Scaling-up nanocellulose-based adjuvants for sustainable pesticide delivery

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SFNMC Contact meeting

Cellulose-based carriers for agrichemicals delivery
Drs. Wheeler Foshee, Horticulture Department, AU
Drs. Jason White & Shital Vayida
Dr. Annakay Newell, Elizabeth
Bowersock and Nina Payen
Southern Forest Nursery Management Cooperative
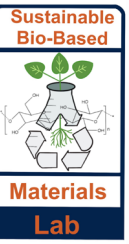
Peresin's lab team members working in this team
Sydney Brake
Duber Garces
Dr. Adriana Restrepo-Osorio

SOUTHERN FOREST NURSERY MANAGEMENT COOPERATIVE
COLLEGE OF FORESTRY, WILDLIFE AND ENVIRONMENT

USDA
United States Department of Agriculture
National Institute of Food and Agriculture

AUBURN UNIVERSITY
ALABAMA AGRICULTURAL EXPERIMENT STATION

Current efforts

A. USDA Foundational and Applied Science (3 years): "Surface Tunable Nanomaterial-Based Biopolymers For Precise Foliar- And Soil-Based Delivery Of Agrochemicals

Total amount requested: $499,998

Partners: USDA FPL, John Hopkins University, CAES → submitted in September 2024 – received ratings a week ago but no decision on funding were made

B. P3 Nano USDA Endowment → Submitted 11/13/2024 ***supported BY IFCO and Westervelt***

1. Development (3 years): "Scaling-up Nanocellulose-based Adjuvants for Sustainable Pesticide Delivery"

Total amount requested: $500,000

Partners: USDA FPL, Purdue University, CAES → Not funded

2. Exploratory (1 year): "Nanocellulose-based Prills for Sustainable Controlled Release of Pesticides"

Total amount requested: $100,000

Partners: USDA FPL, Purdue University, CAES → → this was funded but funds are frozen and won't be released until further notice

Introduction - Background

Challenges

Pine Tip Moth Impact
- Damage to buds/apical meristem → mortality, poor growth, lower timber value
- Major economic losses in SE U.S. (1B+ seedlings/year)

Fipronil (PTM™)
- **A single application** before field out planting
- Long-lasting insecticide (up to 2 years)

Adoption Challenges
- High toxicity & cost
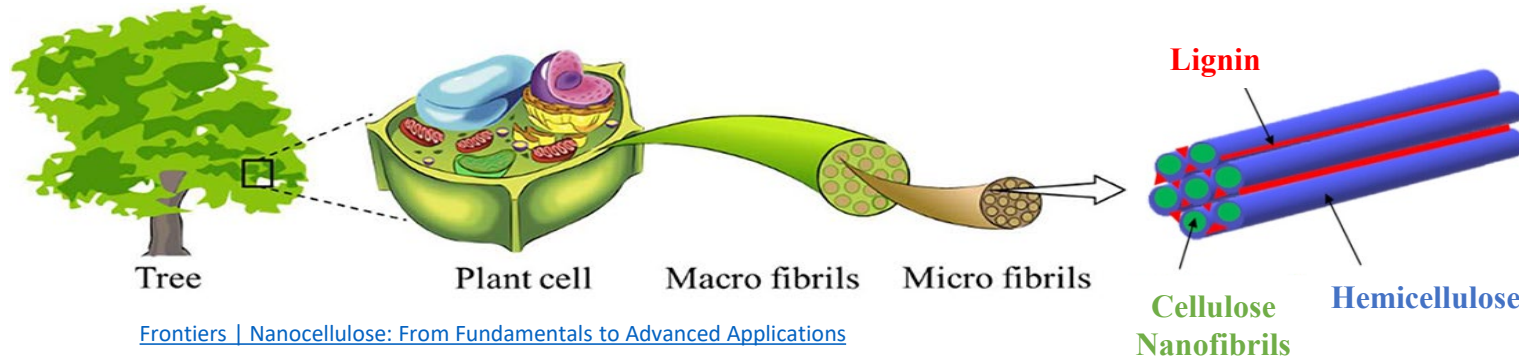- Rain leaching reduces effectiveness

Traditional pesticide applications
- Low retention
- High environmental loss
- Inefficient uptake

Introduction - Approach

Nanocellulose as adjuvant

Adjuvant
- Substance added to pesticide formulations
- Enhances the effectiveness, retention
- Can improve absorption, reduce drift, or increase uptake

Frontiers | Nanocellulose: From Fundamentals to Advanced Applications

•Renewable
•Biodegradable
•Highly tunable
•High surface area enables efficient pesticide adsorption.

