SOILLESS SUBSTRATE SCIENCE

Ferrous Sulfate Pine Bark Substrate Additive to Reduce Leaching

Deveny Gilmore; Kevan W. Lamm, Ph.D.; James Altland, Ph.D.; Tope Arayombo

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Why This Matters:

- Nursery crops use a lot of phosphorus fertilizer because it is essential for general health and vigor.
- Excess phosphorus can leach (drain) out of pots and run off into nearby surface water.
- This runoff causes water pollution, leading to nutrient overload and algal blooms that harm aquatic ecosystems.
- Certain counties have fees for nitrogen leaching.
- Leaching is especially common in nurseries using pine bark-based substrates.
- Phosphorus loss is not only bad for the environment, but also expensive for growers, since they must replace lost fertilizer.
- The study's goal is to reduce phosphorus leaching by adding a layer of ferrous sulfate–amended pine bark to the bottom of nursery pots.

Background & Research Insights:

- The study compared phosphorus leaching from:
  - Pots with only pine bark
  - Pots with a layer of ferrous sulfate–treated pine bark
  - Exp 1 (15 weeks): Soluble fertilizer added daily via spray stakes; 500 cm^3 of base layer and 5.9 kg per cubic m of dolomite.
  - Exp 2 (19 weeks): Controlled release fertilizer in the upper layer (117 mg P per pot); 500 cm^3 of base layer, with or without dolomite; overhead irrigation.
- Results showed a significant reduction in phosphorus leaching and fertilizer loss.
- Ferrous sulfate-treated pine bark layer reduced P in leachate (22–73% depending on Fe rate and layer depth).
- Researchers also tested whether the added iron (ferrous sulfate) affected substrate pH and plant growth.
  - Iron did lower pH slightly, but this effect could be reduced by:
    - Adding dolomite to the substrate, or
    - Lowering the concentration of iron used

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Materials & Inputs Needed:

- The study used iron and sulfate–amended pine bark [hammermilled pine] that had been aged for six months.
- No plants were grown; this study measured leachate from pine bark substrates in container. The pine bark varied in particle size.
    - Coarse: >2.8mm
    - Medium: between 2.8 and 0.71mm
    - Fine: <0.71mm
- Two fertilization methods were tested:
    - Controlled-release fertilizer
    - Soluble fertilizer
- Each fertilizer type was tested in separate trials to see if results were consistent across methods.
- Dolomite was added to neutralize acidity caused by the iron sulfate, helping to maintain stable pH levels.

Step-by-Step Guidelines:

Step 1: Preparing the Substrates
- Mix pine bark with different amounts of ferrous sulfate ($FeSO_4 \cdot 7H_2O$) and dolomite to create ferrous sulfate–amended pine bark (FSB).
- Prepare~~d~~ mixtures in small batches for even distribution.
- Seale~~d~~ and incubated the FSB for seven days to let the iron react with the pine bark before use.

Step 2: Filling the Containers
- After incubation, place~~d~~ the FSB mixture at the bottom of 2.5-liter pots, forming a layer 4 cm or 7.5 cm deep.
- Fill the rest of the pot with non-amended pine bark, creating two distinct layers.
- Control pots should contain only non-amended pine bark for comparison.
- Labele~~d~~ and randomly arrange~~d~~ all pots in the greenhouse.

Step 3: Irrigation and Fertilization Setup
- Install a spray stake and automatic irrigation system for each pot.
- Apply daily watering and fertilization using a liquid solution.
- Use short irrigation cycles to prevent overflow and ensure even wetting.
- Rotate spray stakes weekly for better water distribution.

Step 4: Collecting Leachate Samples
- Place each pot inside a larger bucket to collect runoff (leachate).
- Collect samples weekly during the 15–19-week experiment.
- Measure leachate volume and tested for phosphorus (P), iron (Fe), and pH.
- Use clean buckets each time to avoid contamination.

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Step 5: Substrate Sampling and Analysis
- At the end of the experiment, removed and separated the top and bottom substrate layers.
- Test samples for soluble and total phosphorus and iron.
- Use standard lab methods (e.g., saturated media extracts and acid digestion).
- Calculated how much phosphorus was retained by the FSB layer versus how much leached out.

Step 6: Data Recording and Statistical Analysis
- Record all measurements and observations throughout the experiment.
- Conduct statistical analyses (ANOVA and regression tests).
- Evaluate the effects of iron rate, layer depth, and dolomite addition.
- Compare treatments to find which setup most effectively reduced phosphorus leaching.
- Determine if the FSB layer was a practical solution for controlling nutrient runoff.

