KVH Information Sheet

Copper Spray Information

Background

Copper sprays are used in many horticultural industries to protect foliage and fruit from a range of diseases. Successful disease control depends on both an even distribution, and good retention of the copper across all plant surfaces. Copper is most effective on those diseases that need water present to develop—such as Psa-V.

How copper works

Copper is a bactericide

- Copper kills bacteria on contact. The copper ions travel through the cell walls of the bacteria and disrupt the cellular enzyme activity.
- Copper bactericide is non-systemic.
- Copper is a protectant and needs to be applied evenly to the plant surface before the disease develops.

Water on plant surfaces (from rain, dew or irrigation) reacts with leaf excretions to form weak acids (pH<6.0). This low pH increases the solubility of copper products, slowly dissolving them to release a small and constant supply of copper ions.

Copper coverage

Application of copper to young leaves protects against infection. However, protection reduces as the leaf surface expands—gaps appear between copper particles. Copper coverage is also lost through the action of wind and rain.

Depending on the retention characteristics of the applied copper, re-application of copper will be needed.

Copper formulations

There are different types of copper compounds: copper oxides, copper oxychlorides, copper hydroxides, copper sulphates and TEPA chelated coppers.

These all have different characteristics (varying solubility, particle size and retention). These affect product efficacy.

Solubility

Least soluble ← → **Most soluble**

Copper Oxide — Copper Oxychlorides — Copper Hydroxide — Copper Sulphate — TEPA Chelated copper

- Copper Oxides (e.g. Nordox 75 WG™, AgCopp 75)
- Copper Oxychlorides
- Copper Hydroxides (e.g. Kocide® Opti, Champ® DP, Hortcare® Copper Hydroxide 300, ChampION++®)
- Copper Sulphates (e.g. Tri-base Blue)
- TEPA Chelated Copper (e.g. Coptyzin)

Soluble coppers erode faster and require more frequent applications as they are less persistent. Least soluble coppers are more persistent and release a supply of copper ions for a longer period of time. These least-soluble formulations require less frequent re-application.

For TEPA chelated coppers, the chemistry and mode of action is different to that of salt-based products. The positively charged chelating agent has a high stability constant and this allows the free copper ions to be released gradually over a period of time. Efficacy is achieved at lower copper concentrations not only on the surface of the leaf, but also within.

Particle size and retention

Research has shown the efficacy of copper formulation is related to particle size and particle retention on the plant surface.

Copper formulation and particle size

Copper Oxide	1.0 micron
Copper Oxychloride	1.8 - 3.1 micron
Copper Hydroxide	2.5 - 3.1 micron
Copper Sulphate	0.7 - 3.0 micron

Particle size

- The smaller the particle size the greater the surface area. Therefore, more particles are available to react and form copper ions resulting in decreased bacterial activity.

Retention

- The smaller the particle size, the greater the surface area. This results in better adhesion on plant surfaces, and particles have difficulty dislodging.

Product retention can be affected by rainfall, and wind through direct dislodgement of copper particles and through copper dissolving to form copper ions which wash off. Wind, physical contact and rubbing of plants also dislodge copper particles.

The initial high loss of copper noted during weathering is from a rapid loss of larger particles.

TEPA chelated coppers differ in their formulation supplying copper in an aqueous solution.

Water pH and its importance

Most copper products are formulated to be almost insoluble in water (pH=7). As the pH decreases, the copper solubility increases. If the water is acidic - less then pH 6.5 (depending on copper formulation) - excessive amounts of copper ions may be released rapidly, and this may cause foliage/fruit damage.

Damage from copper

Uptake of too many copper ions at any one time can cause damage (phytotoxicity) to the plant. This appears as follows.

- Darkening of leaf surface.
- Dead spots on the leaves.
- Darkening of leaf underside and leaf margin burn.
- Marking on the fruit.
- Loss of vine vigour—less growth.

Copper phytotoxicity can occur when:

- copper formulations are too soluble (e.g. copper sulphate);
- amount of copper applied is too high (application rate is too high, or applications are too frequent);
- pH of spray solution is acidic (below 6.5)—resulting in over-solubilising of the copper;
- copper is tank mixed with other products;
- copper is applied at high temperatures;
- copper is applied to wet canopies;
- poor drying conditions and high humidity;
- there are impurities in the product;
- plant growth stages are sensitive.

Copper budget calculation

ZESPRI *Crop Protection Standard* requirement for annual copper usage: Conventional orchards limited to maximum of 8kg active Cu/ha/year Organic orchards limited to maximum of 3kg active Cu/ha/year

The amount of copper applied per ha can be calculated to determine annual copper budget inputs as follows:

1. Calculate the rate of copper being applied/100L of spray mix

Rate = product rate/100L x % active ingredient (a.i) of chosen product.

e.g Nordox75WG (Nordox 75WG= 75% a.i) applied at 30g/100L.

