Tips for the emergency use of iprodione and Amistar®

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To combat the higher than normal impact of fungal diseases in citrus this season, emergency use permits have been obtained for iprodione (e.g. Rovral®) and azoxystrobin (Amistar®). This article aims to assist growers to make the most of these additional fungicides in their orchards.

Summary

- **Use iprodione (e.g. Rovral®) and Amistar® sparingly, in a protective strategy, and alternated with other fungicide activity codes to minimise resistance.**
- **Remember to consider the impact of fungicide residues on potential export markets.**
- **Avoid using dithiocarbamate fungicides such as mancozeb late in the season to keep residues below 0.2 mg/kg.**
- **Use postharvest fruit washes to reduce mancozeb residues in blocks where residues may be a problem.**

There is little doubt that the 2010-11 citrus production season has been favourable to fungal diseases. The largest economic impact is likely to be in Queensland, where mandarins that are susceptible to brown spot, caused by the fungus *Alternaria alternata*, are already showing 30% fruit infection according to local pest scouts. Some blocks have been reported to be carrying up to 80% fruit infection! It is also likely that harvest will reveal the prevailing conditions in Queensland have favoured infection by the fungus *Guignardia citricarpa*, which causes citrus black spot. Infection by the fungus *Colletotrichum gloeosporioides*, which causes postharvest anthracnose, is also likely to have been favoured in most citrus production regions around Australia.

Wherever possible, integrated disease management approaches are encouraged to reduce the impact of fungal diseases in citrus orchards. Examples include:

- selective limb removal and skirting to reduce leaf wetness and humidity in the canopy,
- mulch applications to suppress spores released from leaf litter (e.g. black spot and greasy spot), and
- responsible use of registered fungicides (i.e. copper and dithiocarbamates).

However, the reality is that in some seasons implementing the ideal integrated disease management strategy is simply not possible, with soils being too wet to allow equipment access, or trees even being under water! In seasons like this, there will unfortunately be many cases where the pathogens will win the battle. However, to help win the war at the citrus disease frontline, Citrus Australia Limited with the assistance of Bayer and Syngenta have coordinated attaining emergency use permits for two additional fungicides: iprodione (e.g. Rovral®) and azoxystrobin (Amistar®).

Whilst access to these fungicides doubles the chemical options available, and will greatly assist in disease control, it is important that growers have a good understanding of the potential residue and resistance issues that can arise. This article profiles the fungicides available, how they may best be used together, and provides advice on how resistance and residues might best be managed to ensure these important disease management tools are useful to growers for as long as possible.

Copper fungicide profile

Product name: Several (e.g Kocide®, Coppox®, Norshield® etc)

Active ingredient: Several (e.g. copper hydroxide, copper oxychloride, cuprous oxide)

Use type: Surface protectant – copper fungicides only work if the fruit/foliage are thoroughly covered *before* a fungal spore lands on the fruit or leaf and tries to infect it.

Typical use pattern: Full-rate application during petal fall, or a half-rate application at petal fall and two to four weeks later. Copper fungicides are generally not used during the summer months to avoid copper causing fruit stippling and darkening of rind blemishes.

Use pattern will contribute to the control of: black spot (*Guignardia citricarpa*), brown spot (*Alternaria alternata*), scab (*Elsinoe fawcettii*), melanose (*Diaporthe citri*), and anthracnose (*Colletotrichum gloeosporioides*).

Australian Maximum Residue Limit (MRL): 10 mg/kg

Withholding period (WHP): 1 day

Residue management: Copper residues are generally not considered of great concern in citrus due primarily to its early-season use, and comfortable MRL. Copper is not systemic or mobile in plants, therefore residue persistence is primarily effected by rainfall and dilution from increases in fruit surface area during growth.

Fungicide resistance code: (new) “M1”, (old) “Y” (fungicides of different codes should be alternated throughout the season to prevent resistance development).

