological Control

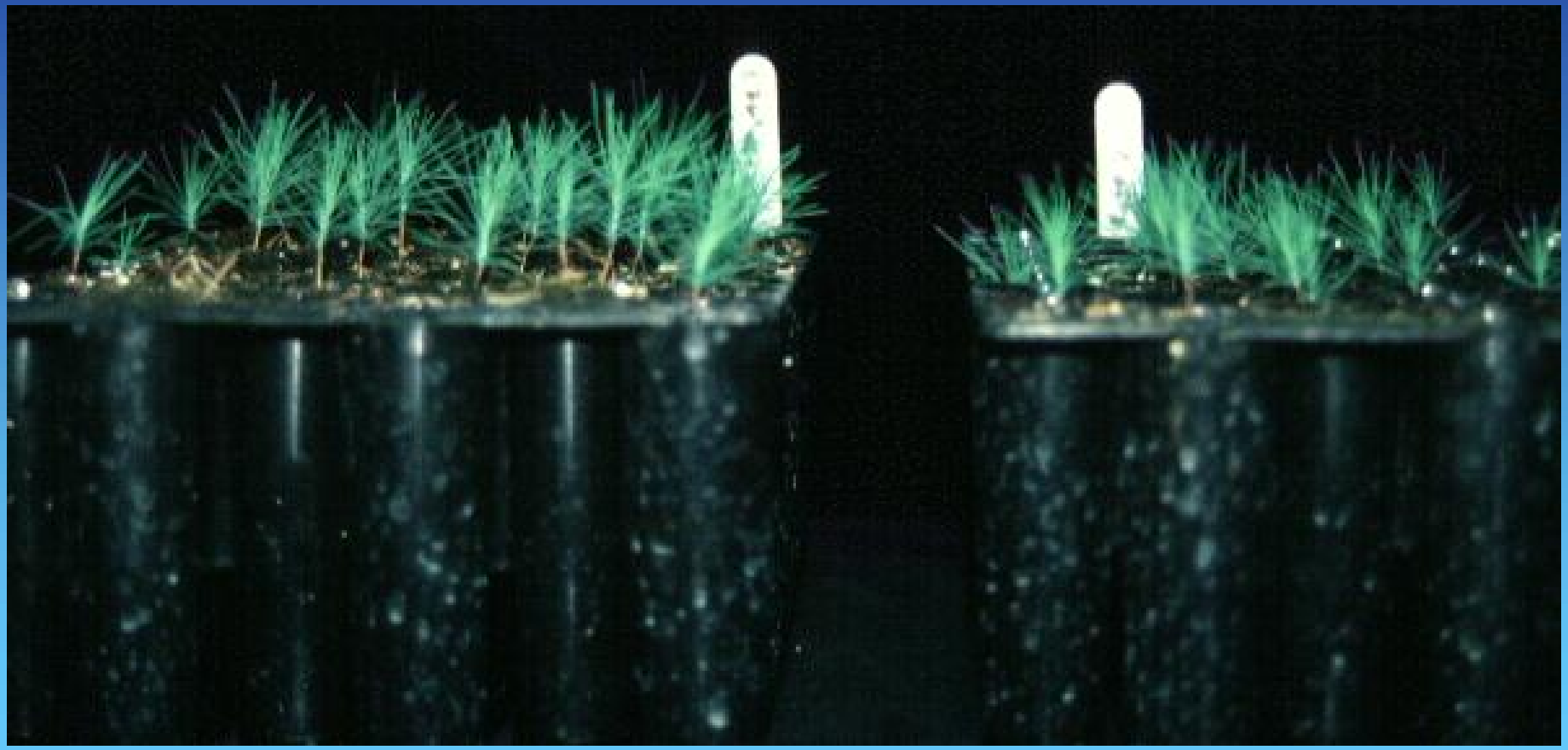
Agents

- Bacteria – PGPR
- Fungi
- Mycorrhizae
- Soil amendments

Commercially Available Products

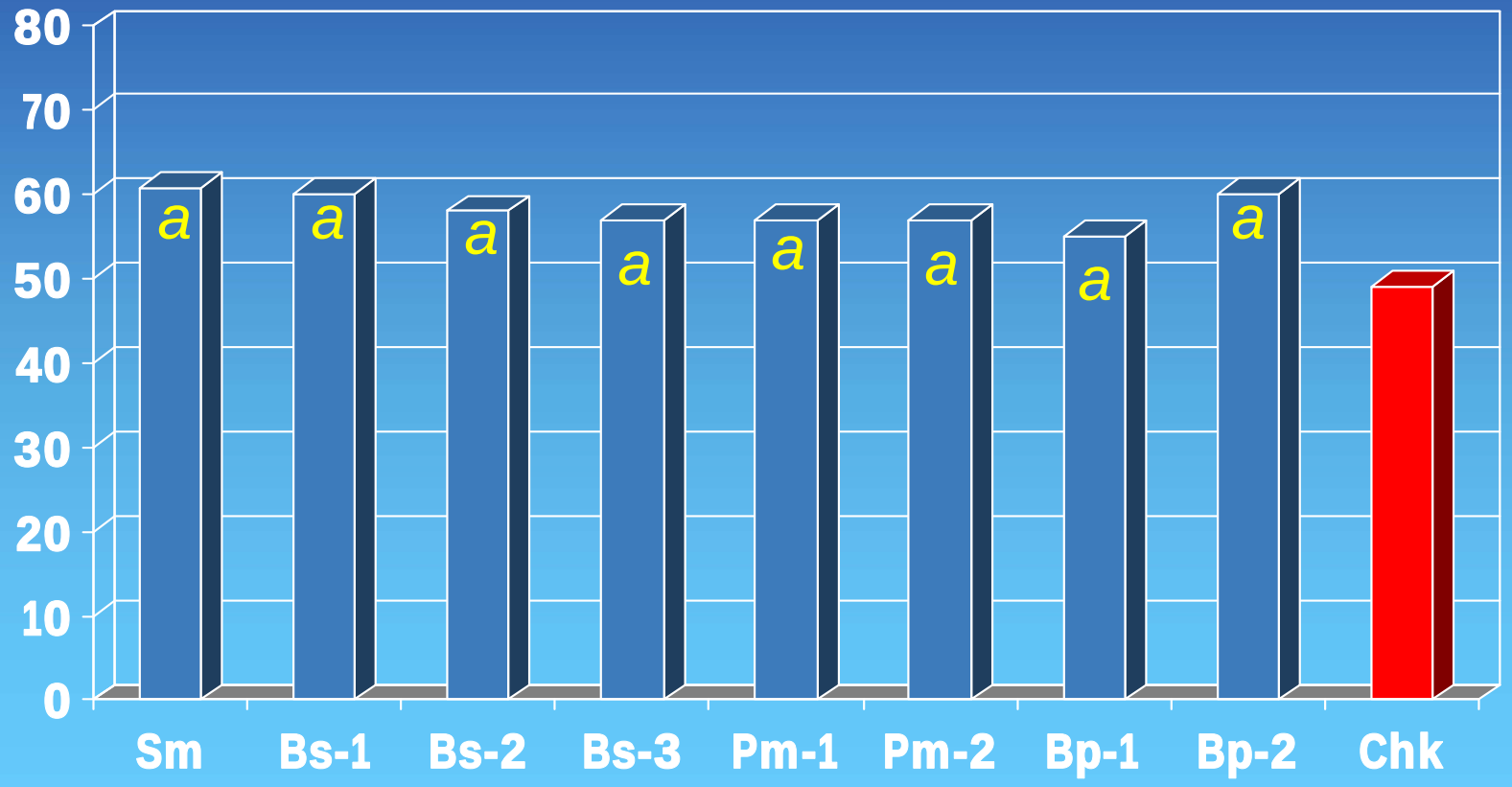
Product	Bacteria	Target Effect
Kodiak	Bacillus subtilis	Growth promotion & Biocontrol of Rhizoctonia and Fusarium
Deny	Burkerholdia cepecia	Biocontrol of Fusarium & Pythium
Actinovate	Streptomyces lydicus	Biocontrol of Pythium, Fusarium & Rhizoctonia
YIB	Bacillus spp.	Root growth promotion
Epic	Bacillus subtilis	Growth promotion & Bio-control of Rhizoctonia and Fusarium

EPR - Emergence Promoting



EPR - Emergence Promoting

Three week-old loblolly pine seedlings



Symbiotic Relationships

- Increase / Decrease ectomycorrhizae infection
- Increase / Decrease endomycorrhizae infection
- Alter species of mycorrhizae

Table 1. Mean seedling density, size and dry weight by seed treatment with *Paenibacillus macerans* for loblolly pine at Flint River GA in 1998, 1999 and 2000.

Year	Bacteria	Density (ft2)	RCD (mm)	Hgt (cm)	Root Wgt (g)	Shoot Wgt (g)
1998	No	21.4	4.3	21.4*	0.68	3.1
	Yes	21.8	4.2	19.7	0.72	3.0
1999	No	21.7	3.6	25.3*	0.71	2.7
	Yes	22.7	3.6	24.5	0.66	2.6
2000	No	22.0	4.2	27.0	0.85	2.9
	Yes	22.4	4.1	26.6	0.81	2.9

Table 2. Mean seedling density, size and dry weight treated with *Paenibacillus macerans* for loblolly pine at Hauss and Carter Nurseries in 1998, 1999 and 2000.

