

DEMYSTIFYING COPPER FOR DISEASE MANAGEMENT



Brian Lehman and Kari Peter, Ph.D.
Department of Plant Pathology and Environmental Microbiology
Penn State University Fruit Research and Extension Center
Biglerville, PA

kap22@psu.edu 717-677-6116 Ext 223

 @drtreefruit



PENNSTATE



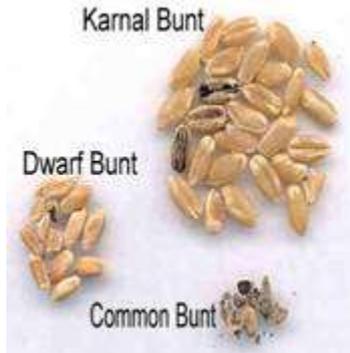
College of Agricultural Sciences

Understanding the ins and outs of copper and the best practices for using it in disease management



- Brief history of copper as a management tool
- How copper works
- Factors that impact the efficacy of copper sprays
- Copper injury: how phytotoxicity occurs
 - Why pH matters
 - Dos and don'ts of using copper
- Using copper for disease management
 - Apple Scab, Fire Blight
 - Peach Leaf Curl, Bacterial Canker
 - Bacterial Spot

Copper: First fungicide



<http://agridr.in>

1807 B. Prévost and bunt of cereals: seed treatment

Demonstrated wetting wheat kernels in copper sulfate solution control bunt on cereals

(serendipitous finding when using a copper “vessel” to soak seeds)



<http://apsnet.org>

1885 P.M.A. Millardet and grape downy mildew: foliar treatment

Described use of copper sulfate and lime to control downy mildew on grapevines

(serendipitous finding when he noticed a farmer in the Bordeaux region using the concoction to discourage “pilferers”)



How does copper work?

Copper is a general biocide: **Non-selective (plant, fungi, bacteria)**

- Acts as a protectant for fungicide-bactericide treatments
 - **Apply before infection**
- NO post-infection activity
 - **Sticks where it hits**
 - **No re-distribution post application**

While on the leaf...

- Requires moisture to be present on plant surface to be active
- Copper particles gradually desintegrate releasing copper ions
- Copper is most effective on those diseases that need free water present to develop

Going in for the kill...

- The copper ions destroy critical enzymes important for cell to function

How does copper work?

The challenge:

To have copper ions present to kill the target (fungi, bacteria) while keeping concentration low enough to avoid copper injury on plants

→ Using copper products that are relatively insoluble in water

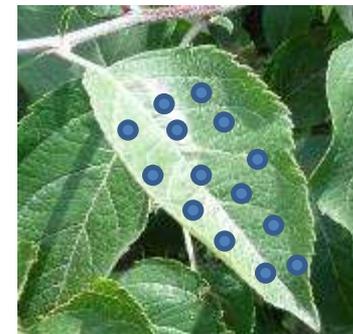
Soluble

- Bluestone: Copper sulfate pentahydrate
- **Copper ions available all at once** on leaf surface anytime water is present
- Residues rapidly removed by rain



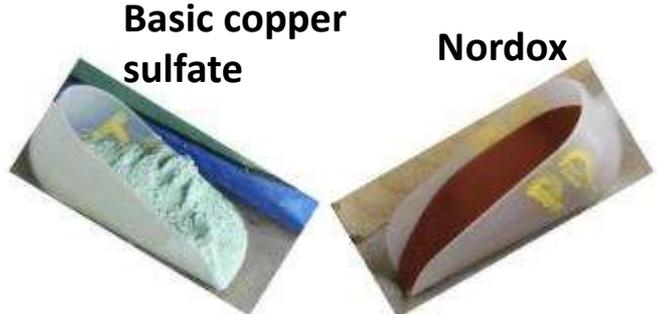
Low solubility (insoluble)

- Fixed copper
- Spray solution of fixed copper: suspension of copper particles
- **Particles persist** on leaf surface after dries
- **Gradual release of copper ions** when particles react with water on the leaf surface
- Residual protection; reduces phytotoxicity to plant tissues



