

What Copper Formulations are Best for Tree Fruit Applications?

2012 Mid-Atlantic Fruit and Vegetable Convention

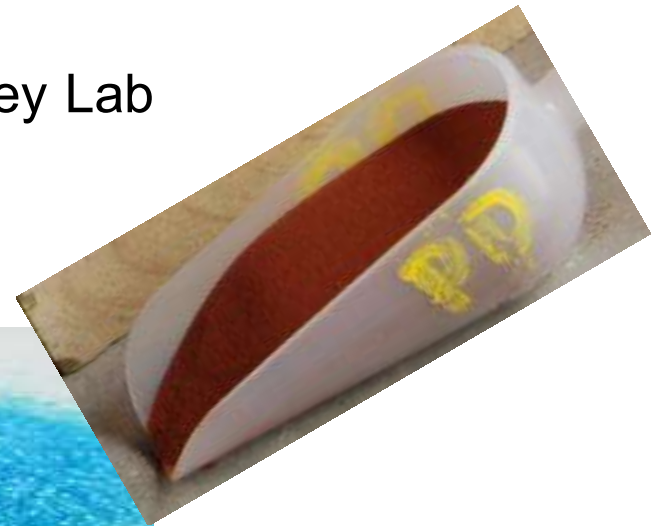
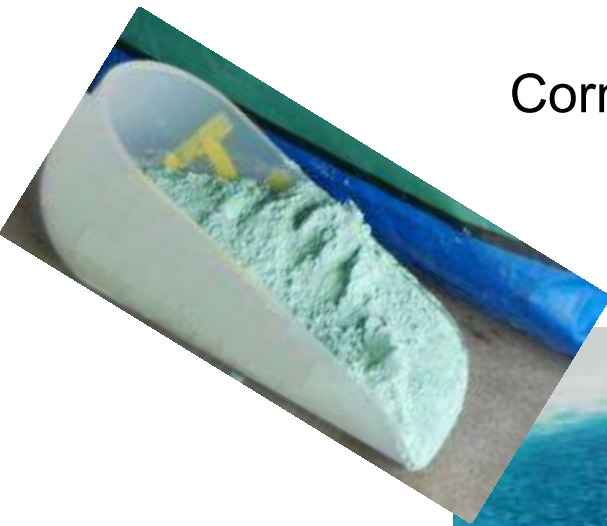
Hershey, PA

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Background on Copper Sprays



Tree fruit diseases for which copper sprays are useful:

A. Bacterial diseases

1. Fire blight (as a dormant spray)
2. Bacterial canker of cherries (at leaf drop and/or in spring)
3. Bacterial spot on peach and nectarine

B. Fungal diseases

1. Peach leaf curl
2. Cherry leaf spot on tart cherries
3. Secondary effects on apple scab and other apple fungi ?
4. Summer diseases in organic apple production

Background on Copper Sprays



Copper has a long history in agriculture

- 1807: seed treatment for wheat
- 1882: Bordeaux mixture (copper sulfate + lime)

How copper controls pathogens:

- Copper ions (Cu^{++}) denature proteins and enzymes.
- Toxicity of copper is non-selective: it will kill exposed plant cells as well as bacteria and fungi.
- It works as a fungicide/bactericide without damage to plants so long as it stays on plant surfaces.
- Copper sprays do not have post-infection activity because they cannot access pathogens that have already entered plant tissue.

Background on Copper Sprays



Many forms of copper are labeled on tree fruit:

- Copper sulfate (copper sulfate pentahydrate)
 - > Soluble in water (320 mg/L at 68 F)
 - > High solubility increases phytotoxicity and decreases its residual activity on plant surfaces.
- Fixed coppers make better fungicides:
 - > low solubility in water (2 to 6 mg/L)
 - > After deposition on plants, Cu^{++} ions are slowly released from the non-soluble deposits when water is present.
 - > Complex interactions on the plant surface have huge effects on efficacy of copper sprays.

