Biologically based treatments for the production of loblolly pine.

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Biological Control

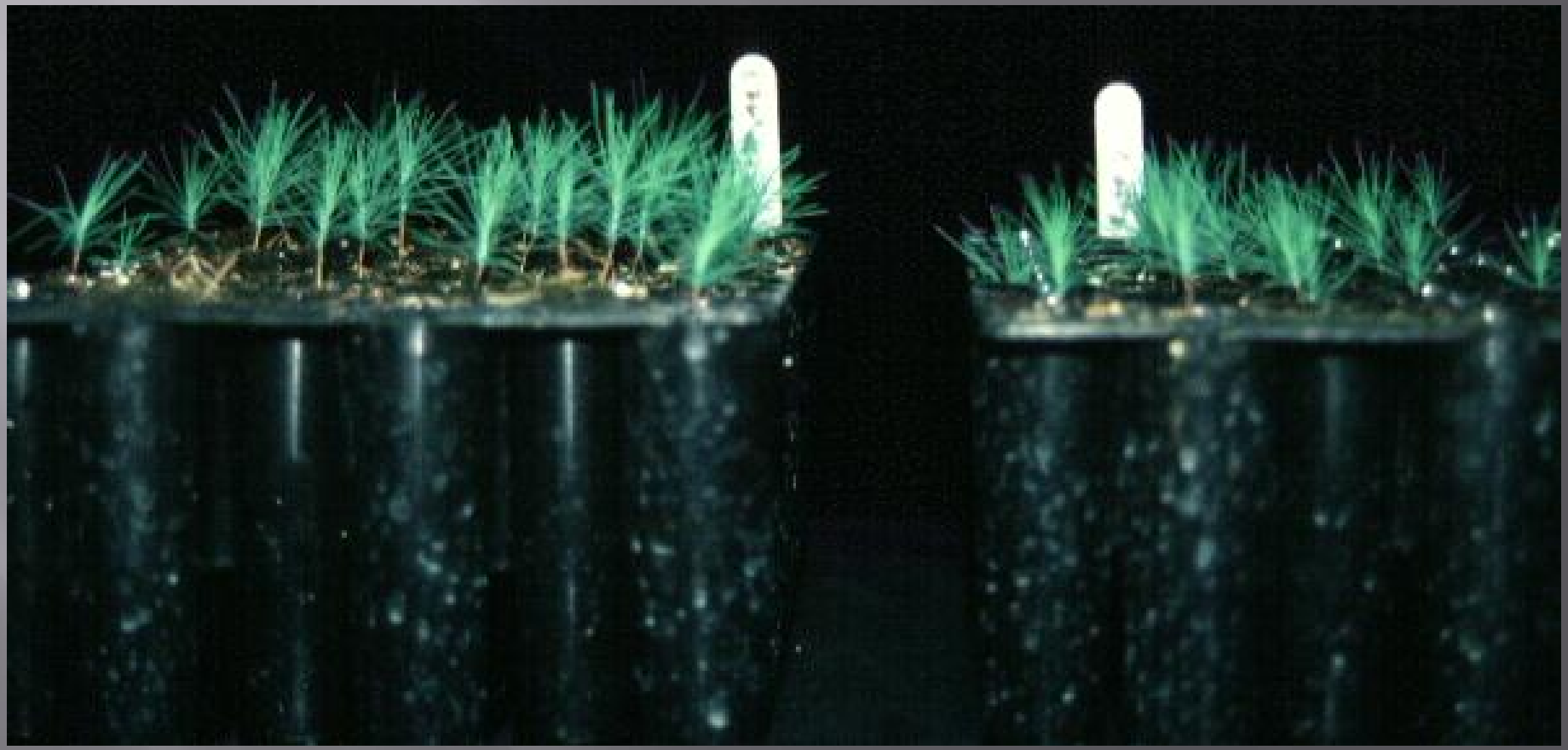
Agents

- Bacteria – PGPR
- Fungi
- Mycorrhizae
- Soil amendments

Commercially Available Products

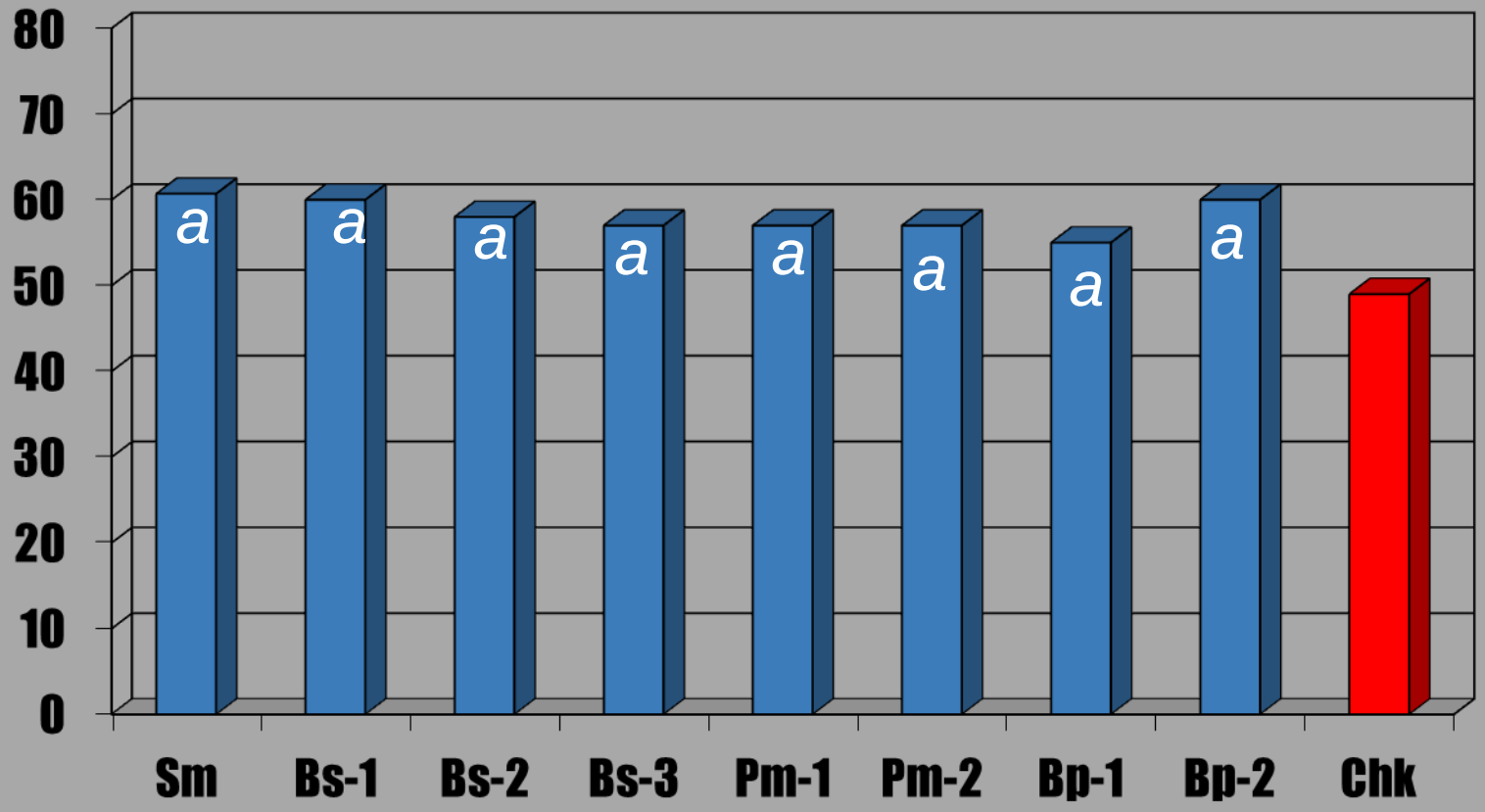
Product	Bacteria	Target Effect
Kodiak	Bacillus subtilis	Growth promotion & Biocontrol of Rhizoctonia and Fusarium
Deny	Burkerholdia cepecia	Biocontrol of Fusarium & Pythium
Actinovate	Streptomyces lydicus	Biocontrol of Pythium, Fusarium & Rhizoctonia
YIB	Bacillus spp.	Root growth promotion
Epic	Bacillus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

Year	Bacteria	Density (ft2)	RCD (mm)	Hgt (cm)	Root Wgt (g)	Shoot Wgt (g)
1	No	**21.4**	**4.3**	**21.4***	**0.68**	**3.1**
	Yes	**21.8**	**4.2**	**19.7**	**0.72**	**3.0**
2	No	**21.7**	**3.6**	**25.3***	**0.71**	**2.7**
	Yes	**22.7**	**3.6**	**24.5**	**0.66**	**2.6**
3	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 over three years.