Resistance management: The likelihood of fungal pathogens developing resistance to copper is considered low, because the active ingredient “poisons” the fungi in multiple ways. Testament to this is copper fungicides remaining in use despite being first used over 100 years ago.

Dithiocarbamate fungicide profile

Product name: Several (e.g Dithane®, Antracol®, Zineb etc)

Active ingredient: Several (e.g. mancozeb, propineb, zineb)

Use type: Surface protectant – fungicides such as mancozeb only work if the fruit/foliage are thoroughly covered *before* a fungal spore lands on the fruit or leaf and tries to infect it.

Typical use pattern: Application at 6 and 12 weeks after the copper application/s at petal fall. Subsequent applications for the control of mites occur depending on the activity of the pest.

Use pattern will contribute to the control of: black spot (*Guignardia citricarpa*) – applications within 20-24 weeks of flowering, brown spot (*Alternaria alternata*) and anthracnose (*Colletotrichum gloeosporioides*).

Australian Maximum Residue Limit (MRL): 0.2 mg/kg

Withholding period (WHP): 14 days or "withholding period not required when used as directed".

WARNING: it is unlikely that this nominated withholding period will be sufficient to avoid MRL breaches i.e. do not spray mancozeb late in the season.

The use of mancozeb within even three months of harvest may be risky – see 'Dealing with mancozeb residues' on page 10.

Residue management: Dithiocarbamate residues in mandarins are of significant concern due to an extremely low MRL of only 0.2 mg/kg. Mancozeb does not readily move within the plant, and should only be present on the surface of fruit. In the field, residues should be reduced over time by rainfall and fruit expansion, therefore residues will be minimised by using mancozeb only early in the season.

Fungicide resistance code: (new) "M3", (old) "Y" (fungicides of different codes should be alternated throughout the season to prevent resistance development)

Resistance management: As with copper the likelihood of fungal pathogens developing resistance to dithiocarbamates is considered low, due to the fungicide "poisoning" fungi in multiple ways.

Dicarboximide fungicide profile

Product name: Several (e.g. Rovral®, Corvette®, Ippon® etc)

Active ingredient: Iprodione

Use type: Surface protectant and eradicant – fungicides such as iprodione will prevent fungal spores infecting fruit and leaves that have already been sprayed, as well as killing existing fungal infections that the fungicide comes into contact with. The fungicide also has systemic activity in some plants, but this is unconfirmed for citrus. **However, always use iprodione to protect fruit from infection, because using it to "cure" existing fungal infections greatly increases the chance of resistance developing.**

Typical use pattern: (according to emergency use permit for brown spot – *Alternaria alternata*) Three applications, with each application at least 60 days apart. From the permit instructions:
"Time applications to coincide with
(i) Spring flush – fruit set (less than 5 mm) during September/October,
(ii) Following thinning (fruit 20 to 30 mm) during January, and
(iii) Autumn flush (fruit 30 to 40 mm) during April."

Use pattern will contribute to the control of: brown spot (*Alternaria alternata*).

Australian Maximum Residue Limit (MRL): (emergency use permit) 5 mg/kg

Withholding period (WHP): (emergency use permit) 56 days

Residue management: Iprodione residues should not be of concern in citrus if the use pattern of the permit is adhered to. The domestic MRL has been set at 5 mg/kg based on data from the USA, Israel, Italy, New Zealand and South Africa. Be aware that some export markets have a nil, or lower MRL than Australia. A table of the MRLs for various export markets has been provided (Table 1).

Fungicide resistance code: (new) "2", (old) "B" (fungicides of different codes should be alternated throughout the season to prevent resistance development)

Resistance management: The likelihood of fungal pathogens developing resistance to iprodione is considered **medium to high risk**. Resistance of *Alternaria alternata* causing brown spot of mandarins was confirmed in 1989 in a southeast Queensland citrus orchard after four consecutive years of eight applications per season. Similarly, resistance was confirmed in 1994 in an Israeli orchard after three consecutive years of three applications per season. **Responsible use of iprodione will be essential for prolonging the usefulness of this fungicide**. Resistance is best managed by using iprodione to protect, rather than "cure" fruit, and alternating iprodione applications with fungicides of other chemical codes i.e. copper, mancozeb or azoxystrobin.