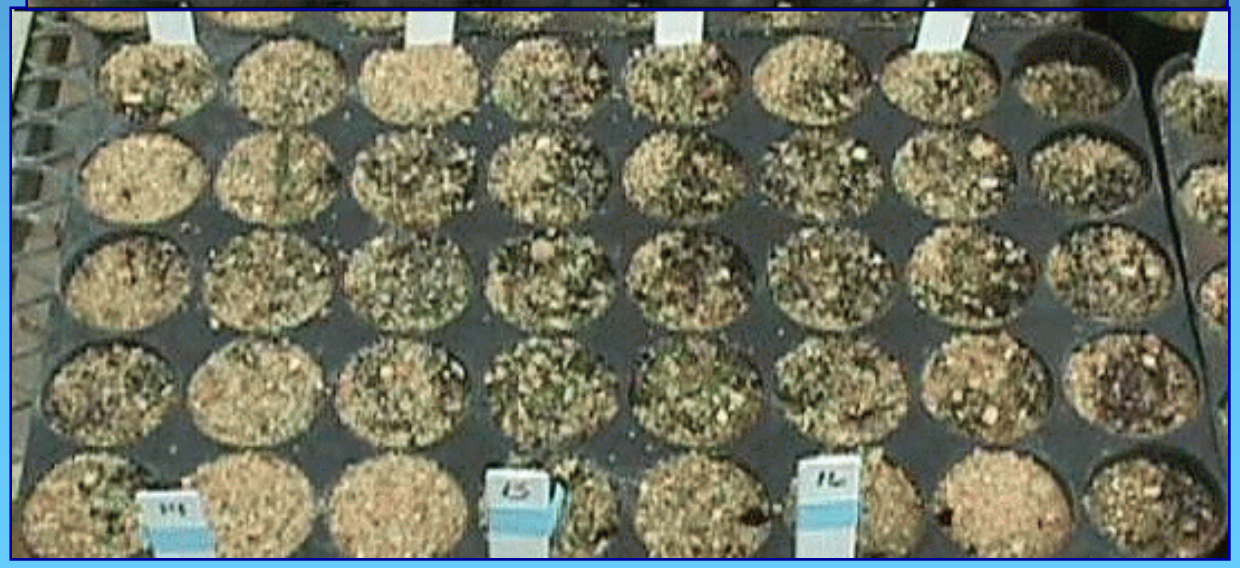
Year	Bacteria	Density (ft2)	RCD (mm)	Hgt (cm)	Root Wgt (g)	Shoot Wgt (g)
1998	No	22.5	4.6	na	0.79	2.9*
	Yes	23.8*	4.4	na	0.72	2.7
1999	No	21.6*	5.0	na	0.89	3.1
	Yes	19.4	5.2	na	0.96*	3.4*
2000	No	24.8	5.1	na	0.90	3.4
	Yes	25.4*	5.1	na	0.90	3.3

Summary – Bare Root Nurseries

- Enhance seedling emergence
- Enhance some seedling growth
- Dose sensitive
- Nursery specific
- Species and family specific
- Fine tuning for nursery, species & family would take years