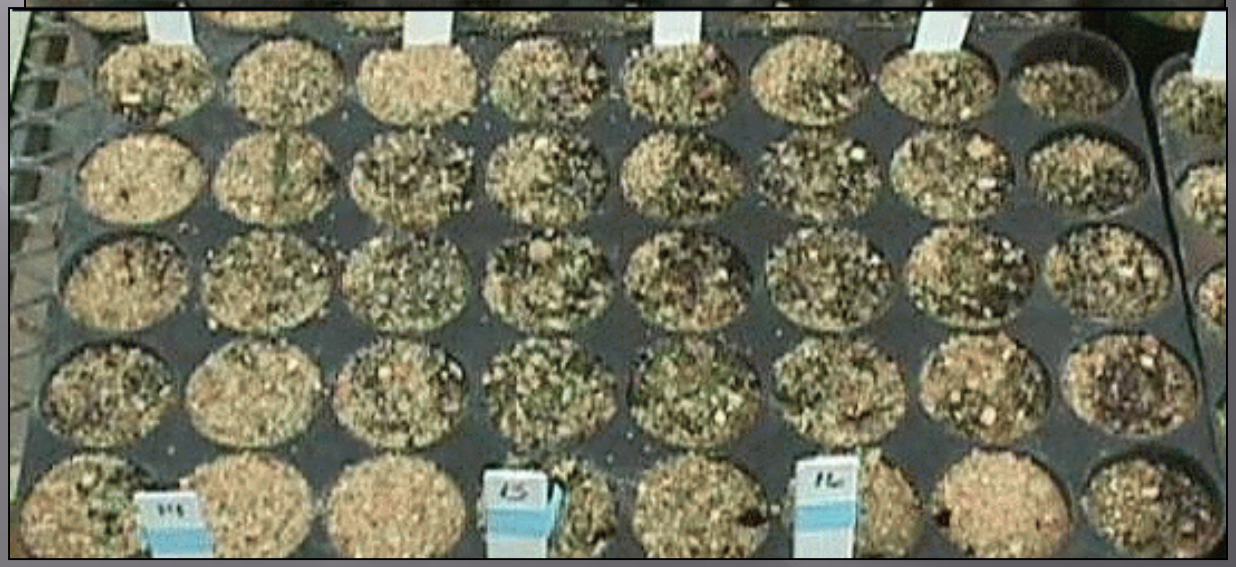
Year	Bacteria	Density (ft2)	RCD (mm)	Hgt (cm)	Root Wgt (g)	Shoot Wgt (g)
1	No	22.5	4.6	na	0.79	2.9*
	Yes	23.8*	4.4	na	0.72	2.7
2	No	21.6*	5.0	na	0.89	3.1
	Yes	19.4	5.2	na	0.96*	3.4*
3	No	24.8	5.1	na	0.90	3.4
	Yes	25.4*	5.1	na	0.90	3.3

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
- More amenable to container systems

