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Using copper sprays to control diseases in citrus

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Introduction

Copper-based fungicides can be used to manage several fungal diseases that affect citrus fruit and foliage including citrus scab in high rainfall areas, Septoria spot in drier inland regions and Phytophthora brown rot, which can occur whenever conditions are favourable. Copper can also be used to manage anthracnose, a very common fungus that can be a secondary invader of fruit damaged by other factors, particularly in wet seasons. Anthracnose symptoms can also be seen postharvest on fruit that are over-mature or held too long in storage.

Warm, humid conditions favour several citrus fungal diseases. In Australia, most disease-management programs rely on copper sprays to protect the foliage and fruit from infection. Successful disease management depends on both even distribution and good retention of copper over all of the plant surfaces.

How copper works

Copper sprays are protectant fungicides that must be applied evenly to the plant or fruit surface before the disease develops to prevent infection. Copper is not a systemic chemical and cannot be carried internally through the plant to kill the pathogen; it only protects where it lands. Once the copper is applied, it sticks and does not spread far across the fruit or leaf surface.

As the fruit and foliage grow, the new tissue is not protected. Rain and wind also erode the copper coverage over time. Re-application timing depends on the disease being targeted, the copper formulation used and weather conditions. More frequent applications are needed during wet seasons, in orchards with overhead irrigation, or in higher rainfall regions. For low rainfall regions such as the Riverina and Sunraysia, one copper spray in autumn is generally sufficient.

In recent years an increase in fruit blemish has been seen in the Riverina where weakened rind tissue is invaded by the anthracnose fungus (Figure 1). Wet seasons and foggy mornings have exacerbated these. Varieties that hang on the tree for longer (i.e. late navels and Valencia) have a greater chance of exposure to stresses such as frost. Follow up sprays might be needed.

Figure 1. Tear staining on fruit where injured cells are invaded by the anthracnose fungus.

Copper is most effective on diseases that need free water to develop. When water is on the plant's surface (from rain, dew or irrigation), exudates from the plant form weak acids, lowering the pH of the surface water. As the pH drops, the solubility of the copper product increases, slowly dissolving to release a small and constant supply of copper ions. When fungal spores or bacteria come into contact with surface water containing these copper ions, the ions travel through the pathogens' cell walls and disrupt cellular enzyme activity.

Copper sprays should be used with other management practices to reduce disease problems in the orchard. Fungal spores linger in the tree canopy in dead wood. Pruning to remove the dead wood reduces the number of fungal spores in the canopy, thereby reducing disease incidence when conditions are favourable for disease development.

Copper formulations

The 5 basic copper formulations available for disease management are copper oxychloride, copper hydroxide, tribasic copper sulfate (green and blue coppers), copper ammonium complexes (a dark blue aqueous complex of copper and ammonia) and cuprous oxide (red copper). Table 1 lists some Australian copper formulations and their particle sizes.

In the past, most copper products were wettable powders and contained about 50% copper as the active ingredient. However, today's formulations contain from 8% to 75% copper and application rates vary accordingly. Products are formulated as wettable powders, water-dispersible granules, liquid flowable suspensions or aqueous liquids.

Table 1. Some Australian copper formulations and their particle sizes.

Active ingredient	Median particle size (microns)
Copper hydroxide	0.15 to 2.50
Copper oxychloride	1.40
Tribasic copper sulfate	0.70 to 3.00
Cuprous oxide	1.00 to 1.44

Source: Company technical brochures.

Copper products can also contain small amounts of impurities. Some cheaper products might contain high levels of undesirable heavy metals such as arsenic, mercury, lead and cadmium. Make sure you use only good quality copper products.

Particle size and retention

The efficacy of a copper fungicide is improved considerably by reducing the particle size. Coverage is improved with smaller particles, and there is significantly more surface area per gram of product from which copper ions can be released in the presence of moisture (Figure 2).