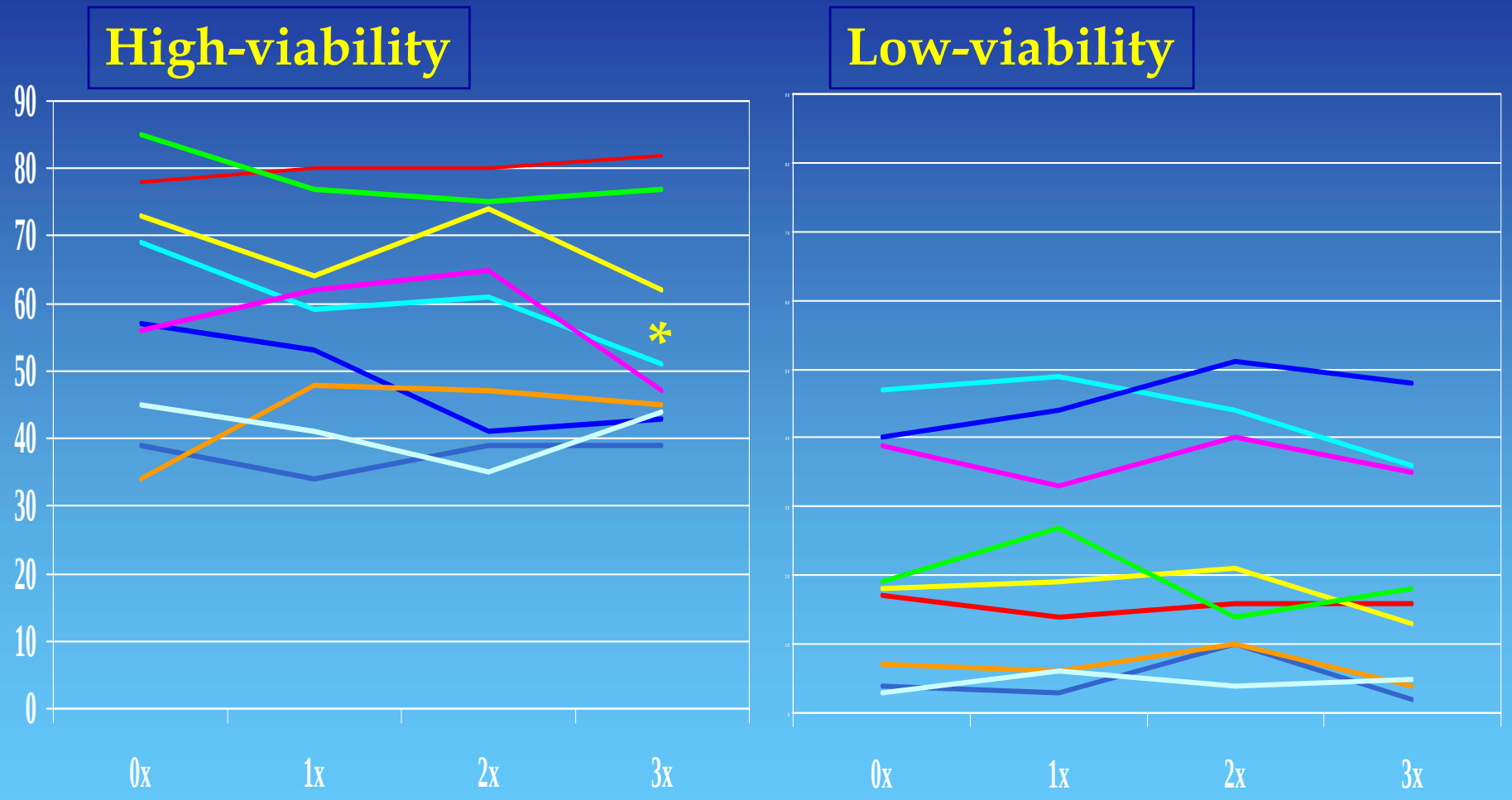
Fungal Seed Treatment

Pre-treatment high-viability seed lot



Pre-treatment low-viability seed lot

Biological Seed Treatment



Summary & Conclusions

- Biological agents neither increased nor decreased longleaf seed germination.

- Five fungicides found to inhibit *Fusarium* sp commonly associated with longleaf pine seed.
- Benlate® and Manzate® treatment resulted in a 10% increase in percent germination.