Copper formulations are not created equal: Solubility in water differs among copper products

Bluestone copper (Soluble)
(Copper sulfate pentahydrate) + Lime = fixed
Ex. MasterCop



D. Rosenberger, Cornell

Addition of Hydrated lime →

← more Solubility in water less →

100% soluble in water

Copper Hydroxide
Ex. Kocide 3000

Copper Oxychloride
Ex. COC DF

Basic copper sulfate
Cuprous oxide
Ex. Nordox

Fixed coppers – only partially soluble in water

Note: “Basic copper sulfate” and “copper sulfate” (aka copper sulfate pentahydrate) are not the same

Efficacy of copper spray depends on the amount of elemental copper: % Metallic Copper

Product Name	Active Ingredient	% Active Ingredient	% Metallic Copper
Cueva	Copper octanoate	10.0	1.8
Nordox	Cuprous oxide	83.9	75
Mastercop (soluble)	Copper sulfate pentahydrate	21.46	5.4
Kocide 3000	Copper hydroxide	30 DF	30
Champ Formula 2 Flowable	Copper hydroxide	37.5 F	24.4
Copper-Count-N (soluble)	Copper diammonia diacetate complex	27.15	8.0
Badge X2	Copper oxychloride + copper hydroxide	23.82 + 21.49	28.2
Nu-Cop	Copper hydroxide	76.77	50
COC DF	Copper oxychloride	84.04	50

Efficacy of copper spray depends on the size of the copper particles:

Particle size

Copper particle size

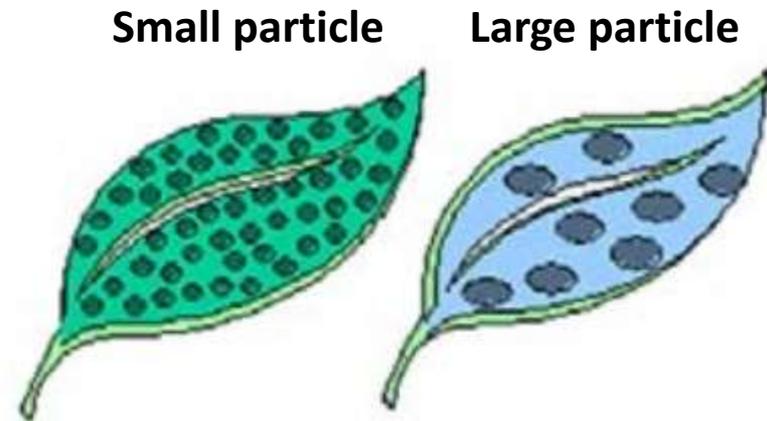
- Determined by how finely copper has been ground
- Cannot be determined by looking at the product

Large particles

- Easily removed by wind or rain after leaf surfaces dry

Small particles

- **More small particles/lb = better spray coverage**
- Adheres to plant surface better
- Longer residual activity (longevity of the product and release of copper ions)



Efficacy of copper spray depends on the size of the copper particles:

Particle Size

Product Name	Active Ingredient	% Active Ingredient	% Metallic Copper	Mean Particle size (microns)
Cueva	Copper octanoate	10.0	1.8	
Nordox	Cuprous oxide	83.9	75	1.0
Mastercop (soluble)	Copper sulfate pentahydrate	21.46	5.4	0*
Kocide 3000	Copper hydroxide	30 DF	30	2.5 – 3.1
Champ Formula 2 Flowable	Copper hydroxide	37.5 F	24.4	1.2
Copper-Count-N (soluble)	Copper diammonia diacetate complex	27.15	8.0	0*
Badge X2	Copper oxychloride + copper hydroxide	23.82 + 21.49	28.2	
Nu-Cop	Copper hydroxide	76.77	50	2.4
COC DF	Copper oxychloride	84.04	50	1.8 – 3.1

When using copper products on tree fruits, keep in mind...the dos and don'ts to minimize copper injury