Fungal Seed Treatment

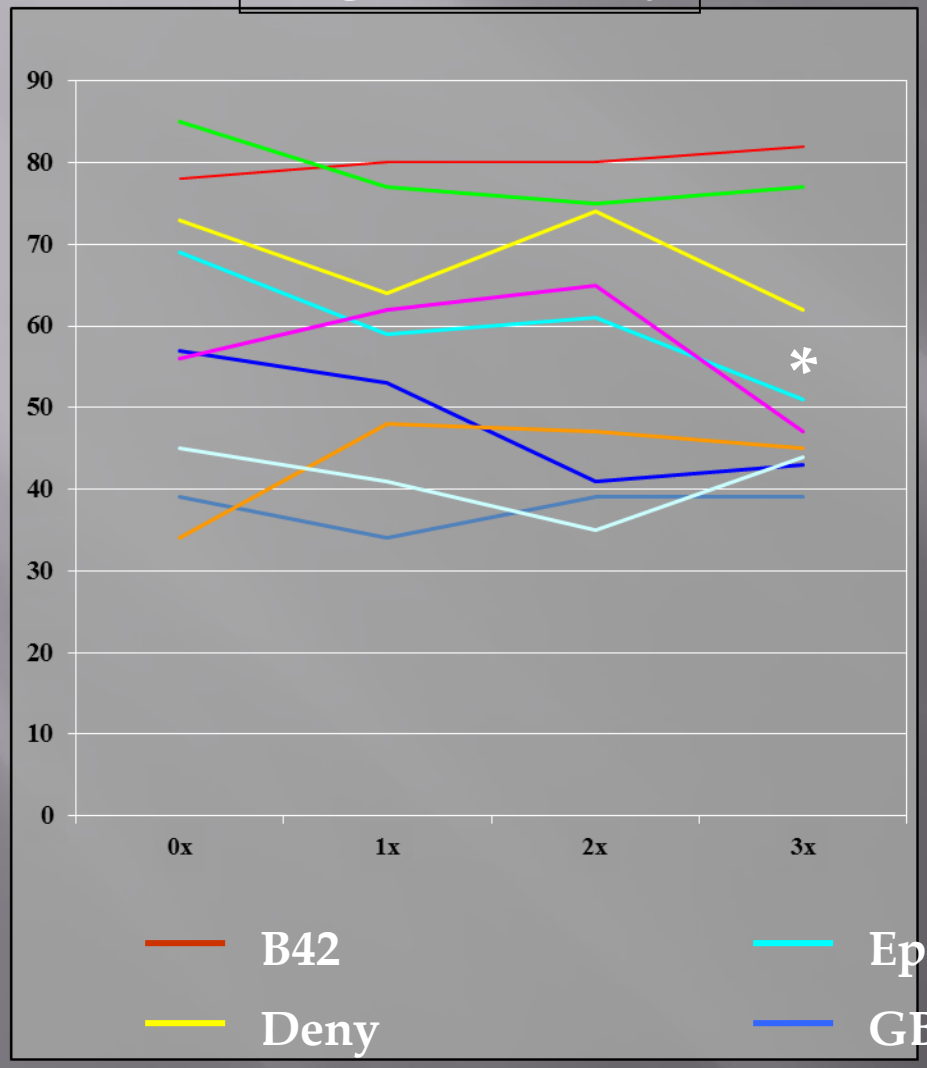
Pre-treatment high-viability seed lot



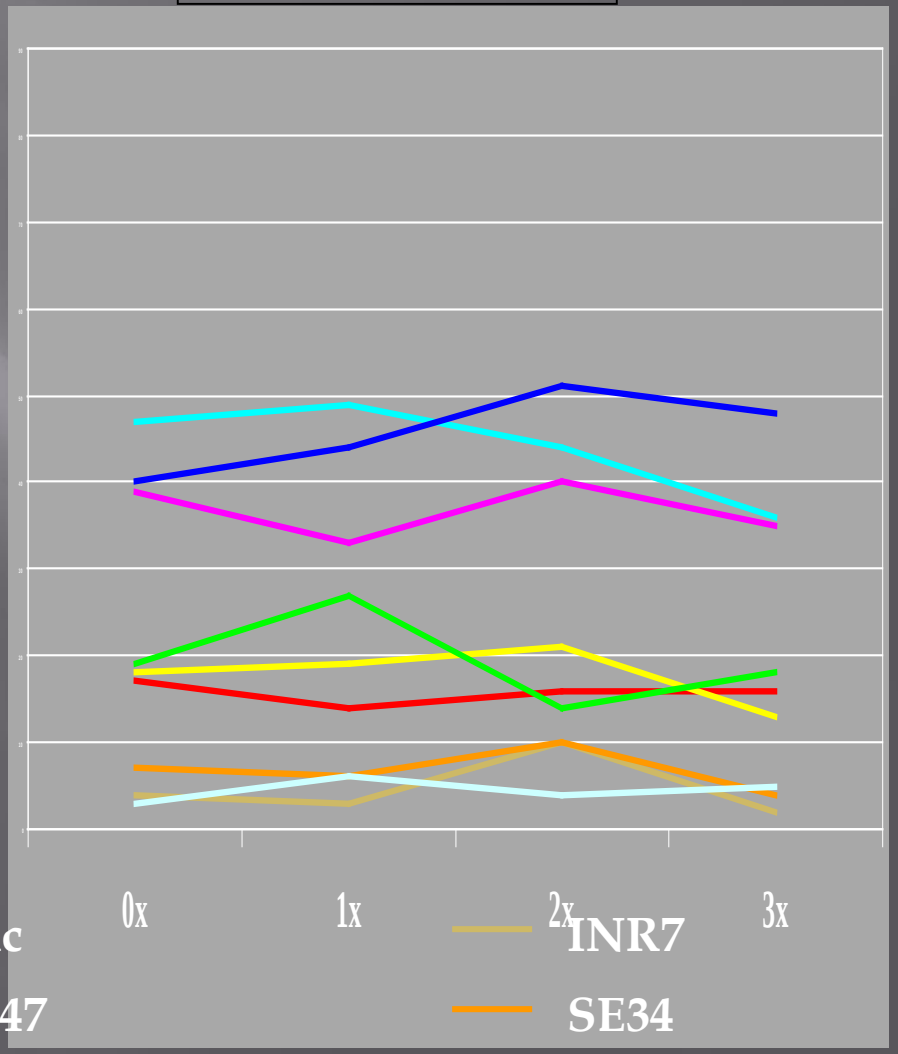
Pre-treatment low-viability seed lot

Biological Seed Treatment

High-viability



Low-viability



Summary & Conclusions

- Biological agents neither increased nor decreased longleaf seed germination.
- Fungicide treatments resulted in a 10% increase in percent germination.
- Biological agents inconsistency is still a factor in their lack of adoption

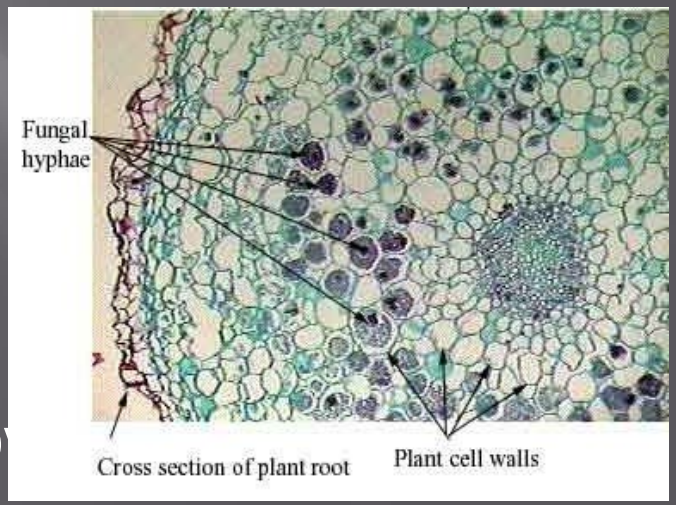
Biological - mycorrhizae

- 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.