Background on Copper Sprays



Many forms of copper are labeled on tree fruit:

- Copper sulfate (copper sulfate pentahydrate, $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$)
(*Mastercop, Phyton 27AG ?*)

→ **Not the same !!**

- Fixed coppers

- > Tribasic copper sulfate $3\text{Cu}(\text{OH})_2 \cdot \text{CuSO}_4$
- > Basic copper sulfate (*Cuprofix Ultra Disperss*)
- > Copper oxide (*Nordox*) Cu_2O or CuO
- > Copper hydroxide (*Kocide, Champ*) $\text{Cu}(\text{OH})_2$
- > Copper oxychloride sulfate (COCS)
 $3\text{Cu}(\text{OH})_2 \cdot \text{CuCl}_2 + 3\text{Cu}(\text{OH})_2 \cdot \text{CuSO}_4$
- > Copper linked to fatty acids (*TennCop, Cueva*)
- > others ??

Background on Copper Sprays



Critical factors:

- Copper ions (Cu^{++}) denature proteins and enzymes.
- Fixed coppers have low solubility in water (2 to 6 mg/L)
 - Effectiveness of copper sprays is highly correlated with the amount of elemental copper that is applied.
 - Elemental (metallic) copper content varies by product !!

ACTIVE INGREDIENT:	
Copper Octanoate.....	10.0%
OTHER INGREDIENTS:	90.0%
TOTAL	100.0%
metallic copper equivalent	1.8%

ACTIVE INGREDIENT:	
Cuprous Oxide (Cu_2O)*	83.9%
OTHER INGREDIENTS:	16.1%
TOTAL	100.0%
*Metallic copper equivalent: 75%	

HOWEVER, other factors also impact efficacy.

Background on Copper Sprays



Factors that impact efficacy of copper sprays:

1. Particle size: smaller particles adhere better, last longer
 - > Due to low solubility, most copper is in crystalline form.
 - > Large particles are more easily dislodged by rain.
 - > More small particles/lb = better spray coverage.
 - Median article sizes range from 0.7 to 3.1 microns
 - When diameter doubles, volume increases 8 times and surface area increases 4 times.
 - Copper at 0.75 microns will have 64 X more particles per pound than copper at 3.0 microns.

Background on Copper Sprays



Factors that impact efficacy of copper sprays:

1. Particle size: smaller particles adhere better, last longer
2. pH: copper solubility increases under acidic conditions.

> low pH = more available Cu^{++} ions

> Things that can lower pH:

More effective
More phytotoxic
Less residual

✧ Spray adjuvants (e.g., LI-700)

✧ Phosphite fungicides (Aliette, Nutri-Phite, ProPhyt, etc.)

✧ Mancozeb fungicides

✧ Acid rain (probably minimal effect)

Background on Copper Sprays



Factors that impact efficacy of copper sprays:

1. Particle size: smaller particles adhere better, last longer
2. pH: copper solubility increases under acid conditions.
3. Copper rate and spray interval.
4. Drying time:
5. Spray adjuvants can be beneficial or detrimental:
6. Leaf condition: tree species, cultivar, leaf age, etc.

Negative Aspects of Copper Sprays



- Accumulation in soils can be a problem:
 - > Copper in soils can inhibit plant growth (especially at low pH).
 - > Some soils in Florida contain several hundred lb/A due to repeated applications of copper to citrus groves.
 - > Not likely to be a problem with deciduous fruit crops.
- Copper is toxic to earthworms.
- Copper can poison both the crop and the target pathogen:
 - > For many crops, one must balance the benefits of maximizing efficacy vs. risks of phytotoxicity

General Recommendations for Copper Sprays

1. READ LABELS:

- Not all copper products are labeled on all crops.
- Even on labeled crops, labels may limit application times.

