Using copper sprays to control diseases in citrus

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Agriculture NSW

Copper-based fungicides can be used to manage coastal diseases such as melanose, citrus scab, *Alternaria* brown spot and citrus black spot, as well as greasy spot, brown rot and *Septoria* spot, which are also found in southern inland growing areas.

Warm, humid conditions favour a range of 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 an even distribution and good retention of copper over all of the plant surfaces.

Septoria spot is a fungal disease of southern inland areas that can be managed by protectant copper sprays.

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. Once the copper is applied it sticks only where it hits and does not spread to a large extent across the fruit or leaf surface.

It’s no coincidence that copper is most effective on those diseases that need free water to develop. When water is present 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.

Over time, the coverage of copper over the plant or fruit surface declines because of leaf and fruit growth.

Rain and wind action also erodes the copper coverage over time. In areas of high rainfall, copper fungicides offer a shorter period of protection than in dry conditions. More frequent reapplication of the protective copper layer is thus needed in coastal locations or subtropical regions. Frequent reapplication may also be required where overhead irrigation is used.

Copper formulations

The five 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).

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.
Copper products may also contain small amounts of impurities. Some cheaper products may 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**

Research has demonstrated that the efficacy of a copper fungicide is improved considerably by reducing the particle size. The smaller the particle size the greater the number of particles per gram and therefore the greater the fungicidal or bactericidal activity. 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 (see figure below).

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The main factors influencing copper retention on plants are:

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

The data in the graph at right shows that smaller particles stick better. Tenacity is the force or ability of a particle to stick to a surface.

Smaller particles resist dislodgement better because they are lighter and have a greater surface area relative to their weight. This results in an increase in the total force of adhesion. The high initial losses experienced from weathering arise from a rapid and complete loss of large particles, whereas the remaining copper residues consist of small particles.

Copper formulations with smaller particles enhance disease management through better coverage, better rain-fastness and improved longevity of the copper ions on the plant surface.

Table 1 lists some Australian copper formulations and their particle sizes.
Research has found 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.

**Impact 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 may be released, burning the plant tissue. Copper formulations that have high amounts of soluble copper may also be prone to releasing too many copper ions.

Copper formulations vary in their solubility. The chart at right shows that the most soluble formulations are less persistent. For example, copper hydroxide has fairly high solubility and activity but is not very persistent under wet coastal conditions.

<table>
<thead>
<tr>
<th>Copper formulation</th>
<th>Solubility</th>
<th>Persistence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper oxychloride</td>
<td>0.00001mg/L</td>
<td>Least</td>
</tr>
<tr>
<td>Cuprous oxide</td>
<td>0.64 mg/L</td>
<td>Most</td>
</tr>
<tr>
<td>Copper hydroxide</td>
<td>2.9 mg/L</td>
<td>Least</td>
</tr>
<tr>
<td>Tri-basic copper sulfate</td>
<td>3.42 mg/L</td>
<td>Most</td>
</tr>
<tr>
<td>Copper sulfate</td>
<td>142 g/L (0°C)</td>
<td>Least</td>
</tr>
<tr>
<td></td>
<td>220 g/L (0°C)</td>
<td></td>
</tr>
</tbody>
</table>

**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 (see photos overleaf).

The spots appear similar to those caused by the disease melanose, but they are almost black and are often on the exposed surface of the fruit. Copper sprays may also darken existing blemishes, such as wind blemishes on fruit.
Copper damage to citrus leaves, causing leaf stippling

Copper stippling on a lemon fruit

Copper-based fungicides can typically be safely applied with low rates (<0.5%) of horticultural mineral oil. However, research has shown that 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 may cause a small reduction in plant vigour. This reduction is caused by too many copper ions passing 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.

Copper chloride rapidly dissolves and could increase the amount of copper ions to excessive levels. Other heavy metal impurities such as lead and cadmium have also been implicated in increased levels of blemish.

Low-quality copper formulations with high levels of impurities may reduce plant growth and cause fruit blemish. Make sure you use a good-quality copper formulation.

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

It is important to apply copper with water volumes that give good coverage but do not cause excessive runoff. 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.

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

Excessive water rates result in spray runoff, wasting spray and contaminating soils.

Source: Citrus Research International

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

Both 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 may be applied with a range of fungicides and insecticides. Check product labels for the manufacturers’ guidelines before mixing and application.

Copper-induced phytotoxicity is more 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 three or four successive applications
- copper is applied to wet, turgid fruit and the drying conditions are slow (e.g. early morning before the dew has lifted, or immediately after rain)
- the drying conditions are cool and slow, or the humidity is high and the cloud cover is close to zero
- certain aqueous liquid formulations (i.e. copper and ammonia complexes) are used
- copper is mixed with high rates (>0.5%) of horticultural mineral oil.

**Best-practice tips**

- Copper sprays are protectant fungicides and need to be applied before disease infection.
- Apply the correct water volume to achieve a good, even coverage of copper to the plant and fruit surfaces.
- The protective layer of copper 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 may 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 just as effective, and less toxic to plants, than infrequent applications at high rates.
- Don’t over-apply copper.
- Don’t apply copper when fruit or leaf temperatures are high, humidity is high or the fruit is wet.

**References**


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