= 30g/100L x 75%

= 22.5gCu/100L or 0.225gCu/L

2. Then calculate how much copper is applied per hectare.

Multiply rate of copper applied (g/L) x water volume per hectare

eg. If Nordox75WG is applied at 1000L/ha,

the amount of copper applied

= 0.225gCu/L x1000L/ha = 225g/ha

Active ingredient ratings for commonly used copper products are:

Product	**Active Cu Content (a.i)**
AgCopp 75	75%
Champ® DP	37%
ChampION++®	30%
Coptyzin*	7.6% (by volume)
Hortcare® Copper Hydroxide 300	30%
Kocide® Opti	30%
Nordox 75 WG™	75%
Tri-base Blue	19%

* Coptyzin is an aqueous solution supplying 7.6% a.i by volume. This equates to 95g Cu/L.

Key points on copper maintenance in the soil.

- Soil pH affects availability of copper.
- Soils with copper residues >100ppm should be maintained at pH>7.
- Applications of lime increases the soil pH (>6) and helps copper to be tightly bound.
- Mulches and composts added to the soil help bind copper residues.
- As best practice, it is recommended to periodically monitor copper levels through soil tests.

Effects of copper on soil

Copper is a trace element which is essential for plant growth and human and animal health. As with other trace elements, copper is generally found at levels <100ppm (parts per million). At elevated levels (500ppm) copper can become toxic and have some effects on the soil biology.

Copper binds strongly to

- clay particles; and
- organic matter in the soil.

The binding of copper as copper oxide and iron oxide complexes is a mechanism for protecting soil life against toxic effects of free copper.

Only a small portion of the total copper content reported through a soil test is bio available.

The natural levels of copper in soil worldwide were reported around 5-20ppm. NZ virgin soils generally have < 30ppm, eg BOP virgin forest levels are around 15ppm. Five orchards from the BOP were tested in 2000-2010 with copper levels averaging 42.6ppm, one orchard exceeded the WBOPDC guideline of > 100ppm. HortResearch with funding from PGSF* looked at copper in soils across 19 Orchards in New Zealand from different districts, BOP, Gisborne, Hawkes Bay, Nelson, and Central Otago. All orchards had previous copper use. Levels ranged from 70-480ppm, 13 of these orchards reported levels <120ppm. Otago locations reported the highest level of copper. These areas have had high copper inputs for 50 years associated with their stone fruit history.

The rate and amount of copper accumulation in soil is complex and is influenced by soil chemistry and composition.

Copper in soils are measured in three different ways

- Total copper—measures accumulated levels of copper. These levels reflect previous copper use history of the site (eg where copper has been used previously for market gardening copper level may be higher)
- Soil bound copper—measures the amount of copper potentially available for release to the soil. (Release level can vary from 30-100% depending on soil characteristics).
- Exchangeable copper –measures loosely bound copper which is freely available.
  These levels are generally low (1-2ppm).

Regional differences occur due to the soil composition, eg Whangarei has high clay soil so more copper is bound, and less is bio available. A recent study of BOP orchard soils showed copper ranges from 80-210ppm. These orchards were previously used for growing kiwifruit, citrus and avocados. These areas have had high copper inputs for 50 years. According to Biogro, if copper is applied at the rate of 2kg of active ingredient/hectare it would take 50 years for copper to accumulate to 100ppm.

Effects of copper on humans and organisms
Copper occurs naturally in rocks, water, plants and animals. Effects on soil microbial activity and toxicity to earthworms and springtails occur when copper levels are around 100-200pm. The acceptance criteria for copper in agricultural soils set by NZ Ministry of Health and Environment range from 38-380ppm.

Handling of copper products may cause irritation of the nose, mouth and eyes, and in extreme cases can cause nausea and stomach upsets. Copper balance is regulated by the body through absorption and excretion mechanisms.
Safety recommendations must to be followed at all times—see product label or MSDS sheets.

Spray drift to surface water must be avoided due to copper toxicity to aquatic organisms.

Monitoring for copper resistance
An ongoing monitoring and testing programme has been in place since 2011 which tests Psa bacteria for signs of product resistance, including copper.

Through this programme, copper-resistant Psa was identified in mid-2015 and further testing has shown an increase in the number of samples with low-to-medium levels of copper resistance.

While the level of resistance identified is still well below the concentration of copper in a spray tank when applied at recommended rates, (meaning copper applied at label rates were still effective against the bacteria) the development is concerning.

KVH has been actively working with the affected growers to reduce both the impact and spread of copper-resistant Psa.

It's essential kiwifruit growers do all they can to reduce the risk of these new resistant strains of Psa developing, and to minimise spread if they do.

To assist growers KVH has developed the following documents:

- KVH Protocol: Resistance to Psa control products
- KVH Best Practice: Managing resistance to Psa control products

* PGSF—Public Good Science Fund