2. Consider pricing, particle size, risk of phyto, ease of use.

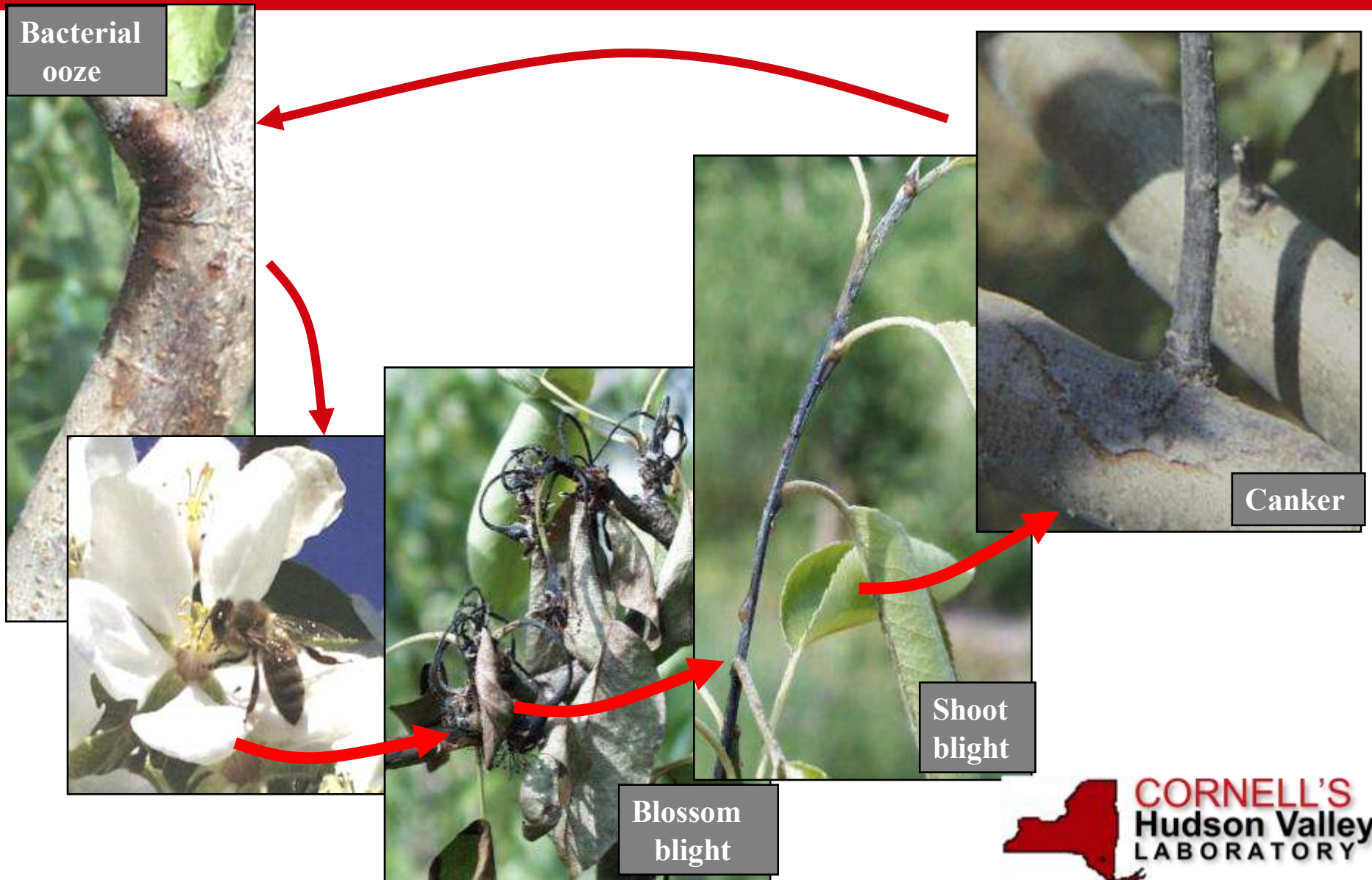
- For dormant applications on apples and cherries:
 - > Look for the best price/lb of metallic copper.
 - > But favor products with smaller particle sizes.
- For sprays applied to leaves of stone fruits:
 - > Look for products that minimize phytotoxicity via small particle size, formulation, lower label rates, etc.
- For apple sprays after green-tip: same as above for stone fruits sprayed during summer.