Strobilurin fungicide profile

Product name: Amistar®

Active ingredient: Azoxystrobin.

Use type: Surface protectant – strobilurin fungicides work best if the fruit/foliage are thoroughly covered *before* a fungal spore lands on the fruit or leaf and tries to infect it. These fungicides also have the ability to move within leaves, but do not move within the entire plant.

Typical use pattern: (according to emergency use permit for brown spot – *Alternaria alternata* and black spot – *Guignardia citricarpa*) Two applications at least 14 days apart, following copper applications

Use pattern will contribute to the control of: black spot (*Guignardia citricarpa*), brown spot (*Alternaria alternata*), and anthracnose (*Colletotrichum gloeosporioides*).

Australian Maximum Residue Limit (MRL): 2 mg/kg

Withholding period (WHP): 28 days

Residue management: Azoxystrobin residues should not be of concern in citrus if the emergency use permit use pattern is adhered to. The domestic MRL has been set at 2 mg/kg based on data from Australia, South Africa, and Brazil. Be aware that some export markets have a nil MRL. A table of the MRLs for various export markets has been provided (Table 1).

Fungicide resistance code: (new) "11", (old) "K" (fungicides of different codes should be alternated throughout the season to prevent resistance development)

Resistance management: The likelihood of fungal pathogens developing resistance to azoxystrobin is considered **high risk**, due to fungicide "poisoning" the fungi in a very specific manner. For example, reduced sensitivity to strobilurins has been reported for *Alternaria* species in other crops within just a few years of use. **Responsible use of azoxystrobin will be essential for prolonging the usefulness of this fungicide**. Resistance is best managed by alternating azoxystrobin applications with fungicides of other chemical codes i.e. copper, mancozeb or iprodione.

Making the most of the available fungicides

Copper, mancozeb, iprodione and Amistar® are best used in protective strategies to ensure good disease control and minimise the risk of the various fungi becoming resistant (in particular to iprodione and Amistar®). Once the fungi in the orchard become resistant, the fungicide becomes useless! **It cannot be stressed enough that iprodione and Amistar® need to be used sparingly (i.e. as few sprays as possible, alternated with other fungicide activity groups) to minimise resistance development e.g. iprodione applications could be alternated with Amistar® to avoid repeated exposure of the pathogens to a single fungicide mode of action. Using these fungicides "curatively" further promotes resistance development.** The development of resistance to these products would return the industry to relying only on copper and mancozeb. Therefore, growers should try to use these fungicides only when infection periods are likely; in the case of brown spot, the disease will be most severe whenever leaves and fruit remain wet and temperatures average 25°C (temperatures below 20°C and above 30°C are less favourable).

In addition to targeting infection periods, other factors needing consideration for fungicide timing include adhering to withholding periods (WHP's) and maximum residue limits (MRL's), and accounting for the length of time after spraying that a fungicide is effective. Adhering to WHP's and MRL's in most cases just requires following the label instructions, however this is not likely to be the case for the dithiocarbamates such as mancozeb, for which residue data collected by the FAO suggests that residues exceeding the Australian MRL may be detected as long as 13 weeks after application – see 'Dealing with mancozeb residues' below for more detail.