The main factors influencing copper retention on plants are:

- particle size, smaller particles stick better (Figure 3)
- rainfall (which can either directly dislodge particles or solubilise them)
- wind (large particles over 3 or 4 microns in diameter can be blown off plant surfaces)
- physical dislodgement or dilution of particles due to plant surface growth (e.g. fruit expansion)

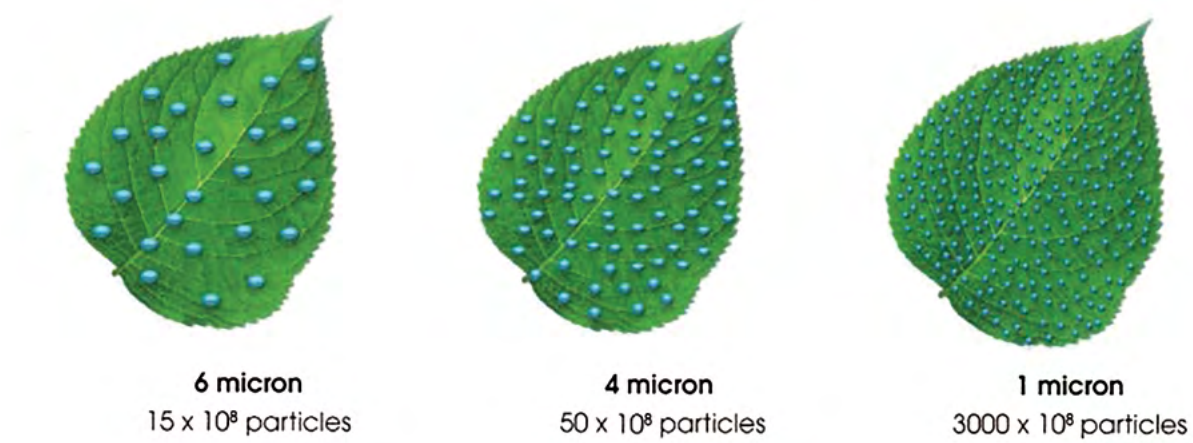

Figure 2. Leaf coverage improves with smaller particles of copper fungicide.

- excessive spray application volumes resulting in run-off and/or stripping of copper from leaf and fruit surfaces.

Research has shown that:

- regardless of whether the product is a liquid, liquid flowable or dry formulation, there is little difference in the level of control per unit of metallic copper. The most important factor affecting product effectiveness is the particle size of the formulation and how well it sticks to the plant surface (i.e. its rain-fastness)
- products with a smaller particle size tend to have better coverage, rain-fastness and longevity
- frequent applications of copper at lower rates are more effective than the same amount of copper applied in fewer applications.

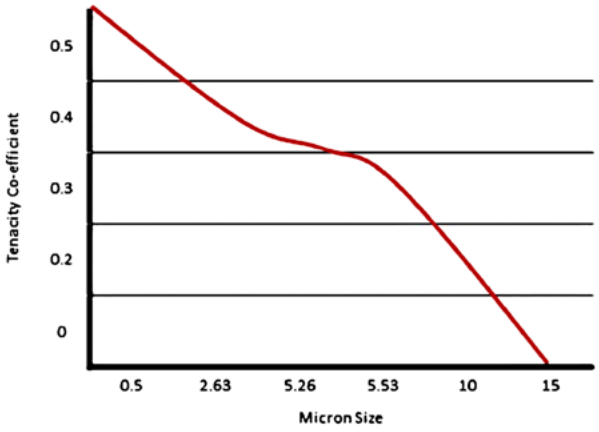

Figure 3. The force required to dislodge particles of differing sizes from a leaf surface. Source: Melpat International Pty Ltd.

Effect of water pH

Most copper products are formulated to be almost insoluble in water at pH 7.0. As the pH of water decreases, the solubility of the copper fungicides increases and more copper ions are released. If the water or spray solution is too acidic (i.e. pH < 6.5), excessive amounts of copper ions can be released, burning the plant tissue. Copper formulations with high amounts of soluble copper can also be prone to releasing too many copper ions.

Copper formulations vary in their solubility. The most soluble formulations are less persistent (Table 2). For example, copper hydroxide has fairly high solubility and activity but is not very persistent under wet coastal conditions.