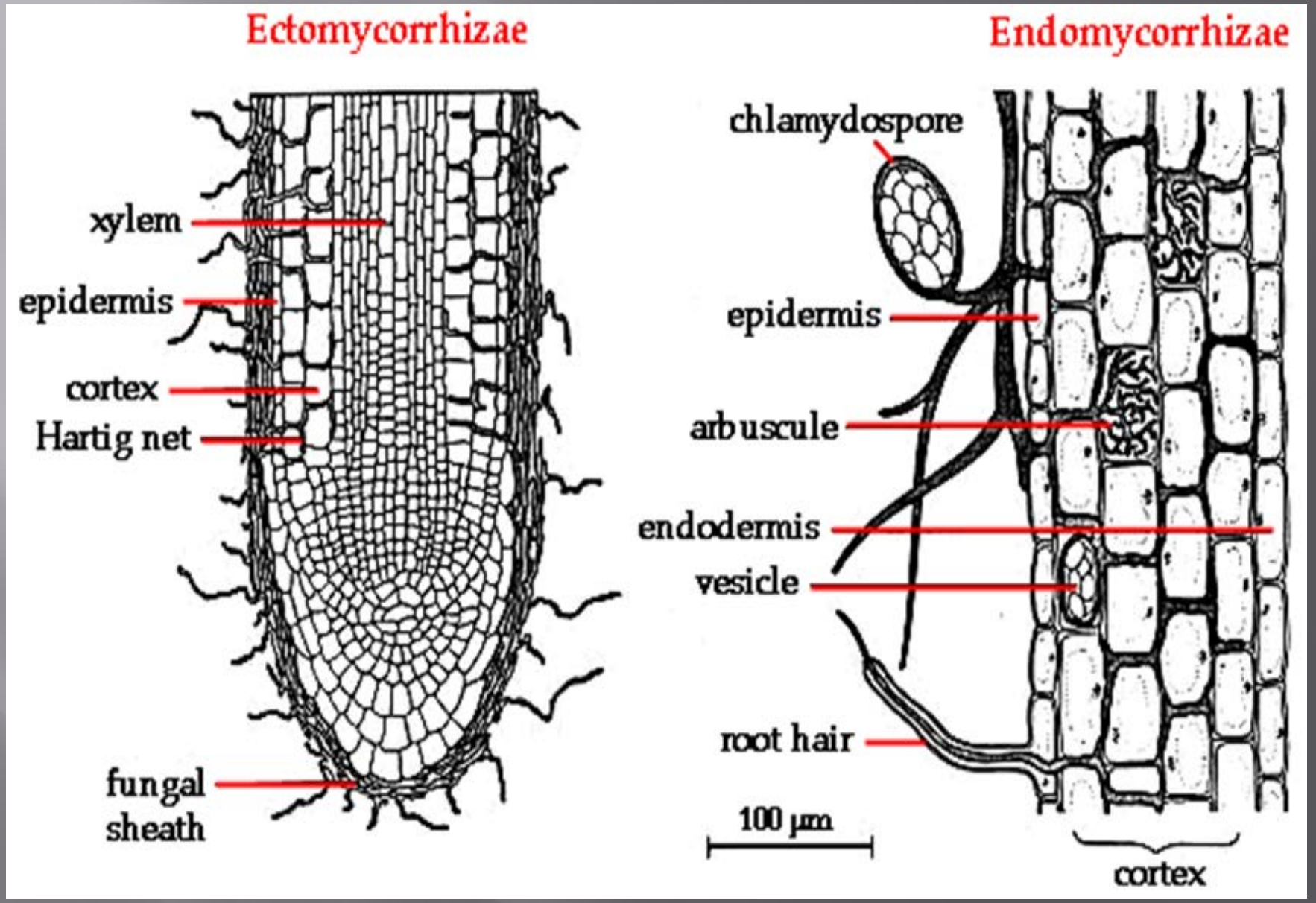
Ectomycorrhizae (outside)

- 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 on plant roots
- Spread via infected roots
- Found on many hardwoods and co


Ectomycorrhizae
xylem
epidermis
cortex
Hartig net
fungal sheath
Endomycorrhizae
chlamydospore
epidermis
arbuscule
endodermis
vesicle
root hair
100 µm
cortex