- Solubility of fixed coppers increases under acidic conditions
 - ❖ Copper will become more phytotoxic if applied in an acidic solution
 - Check the pH of your spray water—acidic solutions worsens phytotoxicity
 - Beware of adjuvants (LI-700)
 - DO NOT mix copper with a foliar fertilizer or phosphorous acid product (Rampart, Phostrol, ProPhyt)
 - DO NOT mix with mancozeb



The pH of copper formulations vary:

Appreciating pH when it comes to copper sprays

solution	Rate/acre	pH
water		7.07
Cueva	2 qt.	6.52
Cueva + Double Nickel	2 qt + 1 qt	6.42
Cueva + Double Nickel + lime	2 qt + 1 qt + 2 lbs	11.41 ←
Mastercop	1.5 pt	5.99
Mastercop + lime	1.5 pt + 2 lbs	9.26 ←
Kocide	12.0 oz	7.52
Kocide + lime	12.0 oz + 2 lbs	12 ←
Cuprofix Ultra	20.0 oz	7.34

“Bordeaux mixture” (copper sulfate pentahydrate + lime = fixed copper)

When using copper products on tree fruits, keep in mind...the dos and don'ts to minimize copper injury

- **Solubility of fixed coppers increases under acidic conditions**
 - ❖ **Copper will become more phytotoxic if applied in an acidic solution**
 - **Check the pH of your spray water—acidic solutions worsens phytotoxicity**
 - **Beware of adjuvants**
 - **DO NOT mix copper with a foliar fertilizer or phosphorous acid product (Rampart, Phostrol, ProPhyt)**
 - **DO NOT mix with mancozeb**
- **Be mindful of slow drying conditions (rain events)**
- **When green tissue is showing, do not apply copper just prior to predicted frosts**
- **Adding oil for mite control during the dormant copper spray helps residual activity (of copper) [temperature appropriate]**

Using copper for disease management on apples: Dormant – Green tip

OBJECTIVE: Generate a copper residue that will persist and provide disease control that extends through leaf development stages (pending rainfall)

Apple scab

- Kills overwintering spores

Fire blight

- Kills bacteria on tree (oozing)

Rate: Aim for metallic copper to be 2 lb/A

Example:

Kocide 3000 metallic Cu Equivalent 30%

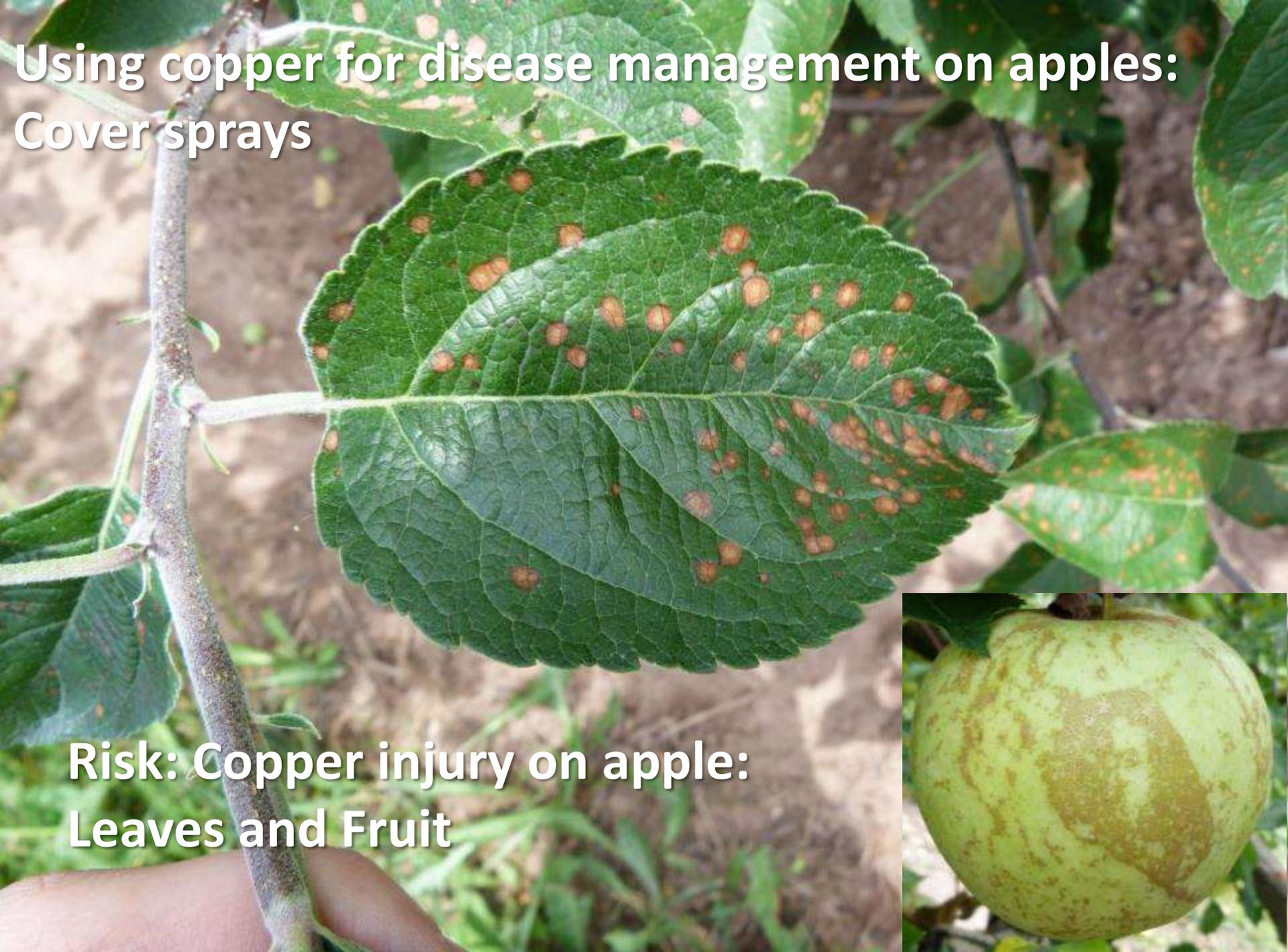
$$\frac{\text{metallic Cu 2 lbs/A}}{\text{Kocide metallic equiv. 0.30}} = \sim 6 \text{ lb}$$

Kocide metallic equiv. 0.30

*Liquid coppers follow a different calculation

Be careful during dry years (no rain between ½" GT to Pink) = Russetting on sensitive cultivars

Using copper for disease management on apples: Cover sprays



**Risk: Copper injury on apple:
Leaves and Fruit**



Using dormant copper sprays for disease management on stone fruit: Early spring

Peach leaf curl

Bacterial canker: Bordeaux mixture



Bacterial Canker Management

- **Goal: reduce number of bacteria before trees enter susceptible period**
- **Using Copper***
 - **Copper alone: evidence shows limited ability to control**
 - **Bordeaux mixture PLUS vegetable oil**
 - **Win Cowgill – Rutgers**
 - **Described:**
<http://jerseyfruitagupdates.blogspot.com/2012/09/spray-cherries-for-bacterial-canker.html>



**Using copper sprays for disease management:
Bacterial spot – Petal fall/Shuck Split**



**Using copper for disease management:
Bacterial spot – cover sprays**



Bacterial spot management during cover sprays: Copper recommendations (N. Lalancette, Rutgers)

Okay to use
1 oz/A rate



Product Name	Active Ingredient	% Active Ingredient	% Metallic Copper	REI	PHI	Post-bloom Label Rate	Post-bloom @ 0.5 oz/A metallic copper
Cueva	Copper Octanoate	10.0	1.8	4 hrs	0 days	0.5-2.0 gal	25 oz
Nordox	Cuprous oxide	83.9	75	12 hrs	0 days	10.7 oz	0.7 oz
Kocide 3000	Copper hydroxide	30 DF	30	48 hrs	0 days	4.0-8.0 oz	1.7 oz
Mastercop (soluble)	Copper sulfate pentahydrate	21.46	5.4	48 hrs	21 days	4.0-8.0 fl oz	7.4 fl oz
Champ Formula 2 Flowable	Copper hydroxide	37.5 F	24.4	48 hrs	21 days	not listed	0.9 oz
Copper-Count-N (soluble)	Copper diammonia diacetate complex	27.15	8.0	48 hrs	21 days	1 qt	5.2 fl oz
Badge X2	Copper oxychloride + copper hydroxide	23.82 + 21.49	28.2	48 hrs	21 days	8.0-32.0 oz	1.8 oz
Nu-Cop	Copper hydroxide	76.77	50	48 hrs	21 days	1.0-3.0 lbs	1.0 oz
COC DF	Copper oxychloride	84.04	50	48 hrs	21 days	1.0-3.0 lbs	1.0 oz