Tips & Pitfalls:

- Mix thoroughly: Ensure ferrous sulfate and dolomite are evenly mixed into the pine bark for consistent chemical reactions and phosphorus retention.
- Maintain uniform irrigation: Keep watering and fertilization consistent, since uneven application can affect leaching results.
- Prevent contamination: Make sure containers are properly sealed in leachate collection buckets to stop evaporation or cross-contamination between samples.
- Avoid inconsistencies: Uneven watering or changing fertilizer concentrations can skew phosphorus readings and lead to unreliable data.

Expected Outcomes:

- Growers should see a clear reduction in phosphorus leaching from nursery pots.
- Adding a base layer of ferrous sulfate–amended pine bark (FSB) helps trap phosphorus in the substrate instead of losing it through runoff.
- Results in less nutrient pollution and more efficient fertilizer use.
- Higher iron levels and thicker FSB layers improved phosphorus retention without harming plants or increasing iron leaching.
- This simple layering method supports sustainable nursery practices while keeping plants healthy and productive.
- Growers can expect:
    - Cleaner leachate (runoff water) (P reduced 22-73% by FSB layer, greater Fe rate or deeper layer, greater reduction)
    - Better nutrient management (Fe loss was small)
    - Compliance with environmental standards (NOTE this study did not assess crop growth or regulatory compliance specifically)

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Additional Resources:

Shreckhise, J. H., & Altland, J. E. (2024). A base layer of ferrous sulfate-amended pine bark reduces phosphorus leaching from nursery containers. *Agronomy, 14*(4), 757. https://doi.org/10.3390/agronomy14040757

Visuals and Graphics:

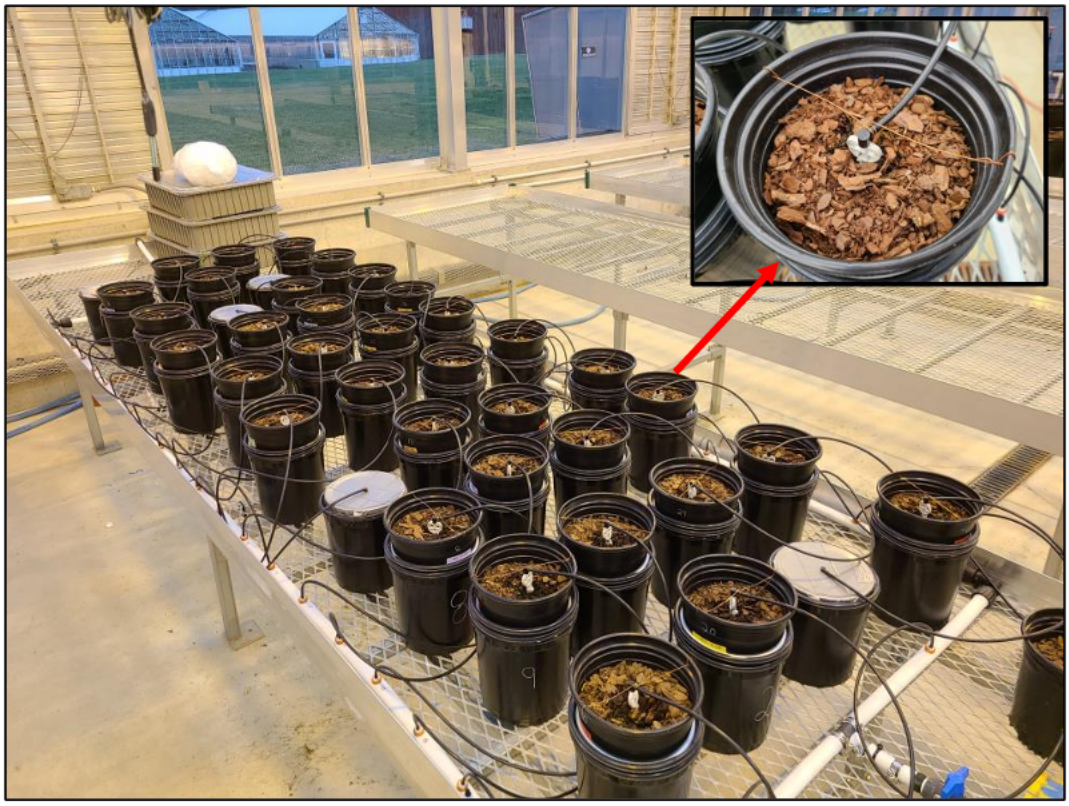

Figure showing the Photograph of a good set up experiment for substrate containers, spray stakes, and leachate buckets.

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