Table 2. Comparison of solubility and persistence of copper formulations.

Copper formulation	Solubility		Persistence
Copper oxychloride	0.00001 mg/L	Least	Most
Cuprous oxide	0.64 mg/L		
Copper hydroxide	0.64 mg/L		
Tri-basic copper sulfate	3.42 mg/L		
Copper sulfate	142 g/L (0 °C)	Most	Least
	220 g/L (0 °C)		

Source: Melpat International Pty Ltd.

Damage from copper sprays

Copper sprays can damage the tissue between the oil glands, causing dead (necrotic) spots to appear. This gives the fruit rind or leaves a speckled or 'stippled' appearance (Figure 4 and Figure 5).

The spots appear similar to those caused by melanose, but they are almost black and are often on the exposed surface of the fruit. Copper sprays can also darken existing blemishes, such as those caused by wind.

Copper-based fungicides can typically be safely applied with low rates (< 0.5%) of horticultural mineral oil. However, some tank mixes that include copper can damage citrus fruit. This hazard was found to be greater when high rates of oil were included in the mixture and applied at low spray volumes.

Some copper-based fungicides can reduce plant vigour if too many copper ions pass into the leaf and/or by other impurities in the product. Copper salts such as copper chloride (an impurity) can be present in some brands of copper hydroxide and oxychloride if not completely oxidised during manufacturing. These levels can be as high as 2% in some low-quality copper formulations.

Low-quality copper formulations with high levels of impurities (for example lead and cadmium) might reduce plant growth and cause fruit blemish. Make sure you use a good-quality copper formulation.

The timing, frequency and rate of application are also very important, particularly with spring and summer applications.

Copper should be applied with water volumes that provide good coverage but do not cause excessive run-off (Figure 6). Excess spray droplets will run to the lowest point and either run off, leaving unprotected strips on the fruit surface, or dry, leaving copper residues. These concentrated copper residues can burn plant tissue (Figure 7).

Copper can also accumulate in some soils, causing damage to citrus roots and soil microorganisms. It can also interfere with the uptake of other plant nutrients.

Citrus leaves and fruit are sometimes difficult to wet, as the leaves are waxy and the fruit is round, with a thick waxy cuticle. Adding a non-ionic wetter will help improve product retention. Always follow the product label recommendations.

Copper-based fungicides can be applied with a range of fungicides and insecticides. Check product labels for the manufacturers' guidelines before mixing and application.

Figure 4. Copper damage to citrus leaves, causing leaf stippling.

Figure 5. Copper stippling on a lemon.

Copper-induced phytotoxicity is common when:

- copper is applied with products that make the tank mix acidic
- copper is applied at high temperatures (> 30 °C)
- copper is applied at high rates for 3 or 4 successive applications
- copper is applied to wet, turgid fruit and the drying conditions are slow (e.g. with early morning dew or immediately after rain)
- the drying conditions are cool and slow, or the humidity is high
- certain aqueous liquid formulations (i.e. copper and ammonia complexes) are used
- copper is mixed with high rates (> 0.5%) of horticultural mineral oil.

Figure 6. Excessive water rates result in spray run-off, wasting spray and contaminating soils. Source: Citrus Research International.

Figure 7. Fruit stippling damage caused by excessive copper residues or the release of excessive amounts of copper ions.

Best-practice tips

- copper sprays are protectant fungicides and need to be applied before infection starts
- use correct water volumes to achieve good, even coverage to the plant and fruit surfaces
- the protective layer diminishes over time and offers only short-term protection under certain conditions (i.e. in wet or humid climates or where overhead irrigation is used); if infection is likely over longer periods, re-application might be necessary
- smaller particle size results in better rain-fastness and retention of the copper product
- apply copper sprays only as per the manufacturers' recommendations
- the pH of the water used to apply copper should be > 6.5
- frequent applications using low rates of copper are effective and less toxic to plants than infrequent applications at high rates
- do not over-apply copper
- do not apply when fruit or leaf temperatures are high, humidity is high or the fruit is wet.

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Acknowledgements

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