Copper Sprays for Apples

Uses for copper on apples:

1. Fire blight (as a dormant spray)
 - Also on newly planted trees to eliminate any strep-resistant bacteria coming from nurseries.
2. Secondary effects on apple scab
and other apple fungi ?
3. Summer diseases in organic apple production

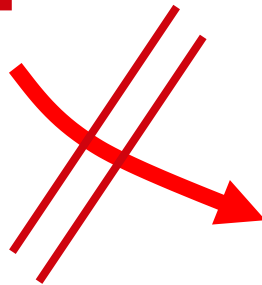
Fire Blight Disease Cycle



Fire blight management decision:

Apply a copper spray at green tip!

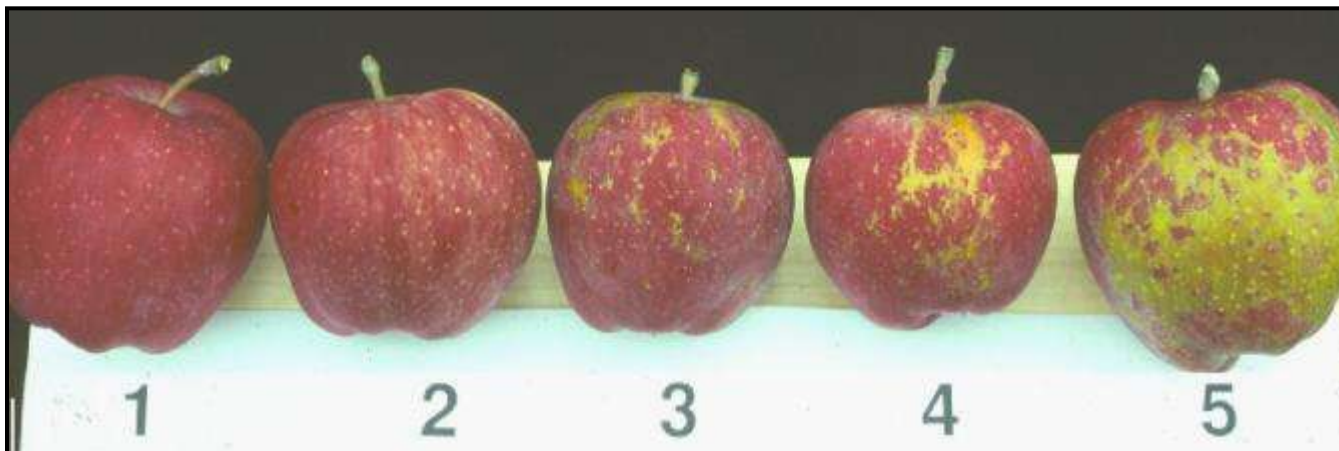
- Reduces inoculum from cankers missed during pruning.
- Benefits may be minimal if > 3 inches of rain falls after application and before pink bud.
- Useful for blight control only in orchards that had blight in either of the last 2 years ?



Fire blight management decision:

Apply a copper spray at green tip!

1. Fixed coppers (Bordeaux, COCS, Kocide, Champ, Cuprofix Disperss) form deposits on trees that release copper ions slowly.
2. Applying copper after green tip increases risks of russetting damage on apples, so reduce rates when spraying after green tip.