After spraying a fungicide it is often not well understood how long the protection against disease will last. However it is widely accepted that fruit expansion and rainfall have a big impact on how long fungicides continue to effectively prevent infection after spraying. In the case of fruit expansion, experiments conducted in Florida have shown that copper residues on fruit can be reduced by about 90%, simply because the fruit increased in diameter by about 50%. Residue reduction because of fruit expansion will be a big issue early in the season when fruit are growing most rapidly. Experiments conducted in Spain have shown that rainfall can significantly reduce the length of time after spraying that a fungicide can provide high levels of protection against brown spot. The experiments showed that most of the fungicides tested (copper oxychloride - wettable powder, mancozeb, iprodione, and pyraclostrobin – similar to Amistar®) provided two to four weeks of protection against brown spot when it did not rain, and fruit were not rapidly expanding. However, 70mm rainfall over a period of 6 days typically halved the number of weeks for which the fungicides provided high levels of protection against the disease. Interestingly, the effectiveness of copper formulations (suspended copper oxychloride, and wettable powder cuprous oxide) in controlling brown spot was not significantly decreased by rainfall. Considering the effects of fruit expansion and rainfall, it may be necessary to apply fungicides more often when fruit are rapidly growing and/or wet weather is common.

Based on the label guidelines for the four available fungicides, their WHPs, MRLs, the demonstrated level of protection against brown spot over time (under dry conditions, and low fruit expansion), and the need for an anti-resistance strategy, it is possible to provide an example spray program for brown spot susceptible varieties (primarily Murcott) this season (Fig. 1). This example program shows the MAXIMUM allowable number of iprodione and Amistar® applications, used according to the label requirements. It aims to avoid mancozeb

residues by avoiding late-season mancozeb sprays. The lengths of the withholding periods are also displayed. It is advised that the program is taken as an *example* only; the exact frequency and timing of applications would need to be adjusted for different varieties and weather conditions.

The example spray program (Fig. 1) aims to:

1. **Adhere to the label use patterns (see fungicide profiles above)**
2. **Alternate fungicide resistance codes to minimise resistance development**
3. **Adhere to domestic withholding patterns and maximum residue limits**

The different colours in Figure 1 indicate the level of protection a particular fungicide offers. So, in the example of copper (top row of the figure), one spray can offer 100-80% protection against brown spot for up to four weeks (i.e. 4 green boxes), reducing to 79-40% protection in the fifth week after spraying (the yellow box), and reducing to less than 39% protection in the sixth week after spraying (the red box). In other words, the copper fungicide should protect nearly as well at 4 weeks after spraying as it does in the first week after spraying. The level of protection over time can be interpreted for the other fungicides in the same way. It should be noted that rainfall and rapid fruit expansion will significantly reduce the number of weeks for which a fungicide can provide high levels of infection against brown spot, so the data in Figure 1 should be considered the best case scenario.