Lignin-containing **nanocellulose**

Residual lignin enhances compatibility with cell wall composition and thus improves retention

-Hydrophobic domains
-Chemical affinity with active ingredients

Objective

To evaluate the effectiveness of nanocellulose as a delivery system for Fipronil in container loblolly pine (*Pinus taeda*) and whether it provides extended protection against pine tip moth (*Rhyacionia spp*.) damage in the field.

Experimental - Adjuvant Formulation

Microfibrillated cellulose production

Raw material:
Lining containing (brown) Softwood (SW)/Hardwood (HW) cellulose pulp 50/50 from a local mill

High shear mechanical defibrillation

Lignin containing microfibrillated cellulose
LMFC HW/SW 50/50 1.66%

Fipronil (PTM) blend with LMFC

Solutions:
0.3% LMFC SW/HW
9.1% Fipronil (PTM)

Full Dose PTM = 1X

Half Dose PTM = 0.5X

Quarter Dose PTM = 0.25X

Site 1 (PRT-IFCO-Doug and Josh) 02-16-2024
Site 2 (The Westervelt Company) 02-29-2024

Nina Payne, Annakay Abrahams, Luke Strickland, Elizabeth Bowersock, Duber Garces.

Materials:
- Fipronil / LMFC SW/HW
- Loblolly pine seedlings
- The pine trees were planted on 1 acre located in:
  - Moultrie, GA
  - Eutaw, AL.

- 12 furrows in which 4 treatments and 1 control (12 feet between each furrow) were applied.

- For each treatment, 10 loblolly pine seedlings were used, around 600 pine trees at each site.

Planting Procedure with Dribble

https://www.aces.edu/blog/topics/forestry/planting-southern-pine-seedlings/
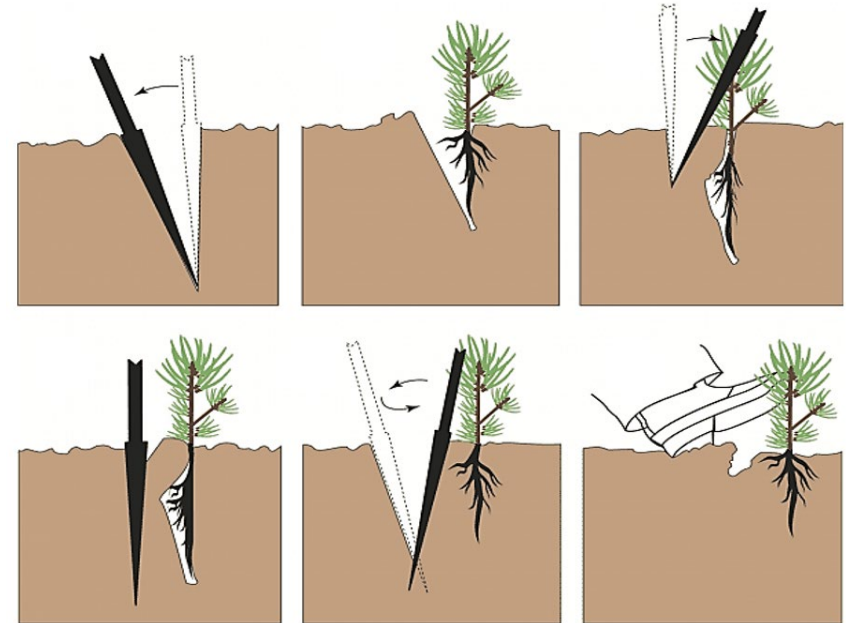
Experimental - Data Collection

Experimental Data Collection

1. **Pine tip moth damage**
2. **Seedling survival**
3. Seedling growth
4. Seedling morphology
5. Fipronil levels in seedlings

Initial data collection was planned 6 months after planting and annually thereafter.

- **Site 1:** First data collected in *August 2024*
- **Site 2:** First data collected in *September 2024*

- **Upcoming visits:**
  - September 2025
  - September 2026

Trt#	Description
1	No treatment
2	1X label rate
3	Nano +1X label rate
4	Nano +1/2X label rate
5	Nano +1/4X label rate

August 2024 (Site 1 ,data collection)

Grooves and colors indicating the treatment applied were identified.

Pine needle samples were taken, dividing the treatments into side A and B to have duplicates of each treatment.

