Chemical properties of substrates

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Today’s talk

• Important chemical properties

• The parent materials
  – Douglas fir bark
  – Pumice
  – Peat

• Substrate monitoring
Nutrient balance

• Plants require 13 mineral nutrients

• Nutrients have to be provided in balance.
Ideal, all nutrients are in relative balance.

One or more nutrients is deficient, so growth is limited.

Excess of one nutrient will not result in increased growth, may cause deficiency in another nutrient.
In terms of crop nutrition, you must consider 3 sources for the nutrients. Some nutrients can be supplied in the irrigation water. Some nutrients are supplied in the substrate (the purpose of this presentation), and a lot are provided in the fertilizer amendments. Your selection of fertilizer amendments, the part you have most control over, should only complement what is not available in the water and substrate.
Important point

• Plants do not absorb nutrients from soil particles.

• Plants only absorb nutrients from soil solution.

• Nutrients must be in solution in order to be absorbed!!!
Water is retained by the substrate. Nutrients from the substrate are released into solution. Only nutrients dissolved in this water are available to the plant. Nutritional monitoring (discussed at the end of this presentation) is based on how to measure the nutrients dissolved in water, which is an indication of the nutritional status of the crop.
Substrate chemical properties

- **Peat moss**
  - pH: 3.5 to 4.5
  - Available nutrients: low
  - High CEC

- **Pumice**
  - pH: 6.6 to 8.3
  - Available nutrients: very low
Peat moss has no measurable effect on pH of Douglas fir bark. Increasing the lime rate or changing the lime formulation increased substrate pH, however, adding up to 50% peat moss at the same time did not influence pH of the substrate.
The chemical properties of Douglas fir bark are the most important for understanding nutrition in container crops. These photos show one of the bark suppliers in Oregon.

It's important to note that Douglas fir bark is often ‘aged’, or stored in large piles for 3 to 7 months. It is not composted. Composting would require that it be stored in piles about 8 feet high, irrigated, turned occasionally, aerated, etc. The process shown above is not composting.
In the foreground is aged bark, in the background is fresh bark. Notice the change in color. The aging process is poorly understood with Douglas fir bark in Oregon. One of our goals was to document the differences in fresh and aged Douglas fir bark with respect to its chemical properties.
Left is aged bark, right is fresh bark.
Acceptable ranges: P=3-5ppm, K=60-149ppm, Ca=80-199ppm, Mg=30-69ppm (Warnke, 1986?. Recommended test procedure for greenhouse growth media). SO4=30-150ppm (Brookside laboratories)

This graph shows the amount of different plant macronutrients found in fresh and aged bark.
The yellow bars indicate the adequate range of each nutrient that a container growing media should have.

Raw Douglas fir bark has:
1. Very high P.
2. Sufficient K
3. Deficient Ca, Mg, and S (we do not worry about these 3 nutrients because they are often added by the grower in the form of lime).
This is a similar graph but for Fe and Mn.
Douglas fir bark seems has sufficient to very high Fe and sufficient Mn.
Fe:Mn ratio should be around 2:1. Aged and fresh bark have 9:1 and 5:1 Fe:Mn ratio, respectively

Cu recommended range: 0.003-0.35 ppm (Brookside labs), 0.02 ppm (Best management practices, 2000)

B recommended range: 0.7-2.5 ppm (Warnke, 1986. Recommended test procedure for greenhouse growth media).


Douglas fir bark has sufficient Cu, somewhat deficient B, and very low Zn.
Bark survey summary

Chemical properties:
- Very high P and sufficient K.
- Deficient Ca, Mg, and S.
- Sufficient micronutrients, except for B and Zn.
- Potentially high Fe:Mn ratio.

Physical properties:
- High air space.
- Low water holding capacity.
Micronutrients in fresh versus aged bark

Substrate type
- fresh bark
- aged bark

• Micronutrient source
  - Bark only
  - Bark + 10% compost
  - Bark + 1.5 lbs/yd³ Micromax

• *Catharanthus roseus* 'Cooler Peppermint'

• The Objective of this study was to determine if there is different micronutrients availability in fresh versus aged bark.

• The two factors analyzed were substrate type (fresh and aged) and micronutrient source (bark only, 10% compost, and 1.5 lb/Yd³ of micronutrient package).

• The test species was annual vinca.
Results first trial (6 WAP)

No differences in growth or color

Plants were measured 6 weeks after potting. Regardless of bark type or micronutrient source, there were no differences in growth or foliar color. Tissue analyses also demonstrated no differences in foliar micronutrient levels.
Summary first trial

• Douglas fir bark alone (fresh or aged) provided sufficient micronutrients for the growth of *C. roseus*.

**Results**

• Douglas fir bark alone provided sufficient micronutrients for the growth of Annual Vinca

• Results were similar in pine bark
I repeated the experiment but this time plants were grown for 8 weeks (2 weeks longer than the first time).

In this case I found differences in growth and color between fresh and aged bark. In this picture and from left to right: The first 3 rows of plants were grown in fresh bark (unamended, with compost, and Micromax), and the rest of the plants in aged (unamended, with compost and Micromax).

The letters correspond to the means separations for dry biomass.