If you use a copper not listed and need assistance figuring out the 0.5 oz/A rate:

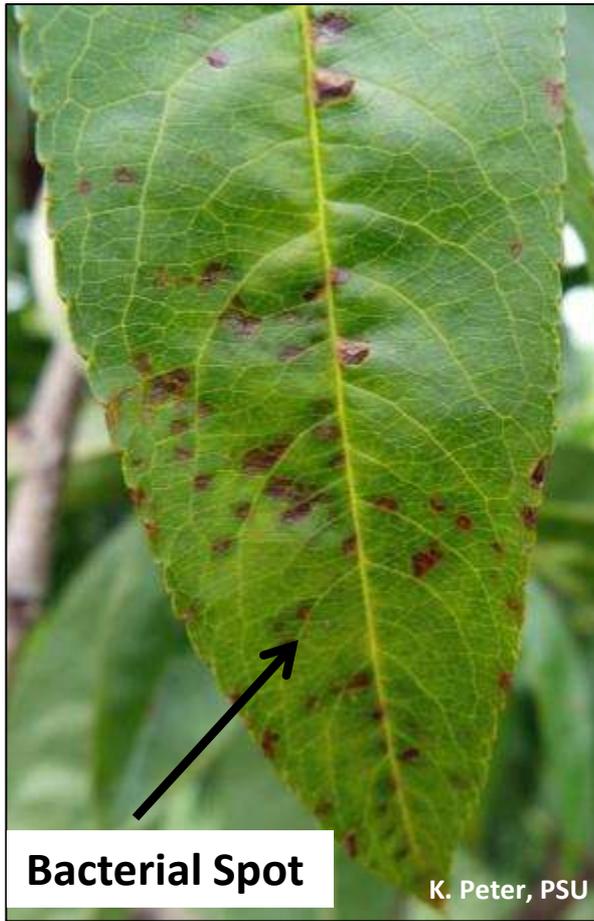
Email kap22@psu.edu

Copper injury on peach/nectarine: Leaves



Bacterial Spot vs. Copper Injury

- Angular
- Always bordered by the veins
- Few or many lesions
- Yellowing associated with lesions
- Defoliation— it does not take many lesions for this to occur



- Round (like a water droplet)
- Follows spray pattern
- “Swiss cheese”
- Yellowing not always associated with lesions
- Defoliation of older leaves
- Captan and sulfur injury: similar symptoms

Take home messages:



- **Solubility differences: fixed vs. bluestone**
→ Addition of hydrated lime to decrease solubility
- **Importance of % metallic copper and particle size: residual nature of the copper**
- **Solubility of fixed coppers increases under acidic conditions**
- **Be mindful of slow drying conditions (rain events)**
- **When green tissue is showing, do not apply copper just prior to predicted frosts**
- **Adding oil for mite control during the dormant copper spray helps residual activity (of copper) [temperature appropriate]**
- **Dormant copper sprays: control apple scab, fire blight, peach leaf curl, bacterial canker, bacterial spot**
- **Cover sprays: Adjusted rates (0.5 oz/A metallic copper) for bacterial spot cover sprays**

DEMYSTIFYING COPPER FOR DISEASE MANAGEMENT



Chemicool.com



QUESTIONS?



periodictable.com

Kari Peter, Ph.D.

Department of Plant Pathology and Environmental Microbiology

Penn State University Fruit Research and Extension Center

Biglerville, PA

kap22@psu.edu 717-677-6116 Ext 223



@drtreefruit



PENNSTATE



College of Agricultural Sciences