September 2024 (Site 2, data collection)

The condition of the pine trees was also studied.

The samples taken were recorded and frozen for further analysis.

Results - Tip Moth Damage

Site 1. Tip moth damage six months after seedling plug application
(08-16-2024)
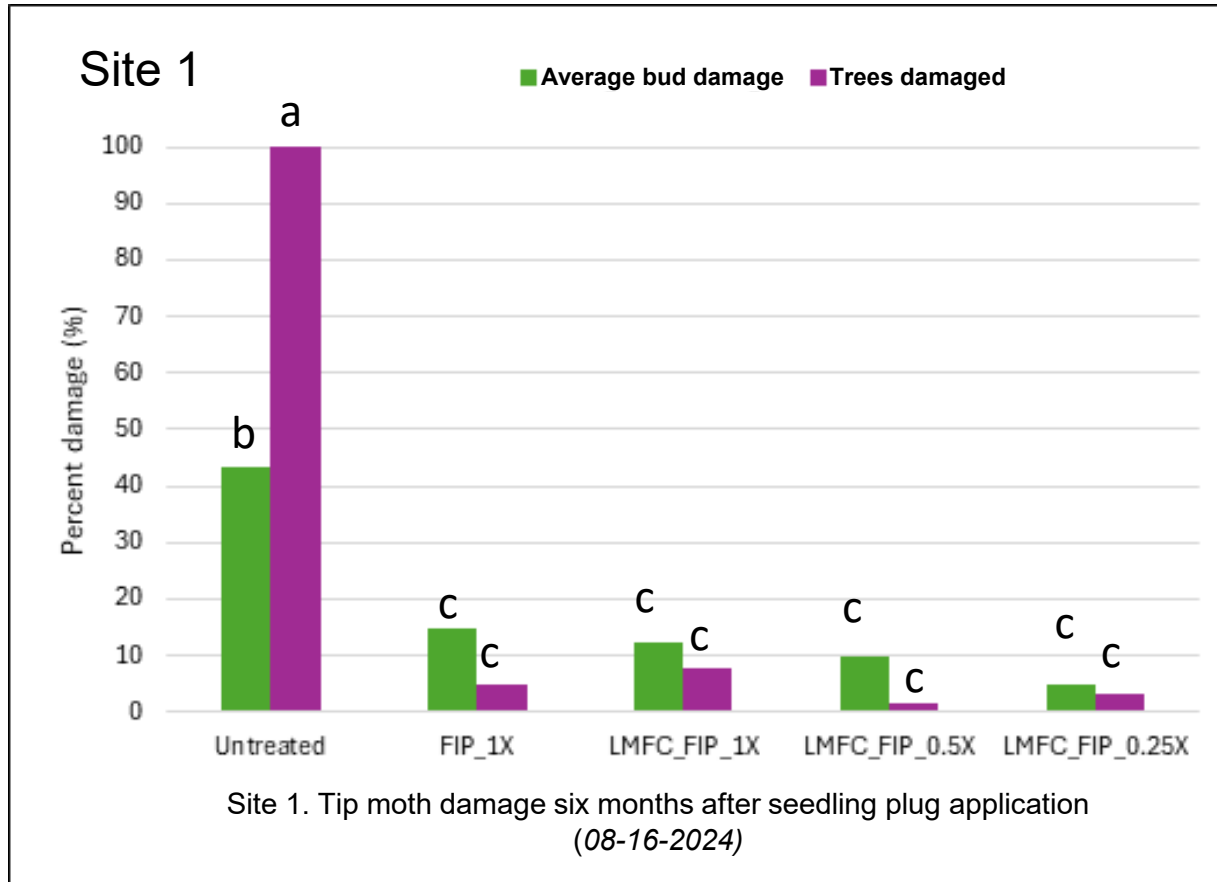
To determine if there were statistically significant differences between treatments, we used the **Tukey's Honestly Significant Difference (HSD) test**.

- The untreated trees (labeled "a and b") were significantly different from the other treatments, which all shared the letter "c."

- These results so far indicate that the use of Fipronil, at any dose, significantly reduces tree and bud damage compared to untreated trees.

Tukey's HSD test was performed (α = 0.05) using a total of 120 trees, with 10 trees per treatment per replicate.