Fire blight management decision:

Protect newly planted trees with copper

- Strep-resistant fire blight is present in most nursery production areas (CA, OR, WA, MO, MI, NY)
- Occasionally (but rarely), trees will be shipped with either internal or external population of the blight bacterium.
- Infected trees may develop blight symptoms as they begin to grow after transplanting.
- If those infections involve strep-resistant bacteria, then strep resistance could be disseminated to your farm.
- This would be a very rare event, but consequences could be significant !!
- **Precautions are warranted: spray new trees with copper at least twice, starting after soil has settled around the trees.**

Other Benefits of Copper Sprays



2010 APS Annual Meeting
Abstracts of Presentations

Resistance to DMI fungicides in

Venturia inaequalis from Pennsylvania

E. E. PFEUFER (1), J. W. Travis (1), H. K. Ngugi (1)

(1) Penn State University, Biglerville, PA, U.S.A. Phytopathology 100:S100

“Use of dormant copper sprays reduced the odds of an isolate being resistant to myclobutanil by about half (odds ratio = 0.446; 95% confidence interval = 0.239 to 0.832; P = 0.011).”

Other Benefits of Copper Sprays



2010 APS Annual Meeting
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“Use of dormant copper sprays reduced the odds of an isolate being resistant to myclobutanil by about half (odds ratio = 0.446; 95% confidence interval = 0.239 to 0.832; $P = 0.011$).”

How do copper sprays impact fungicide resistance mgmt?

We really don't know.

Possible explanations:

1. Growers who apply copper spray earlier in spring and therefore put less pressure on later fungicide sprays.
2. Copper residues persist until pink and assist with scab control.
3. Copper fungicide interactions?

Other applications for copper on apples

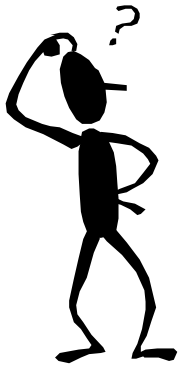
- Labeled for fire blight during bloom:
 - > NOT RECOMMENDED !!
 - > Less effective than streptomycin (Cu is not absorbed).
 - > Will almost always russet fruit under eastern US conditions.



- To control summer diseases & fruit rots:



- > Often causes lenticel spotting if applied before July 4th.
- > May discolor yellow-skinned cultivars.
- > Useful for organic orchards ??
- > Use only at low rates applied under fast-drying conditions.



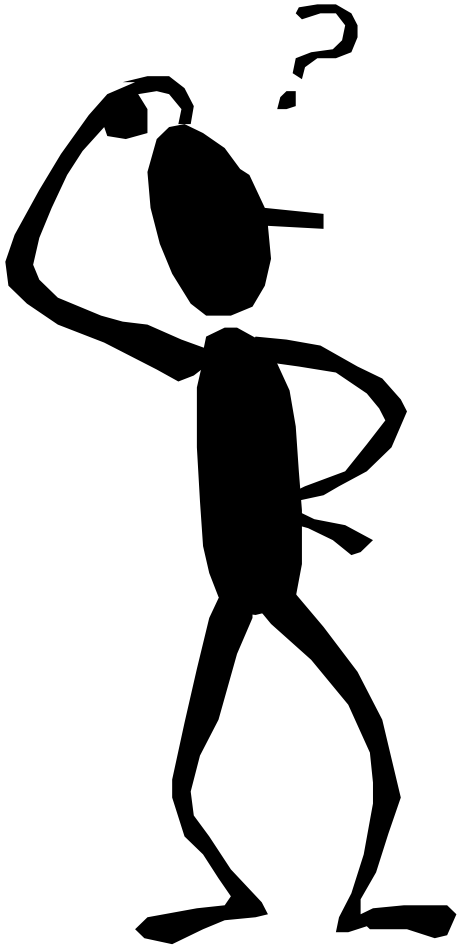
What Copper Formulations are Best for Tree Fruit Applications?

Conclusion: there is no single correct answer!

- In general, higher rates give better residual; For high-rate sprays (e.g., to dormant trees), price sprays based on metallic copper content.
- However, finely ground coppers will stick better than more coarsely ground formulations.

When does low price/lb trump fine-grind benefits?

- For summer sprays, focus on minimizing phytotoxicity, perhaps with higher-quality formulations.



Questions ?