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 ectomycorrhiza 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 / Amendments

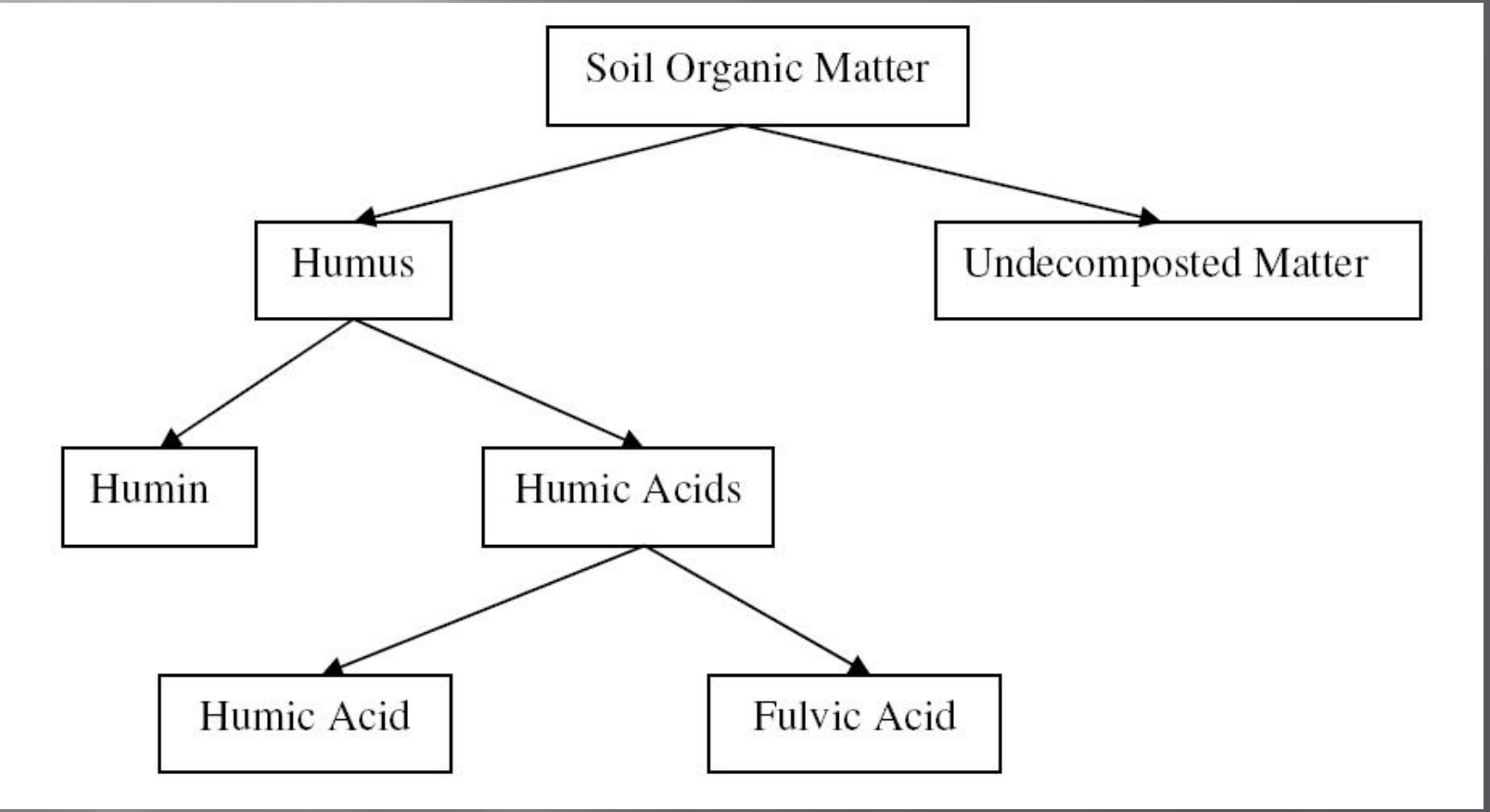
- Test on small areas over a period of a few years under normal conditions before adopting wide scale use.

RESPONSE OF LOBLOLLY AND SLASH PINE TO HUMIC, FULVIC ACIDS AND BIOLOGICAL STIMULANTS

Tom Starkey & Scott Enebak

Southern Forest Nursery Management Cooperative

Where do Humic Acids Come From?



What are "Humic Acids"?

HUMIC ACIDS

- HA defies a precise definition. It is a black or very dark brown, high molecular weight water soluble at pH >2.
- The color has been used effectively as a sales or advertising attribute – conjuring up images of dark fertile soils.

FULVIC ACID

- FA light yellow to yellowish brown in color and are small molecular weight water soluble at all pH ranges
- More active in the plant than HA

What are "Humic Acids"?