It is likely the differences between fresh and aged bark were due to differences in available N.
Summary

• Douglas fir bark probably provides sufficient micronutrients for crop growth
  – 2006 trials on woody crops

• Adding a micronutrient package is inexpensive security.
The **Objective** was to determine if there is different N immobilization in fresh versus aged bark. The factors tested were substrate type (fresh and aged) and nitrogen rate (50, 100, and 200 ppm N).

The test species was Geranium ‘Maverick Red’ in 1 gal. containers.
**Bark type and nitrogen rate affected plant growth**

**Biomass**
Along the x axis is the applied N rate. Along the Y axis is dry stem biomass in grams.
Plants in aged bark were larger than those in fresh bark.

**Foliar N**
Along the x axis is the applied N rate. Along the Y axis is foliar N as a percent of dry matter.
Plants in aged bark had a higher N content than plants in fresh bark independently of the amount of N fertilizer received.
A photo of the geranium experiment.
NDI is the Nitrogen Drawdown Index. It measures the relative amount of N immobilized by a container substrate. The more N immobilized, the more N needs to be applied through the first 30 days of potting. Additional N applied ‘feeds’ the micro-organisms in the bark so that the remaining N is absorbed by the plant.

In the chart, the lower the bar, the more N is immobilized. Fresh bark from both sites 1 and 2 immobilized more N than aged bark. We are not certain why N immobilization was greater in site 2 than in site 1.
Summary

• Differences in geranium growth and foliar N are likely due to greater N availability in aged bark.

• Fresh Douglas fir bark requires supplemental N.

Differences in foliar N are likely due to greater N availability in aged bark, and not to differences in water holding capacity as was determined for pine bark.
Nutritional Monitoring Using the Pour-through Method
pH is the negative logarithm of the hydrogen ion (H+) concentration in a solution. That’s a fancy way of saying the pH is a measure of how much H+ is in water.

On the left, the H+ and OH- ions are in balance, so pH is neutral or about 7.

In the middle, H+ concentration is far greater, so the solution is acidic (less than 7, in this example we are guessing it could be 3).

On the right, H+ concentration is far less than OH-, so pH is high (greater than 7).
EC – electrical conductivity

• Pure water does not conduct electricity.

• The more ions present in water, the more freely electricity is transferred.

• EC meters measure the ability of water to conduct electricity.
EC

• EC values tell us the amount of salts in solution.

• EC does NOT tell us which salts.

• There are problems with interpreting EC readings.
Monitoring container solution

• Many factors influence container pH

• It is impossible to predict exactly what will happen.

• We should measure container pH and EC directly and regularly.
The pour-through method

- Used to monitor pH and EC over time

- Only useful when used repeatedly and regularly over time.
1. Irrigate your crop thoroughly
The pour-through method

• Irrigate your crop to container capacity
• Allow the container to sit for 1 hour
  – This allows excess water to drain
  – This allows container solution to come to equilibrium with the substrate
• Add 150 ml of water for 1 gal container.
  – Avoid channeling down the container side.
• Collect leachate from the drain holes
The pour-through method

• Consistency is critical
  – Use the same person
  – Use the same equipment
  – Use the same protocol

• Define a decision zone.
Monitor pH and EC over time

Charting pH over time is the only useful way to use this information. A single reading is useless. Over time, you can see how your fertilizer program and irrigation water is affecting the pH of your container crops.
Problems with the pour-through

• Inconsistent results?
  – Improper meter calibration
  – Using a different technique at each sampling date

• Channeling down the side of the container
  – Leads to inconsistent results.
Building a better mousetrap

- What factors reduce the consistency of the procedure?
  - Water volume applied.
  - Point of pour-through application.
  - Speed of pour-through application.

I asked the group of guys in this photo see if they can determine what factors lead to inconsistent results (left to right: Mathijs Maes, Walter Briones, and Mark Bus).

They determined that the amount of water applied was an important factor (others have established this fact already).

They determined that the point along the container surface over which the water was poured is an important factor. Improper placement of the water can lead to channeling of the water down along the container.

They also determined that the speed in which the water was applied is an important factor. If you pour the water too fast, some of the water channels along the side.
The basic concept of the pour-through procedure is to get the water inside the container to flush into the saucer beneath the container.
The students used water dyed red, or spiked with NaOH, to determine if various application methods resulted in water channeling. Any practice that results in the water poured on the container surface to channel into the saucer beneath the container is a practice that should be avoided. Remember, the goal is to push water that is in the container out and into the saucer. You want to measure the water that is in the container, not the water you are pouring over the surface.
On the left, this illustrates the problems of pouring the water too fast and the channeling that results. In this scenario, you would be measuring, in part, the water that is poured over the container surface.

On the right, using a device to precisely place the water, and to slowly apply the water, allows you to 'push' the container water out and into the saucer below. This is ideal.
Pour-through procedure

- Slow application of water produces more consistent results.
- Apply the water along the entire substrate surface.
- Time consuming
BAMB Model 2010

- Automated, multi-container pour-through system
- Pressure compensating
- Uniform placement of water, slow application
- Consistent results!

This device was invented by the students to apply our modified version of the pour-through using precise placement of the water, slow application of the water, but in an efficient and easy way.
Summary

• Understand the three sources of nutrition in your container nursery
  – What’s in your irrigation water?
  – What’s in your substrate?
  – What are you adding with your fertilizer program?

• Monitor container nutrition.
Website

• [http://oregonstate.edu/dept/nursery-weeds/](http://oregonstate.edu/dept/nursery-weeds/)