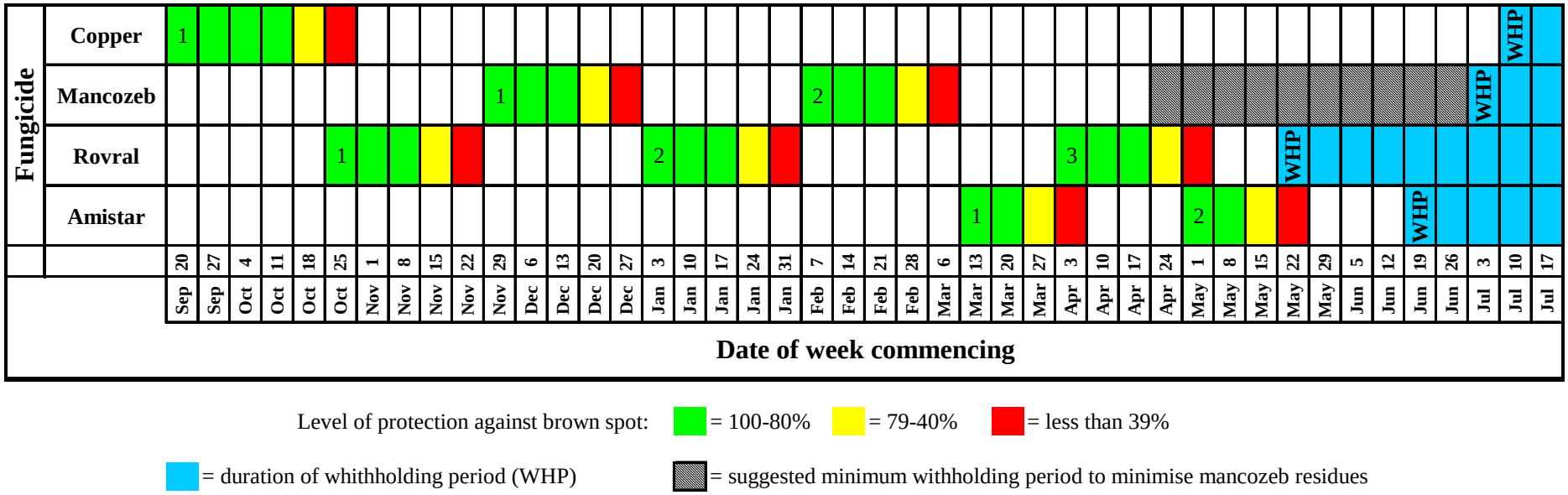

Figure 1. An *example* fungicide program for protection against brown spot on Murcotts incorporating the emergency use guidelines for iprodione and Amistar® for the 2010-11 citrus production season. The level of protection against brown spot, and the number of weeks of protection, is based on dry conditions (no rainfall) and low rates of fruit expansion. NOTE: the exact frequency and timing of applications would need to be adjusted for different varieties and weather conditions.

Fungicides and export fruit

Be sure to keep the MRLs of any export destinations in mind when using fungicides. Table 1 provides the MRLs for mancozeb, iprodione, and Amistar®. Some markets will not be accessible to fruit treated with certain fungicides unless it can be demonstrated that the fruit complies with the export Country's MRL, or does not contain any detectable residues where a nil tolerance is applicable. As more markets have higher MRLs for Amistar® than iprodione, it may be preferable to finish the spray program with Amistar® to increase the time between the last iprodione application and harvest (e.g. Fig. 1).

Table 1. Maximum residue limits (MRL) for various export destinations for mandarins. A nil tolerance to residues (i.e. not detectable in fruit) applies where no MRL value is listed.

Country	**Maximum Residue Limit (MRL) for MANDARINS by Country**		
	Iprodione (e.g. Rovral®)	**Azoxystrobin (Amistar®)**	**Mancozeb**
Codex	-	15	10
Indonesia	-	-	-
United States	-	10	4 (Ferbam)
Hong Kong	-	Codex	Codex
New Zealand	-	Codex	7
United Arab Emirates	-	Codex	Codex
Taiwan	0.5	1	2
Japan	10	2	2
Russia	-	-	0.1
Singapore	-	Codex	Codex
China	-	-	-
Canada	-	10	-
Netherlands	1	15	5
French Polynesia	1	15	5
United Kingdom	1	15	5
Malaysia	10	Codex	10
Sri Lanka			
Italy	1	15	5
Kuwait			
Thailand	-	Codex	2
Saudi Arabia			
Papua New Guinea			
Oman			
Qatar			
Maldives			
France	1	15	5
Bahrain			
Mauritius			
Reunion			
Romania	1	15	5
Guam			
New Caledonia	1	15	5
Brunei Darussalam			

Country	Maximum Residue Limit (MRL) for MANDARINS by Country		
	Iprodione (e.g. Rovral®)	Azoxystrobin (Amistar®)	Mancozeb
India	-	-	3
Seychelles			
Fiji			
East Timor, Dem Rep of			
Vietnam	-	15	-

Dealing with mancozeb residues

The MRL for mancozeb in citrus in Australia is very low at 0.2 mg/kg. To put the Australian MRL into perspective, the international CODEX MRL for mandarins is 50 times higher at 10 mg/kg. The low Australian MRL is probably the result of the original registration in the 1970's being based on only a few sprays very early in the season. Regardless of the reason, the low MRL leaves little margin for error. It is unfortunately very difficult to predict ahead of time if mancozeb residues will be a problem in any particular block, but to best assist growers Table 2 lists examples of different use patterns and the resulting residues after a given period of time, based on data collected from around the world by the FAO.