HUMIC ACIDS

- Some studies have shown HA to increase the effectiveness of inorganic fertilizer by improving nutrient uptake and enhancing the physical, chemical and biological properties of the soil.

FULVIC ACID

- Used as a fertilizer additive, compatible with most fertilizers and pesticides. Commonly applied as foliar/soil application

What are "Humic Acids"?

HUMIC ACIDS

- Humic Acid is probably the most common carrier in the many "biologicals" that are being marketed today.
- Used as a carrier for many chelated iron solutions.
- It has very high cation exchange capacity (CEC) – 500 to 600 meq/100 g soil (sandy soil - 3 to 25 meq/100 g soil)
- Available in both liquid and granular form

FULVIC ACIDS

- Studies using marked FA have shown that FA is capable of entering the plant while HA remain outside.
- Available in liquid form.

Nursery Cooperative Studies

- 2008 – Greenhouse study comparing HA and 2 biologicals on growth of slash and loblolly pine
- 2009 – Study at 2 nurseries looking at 3 rates of granular HA. (Applied post sowing)
- 2009 – Greenhouse study comparing 2 "biologicals" with HA and FA.
- 2010 – Rate response of 3 levels of HA & FA

"Biologicals" vs humic and fulvic acids

- Nature's NOG - The MSDS sheet describes the product as processed and modified seaweed extract and humate derivatives. Forty elements and compounds are listed..
- Hydromax - A liquid extract from metal tailings from the Iron King Mine. Tailings were used for production of Ironite® which contains 22 beneficial elements.
- Hydra-Hume – 12 % Humic Acid +
- NutrAsyst – 5% Fulvic Acid
- Fertilizer (Control) – 30-10-10 water soluble

SPECIMEN

Hydra-Hume

0-0-1

GUARANTEED ANALYSIS:
Soluble Potash (K_2O).....1.00%

Derived from potassium hydroxide.

ALSO CONTAINS NON-PLANT FOOD INGREDIENTS:

ACTIVE INGREDIENTS: 12.00% .....Humic Acid (Derived from leonardite)
INERT INGREDIENTS: 87.00%.....INERT INGREDIENTS

KEEP OUT OF REACH OF CHILDREN

CAUTION

See Inside Panel for Additional Precautionary Statements.

SN 0505/0108-Ag WEIGHT PER GALLON: 8.8 lbs (3.99 kg)

NET CONTENTS:
- ☐ 5 gal (18.93 L) Net Wt: 44 lbs (19.96 kg)
- ☐ 250 gal (946.25 L) 2,200 lbs (997.92 kg)
- ☐ 275 gal (1,040.88 L) 2,420 lbs (1,097.71 kg)

Information about the components of this lot of fertilizer may be obtained by writing to Helena Chemical Company, 225 Schilling Boulevard, Suite 300, Collierville, TN 38017 and giving the lot number which is found on the container.

Information regarding the contents and levels of metals in this product is available on the Internet at http://www.aapfco.org/metals.htm .

F224
MANUFACTURED FOR
HELENA CHEMICAL COMPANY
225 SCHILLING BOULEVARD, SUITE 300
COLLIERVILLE, TN 38017

SPECIM

NutrAsyst

FERTILIZER ADDITIVE

ACTIVE INGREDIENT(S):
5.00%.....Fulvic Acid.
95.00%.....Other Ingredients
100.00%.....TOTAL

THIS PRODUCT IS NOT A PLANT FOOD OR SOIL AMENDMENT

KEEP OUT OF REACH OF CHILDREN

CAUTION

See Inside Panel for Additional Precautionary

SN 090308
NET CONTENTS: 5 Gallons (18.93 Liters)
30 Gallons (113.55 Liters)
275 Gallons (1040.88 Liters)
Bulk gallon

WT. PER GALLON: 8.5 lbs. @ 68°F (3.95 kg PER LITER @20°C)

MANUFACTURED FOR
HELENA CHEMICAL COMPANY
225 SCHILLING BOULEVARD, SUITE 300
COLLIERVILLE, TN 38017

GENERAL INFORMATION

2009 "Biologicals" vs humic and fulvic acids

- Rate used were suggested label rates.

Component treatments applied at all biweekly applications.