Results - Tip Moth Damage

Site 2. Tip moth damage six months after seedling plug application *(09-15-2024)*
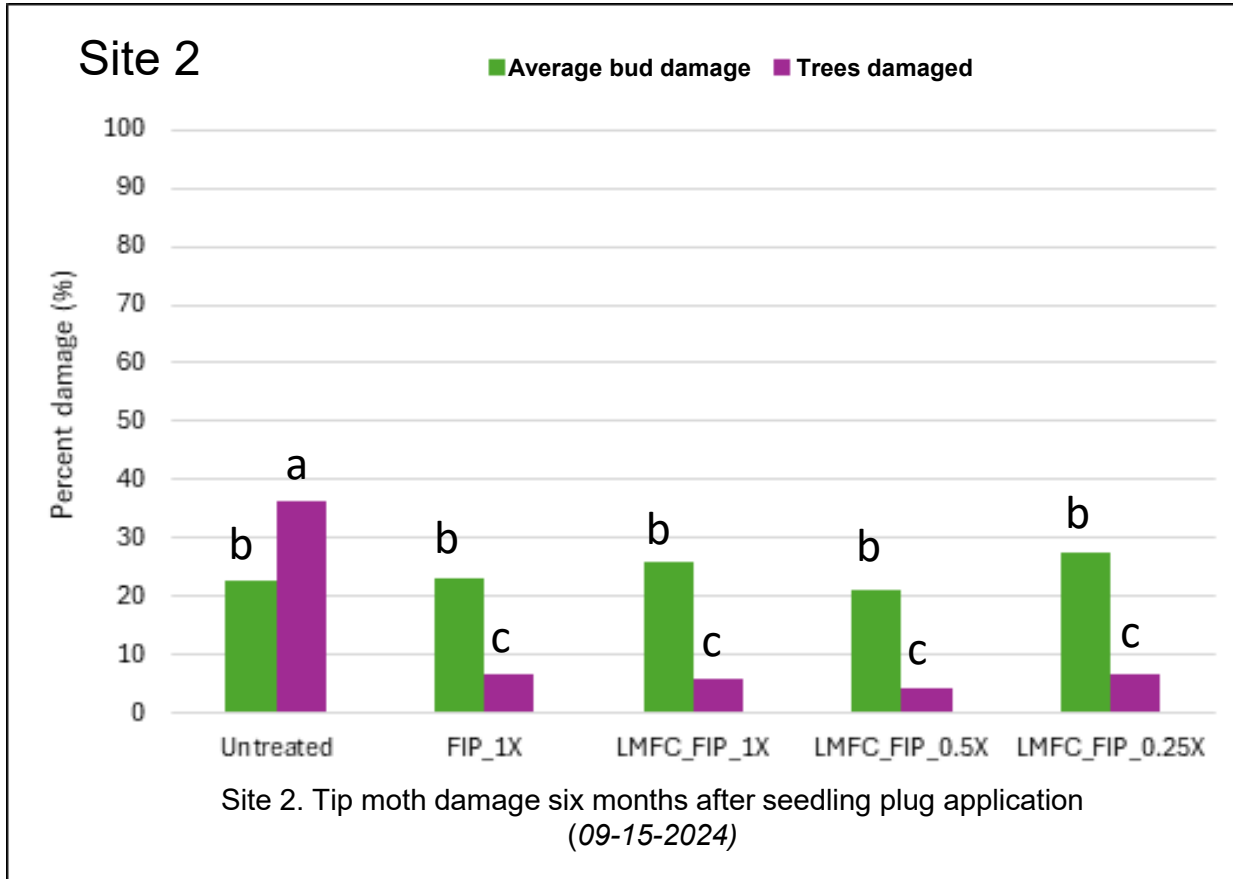
Means followed by different letters are significantly different (Tukey's HSD, α = 0.05).

- The untreated had a **significantly higher** percentage of damaged trees compared to all other treatments.

- The remaining treatments, **even those with reduced Fipronil dosage**, **did not differ significantly from each other**.

Tukey's HSD test was performed (α = 0.05) using a total of 120 trees, with 10 trees per treatment per replicate.

Partial conclusions and next steps

- The combined use of fipronil with nano/microfibrillated lignin-containing cellulose, especially at reduced doses, indicates promising results regarding extended trees protection.

- Reducing the fipronil dose by half and then by a quarter (with nanocellulose) maintains the effectiveness of the treatment.

What's next?

- Collect data and send leaves for analysis to determine the persistence of fipronil.

New chapter coming up

- Director, Wood Utilization and Design Institute
- Professor Forestry & MSE (effective August 1st, 2025)

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- **Professor** Forest Biomaterials (announced April 15th, 2025)

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