Biological - mycorrhizae

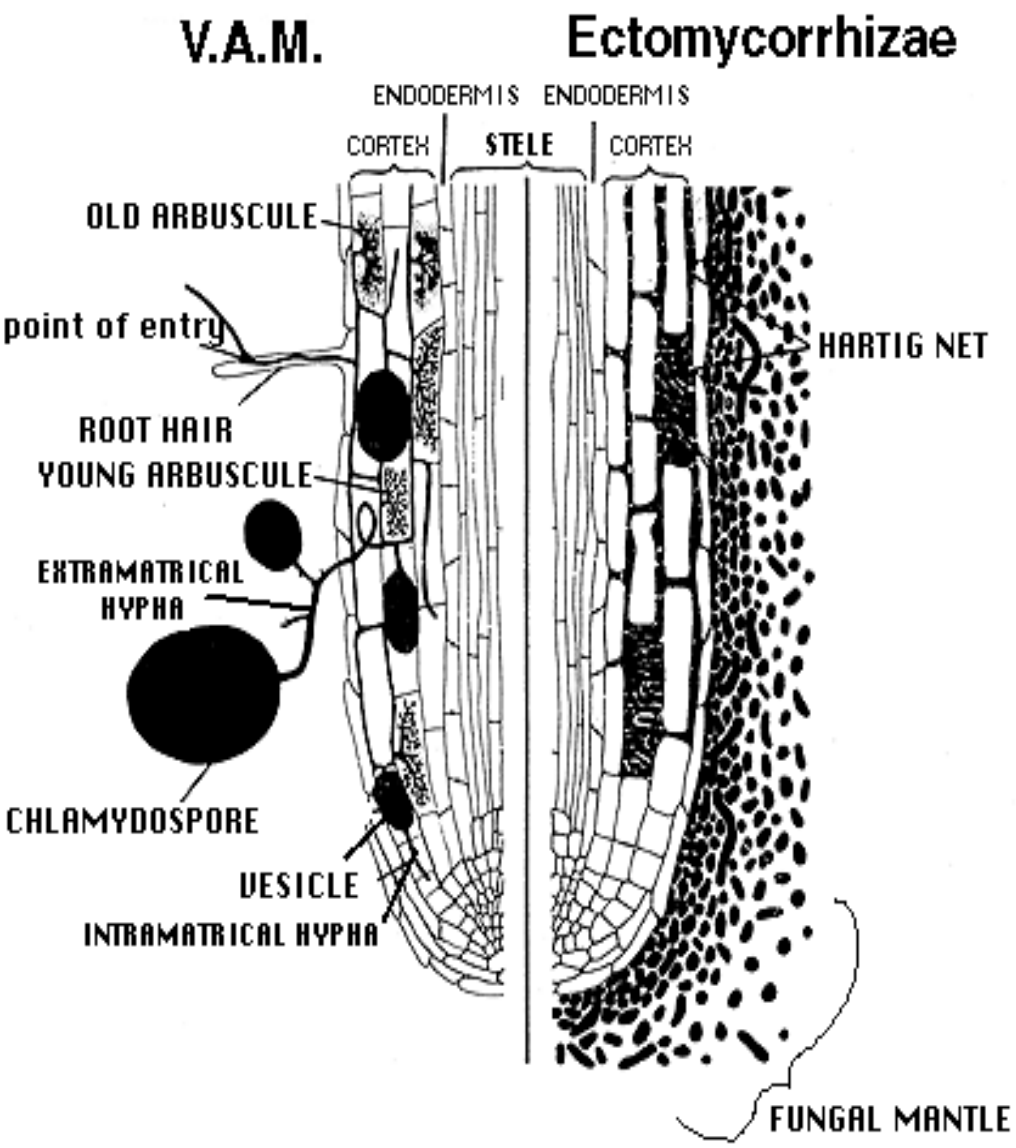
- **Mycorrhizae: A Greek word that means Root - Fungus. Much research has shown that mycorrhizae are a critical ingredient to the survival of forest trees**.
- Symbiotic relationship. Both tree and fungus benefit.
- Tree benefits from increased root area for absorption of nutrients and water.
- **Fungus benefits because it receives food from the tree's roots.**

Ectomycorrhizae (outside)

- Produces a fungal mantle
- Roots tend to be “forked”
- Spread via spores in the wind
- Found on many conifer species
- Found in many bare-root and container systems

Endomycorrhizae (inside)

- No visual difference externally
- Produce swellings, or vesicles, on plant roots
- Spread via infected roots
- Found on many hardwoods and cover crops



DIAGRAMMATIC REPRESENTATION
OF THE TWO TYPES OF MYCORRHIZAE

Mycorrhizae

- Selectively absorb and accumulate certain nutrients, especially Phosphorus
- Solublize and make available non-soluble minerals
- Keeps feeder roots functional longer
- “Protects” feeder roots from soil pathogens
- Result in forking of fine roots

Thelephora terrestris

Most common ecto in nursery soils.

Spread via spores from neighboring fields.

Not unusual to have 100% colonization.

‘Smothering’ fungus.

Can be quickly replaced by native mycorrhizae after out-planting.

Pisolithus tinctorius
also known as Pt

Second most common ecto

Has been shown to increase survival of seedlings after out-planting on harsh sites.

Not easily spread. Needs vegetative mycelia.

Easily replaced after outplanting.

Mycorrhizae

- Except for purposes of ‘market forces’ or EXTREMELY harsh sites, the addition of fungal inoculum to either nursery soils or container systems to “increase mycorrhizae” and consequently seedling survival, is not necessary with respect to growing conifer seedlings in the southern United States.

Soil Amendments

- Bark – Conifer / Hardwood
- Green manures
- Pulp mill waste
- Saw dust
- Chicken House waste
- Compost

Biologicals

- In the competitive business such as forest-tree nurseries, the lack of a consistent response of a biologically based practice for the control of a target pest (insect, pathogen, weed) makes their wide-spread use significantly limited.

- Test on small areas over a period of a few years under normal conditions before adopting wide scale use.