	Total Water	Hydromax	NOG	Hydra-Hume	NutrAsyst	Fertilizer
Hydromax	15.1 l	15.8 ml/l				0.4g/l
Natures NOG	15.1 l		15.8 ml/l			0.4g/l
Hydra-Hume	15.1 l			1.6 ml/l		0.4g/l
NutrAsyst	15.1 l				1.6 ml/l	0.4g/l
Fertilizer	15.1 l					0.4g/l

- 15 container sets (replication) /treatment. 20 cavities (experimental unit) of Loblolly pine and 20 cavities (experimental unit) of Slash pine per container set.
- Biweekly applications of treatments began 6/18/09. There were a total of 9 applications over the season

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Loblolly Pine

	October 2009 Final				
	RCD (mm)	HT (cm)	Top Dry (gm)	Root Dry (gm)	Total Top Dry (gm)[1]
Hydromax	2.8 b	28.5 a	1.30 a	0.397 b	1.34 a
Natures NOG	2.5 c	27.2 b	0.94 c	0.429 ab	0.98 c
Hydra-Hume	2.7 b	26.4 b	1.07 b	0.398 b	1.09 b
NutrAsyst	3.0 a	28.5 a	1.26 a	0.467 a	1.30 a
Fertilizer	2.7 b	28.6 a	0.97 bc	0.333 c	1.00 bc
lsd	*0.12*	*1.2*	*0.101*	*0.524*	*0.101*

[1] Total Top Dry = includes dry weight of top clippings from July

Boxes in yellow are significantly greater than fertilizer control

Slash Pine

	October 2009 Final				
	RCD (mm)	HT (cm)	Top Dry (gm)	Root Dry (gm)	Total Top Dry (gm)[1]
Hydromax	3.1 b	29.1 a	1.54 a	0.506 b	1.61 a
Natures NOG	2.9 c	25.8 b	1.11 c	0.642 a	1.17 c
Hydra Hume	3.1 b	26.2 b	1.29 b	0.522 b	1.36 b
NutrAsyst	3.3 a	28.6 a	1.46 a	0.556 ab	1.52 a
Fertilizer	3.1 b	26.5 b	1.26 b	0.522 b	1.33 b
lsd	*0.12*	*1.2*	*0.126*	*0.109*	*0.115*

[1] Total Top Dry = includes dry weight of top clippings from July

Boxes in yellow are significantly greater than fertilizer control

Price (w/o quantity discounts)

- **Hydromax** - Per acre rate of 88 fl oz/acre = $17.18
- **Nature's NOG** - Per acre rate of 88 fl oz/acre = $41.25
- **Hydra Hume** – Per acre rate of 1 gal/acre = $11.50 (Humic Acid)
- **NutrAsyst** – Per acre rate of 1 gal/acre = $12.50 (Fulvic Acid)

2010 Rate Study of Humic and Fulvic Acid

- Purpose: to test three rates of humic and fulvic acid to determine response range.
- 15 container sets (replication) /treatment. 20 cavities (experimental unit) of Loblolly pine and 20 cavities (experimental unit) of Slash pine per container set.
- Biweekly applications of treatments began 5/17/10. There were a total of 10 applications over the season.

Amount of water and treatments applied to each 15 container sets per treatment at each biweekly application.

Treatment	Total Water	Hydra-Hume	NutrAsyst	Fertilizer
HA 1	15.1 l	1.6 ml/l		0.4g/l
HA 2	15.1 l	4.0 ml/l		0.4g/l
HA 3	15.1 l	8.0 ml/l		0.4g/l
FA 1	15.1 l		1.6 ml/l	0.4g/l
FA 2	15.1 l		4.0 ml/l	0.4g/l
FA 3	15.1 l		8.0 ml/l	0.4g/l
Control	15.1 l			0.4g/l

Loblolly Pine

		FULVIC ACID			HUMIC ACID		
	Control	FA1	FA2	FA3	HA1	HA2	HA3
RCD	2.29	2.38 **	2.30	2.33	2.30	2.32	2.33
Root DW	0.29	0.33 **	0.42 **	0.31	0.31	0.31	0.32
Shoot DW	0.69	0.79 **	0.77 **	0.69	0.69	0.72	0.73
Total DW	1.01	1.15 **	1.24 **	1.04	1.02	1.05	1.07

*** - Significantly different from Control at the 0.05 level using Dunnetts test*

Slash Pine

		FULVIC ACID			HUMIC ACID		
	Control	FA1	FA2	FA3	HA1	HA2	HA3
RCD	2.44	2.63 **	2.55 **	2.66 **	2.63 **	2.76 **	2.54
Root DW	0.31	0.40 **	0.32	0.35	0.39 **	0.32	0.37 **
Shoot DW	0.67	0.91 **	0.75 **	0.72	0.79 **	0.83 **	0.83 **
Total DW	1.05	1.32 **	1.12	1.13 **	1.24 **	1.19 **	1.24 **

*** - Significantly different from Control at the 0.05 level using Dunnetts test*

Conclusions and observations

- Slash pine responded more to "Humic Acids" than loblolly pine.
- Slash pine responded more to fulvic acid than humic acid.
- Optimum rate for HA may be higher than study rates
- More potential for use in container nurseries which rely on water soluble liquid feed than bareroot nurseries
- HA and FA are safe for use in nurseries @ label rate
- When purchasing HA or FA stay with a reputable vendor. Industry standards (especially for HA) have not been developed.

Biologicals / Amendments

- **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 limited.**