Table 2. Examples of use patterns and their resulting residue levels, based on residue trial data from citrus around the world collected by the FAO, are as follows:

Country, cultivar	Use pattern	Days after spraying	Residues (mg/kg CS_2)
Spain, Navel orange	1 spray of 44g/100L at 2000L/ha	24	0.12
Spain, Havelina orange	1 spray of 250g/100L at 6000L/ha	28	0.19
Japan, Amanatsu orange	2 sprays of 130g/100L at 3800L/ha	91	0.32
Australia, Valencia orange	2 sprays of 150g/100L (volume unspecified)	28	0.5
Japan, Okitsuwase mandarin	2 sprays of 190g/100L at 2500L/ha	60	1.8
Australia, Valencia orange	2 sprays of 300g/100L (volume unspecified)	28	1.6
Japan, Okitsuwase mandarin	4 sprays of 190g/100L at 2500L/ha	60	2.1
Florida, Valenica orange	4 sprays of 200g/100L at 9000L/ha	28	0.93
Florida, Bearss lemon	5 sprays of 190g/100L at 4700L/ha	27	0.82
Australian MRL			**0.20**

For more data see:
http://www.fao.org/ag/AGP/AGPP/Pesticid/JMPR/Download/93_eva/mancoz.pdf

Packers also have a role in dealing with chemical residues. The packing process involves washing, which provides a means to remove mancozeb residues on the fruit surface. The proportion removed can be quite significant, as seen in Table 3. High pressure washing systems are likely to remove surface chemical residues and, thereby, provide greater

confidence that MRL's are not exceeded. However, it would be prudent for packers to test fruit for mancozeb residues before and after high pressure washing to ensure their system is effective for this purpose. High pressure washing has many additional benefits, including the removal of sooty mould, dirt and pathogens. This increases pack-out into higher value grades by removing cosmetic 'defects', and improves shelf life by removing decay-causing organisms.

Table 3. Examples of the effectiveness of postharvest removal of mancozeb residues from citrus and other fruit and vegetables.

Crop	**Residue removal method**	**Residue reductions of:**
Citrus - Satsuma	Washing (details unavailable)	52-93%,
Citrus - Clementine	Washing (details unavailable)	93-99%
Citrus - Newhall	Washing (details unavailable)	89-97%
Various vegetables	Washing with tap water for 2 minutes	20-52%
Apples	Fruit dips at various concentrations of chlorine, chlorine dioxide, ozone and hydrogen peroxyacetic acid (HPA), for varying durations	56-99% (chlorine), 36-87% (chlorine dioxide) 56-97% (ozone) 44-99% (HPA)
Apricots	Agitation in distilled water for 1 minute	35-70%

In the long term, fungicide residues in citrus susceptible to brown spot will be best alleviated by the introduction of varieties resistant to the disease. The citrus breeding program based in Bundaberg has recently made the selection of resistant varieties routine, with resistant germplasm already identified in early and advanced selections (see the Aug/Sept 2010 issue of Australian Citrus News).

Summary

- **Use iprodione (e.g. Rovral®) and Amistar® sparingly, in a protective strategy, and alternated with other fungicide activity codes to minimise resistance.**
- **Remember to consider the impact of fungicide residues on potential export markets.**
- **Avoid using dithiocarbamate fungicides such as mancozeb late in the season to keep residues below 0.2 mg/kg.**
- **Use postharvest fruit washes to reduce mancozeb residues in blocks where residues may be a problem.**

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