Managing the chemicals in the drench system

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What is a drench?

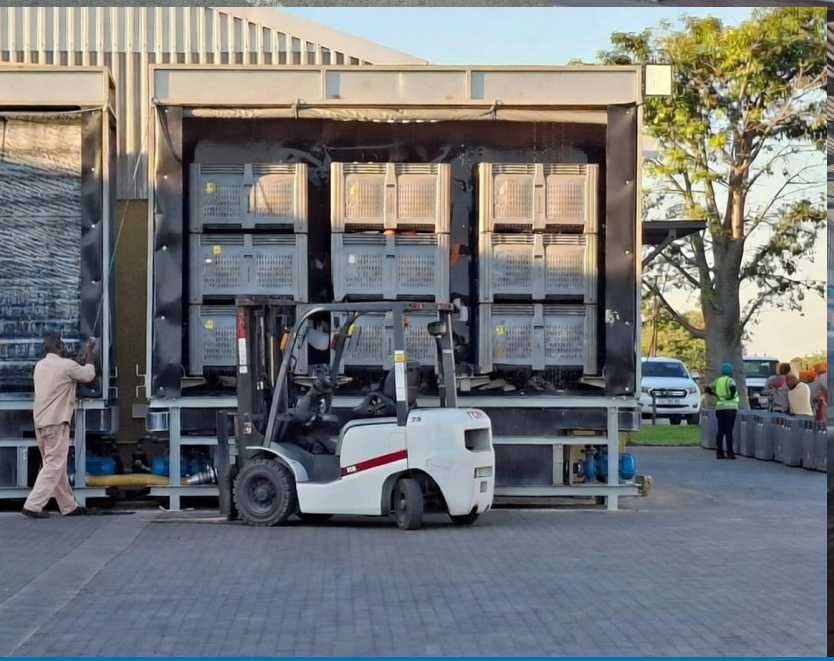
Yes, it's an obvious question.

- Drenching is the action of soaking or flooding picking bins full of fruit with a mixture of chemicals to treat them for different purposes.
- Various drench system types – Chemicals are managed the same.










Why drench?

1. **Decrease rind temperature** – Reduces moisture loss and the risk of rind pitting.
2. **Rinse the fruit –** Dust and dirt.
3. **Sanitation of fruit surface** – Spores washed off the fruit and deactivated in the solution.
4. **Reduce decay –** Inhibits early fungal infections and protects against disease during degreening, delayed tipping, or prolonged storage.
   - Legs during export.
5. **Delays calyx abscission**

What do I include in my drench mixture?

- Recommendation and decisions made based on:
- The needs of the packhouse – e.g. degreening protection or high levels of decay.
- Existing market restrictions on residues from certain actives.
- AND of course, it finally comes down to the **COSTS.**

Standard drench mixture program

Industry standard:

- Thiabendazole
- Pyrimethanil
- 2,4-D
- Peracetic acid/ Peroxyacetic acid (PAA)

Important to know why this program is and/ or was recommended in the first place.

Standard drench mixture program

Active ingredient	Type	Target	FRAC	Mode of action	ppm
2,4-D	Plant growth regulator (PGR)	Delays calyx abscission	PGR	Delays ageing & strengthens calyx attachment to the fruit	250
Thiabendazole	Fungicide	Green and blue mould; Stem-end rot pathogens	1	Cell division inhibition	1000
Pyrimethanil	Fungicide	Green and blue mould	9	Interferes in protein creation (Fungal growth) & host infection	1000
Peracetic acid (PAA)	Sanitiser	Broad spectrum – Fungi, bacteria, etc.	N/A	Multi-target & rapid action mechanism Breakdown the structural and functional components	140 - 420

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Peracet (PAA)				m onal	140 - 420

- Delays ageing & strengthens calyx attachment to the fruit.
- During degreening and the export chain.
- Now, almost exclusively used if the fruit is degreened.
- Market restrictions – China (0.1 mg/kg for oranges and soft citrus).

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- **TBZ and PYR** – **Protective** control vs. green and blue mould.
- **PYR – Curative control** (green mould) if treated within 18 hours.

- Main reason for two different fungicides with similar targets?
- **Reduces the risk of resistance development.**

- Different modes of action (FRAC groups) – 1 & 9
- Important because of degreening → Several days → Spore development

Period for the disease to develop from initial infection to first symptoms

Disease	Causal organism	Days to first symptom at 25 ˚C
Green Mould	*Penicillium digitatum*	1-2 days
Blue Mould	*Penicillium italicum*	3 days
Sour Rot	*Galactomyctes citri-aurantii*	6 days
Brown rot	*Phytophthora* sp.	3 days
Stem end rot	Various	2 Weeks

Table 28.2 Resistance development in decay organisms of citrus against postharvest fungicides in the United States

Fungicide class	FRAC group	Fungicide	Year introduced on citrus	Currently registered	First occurrence of postharvest resistance		
					Year	Decay organism	Reference
Phenol derivative	–	OPP, SOPP	1936	Yes	1959	*Penicillium digitatum*	Harding (1962)
Aromatic hydrocarbon	14	Biphenyl	1944	No	1962	*Penicillium* spp.	Harding (1962)
Aliphatic amine	–	2-Aminobutane	1962	No	1976	*Penicillium* spp.	Harding (1976)
Methyl benzimidazole carbamate (MBC)	1	Benomyl	1967	No	1973	*P. digitatum*	Wild (1983)
		Thiabendazole	1967	Yes	1970	*Penicillium* spp.	Harding (1972) and Muirhead (1974)
Sterol demethylation inhibitor (DMI) – imidazole	3	Imazalil	1980	Yes	1982 (lab, subsequently in packinghouses)	*P. italicum*	De Waard et al. (1982)
					1987 (lab, subsequently in packinghouses)	*P. digitatum*	Eckert (1987)
DMI – triazole	3	Propiconazole	2008	Yes	Present at introduction[a]	*P. digitatum*	McKay et al. (2012)
Anilinopyrimidine	9	Pyrimethanil	2005	Yes	2009	*P. digitatum*	Kanetis et al. (2010)
Quinone outside inhibitor (QoI, strobilurin)	11	Azoxystrobin	2008	Yes	2011 (lab)[b]	*P. digitatum*	Zhang et al. (2009)
Phenylpyrrole	12	Fludioxonil	2006	Yes	2010 (packinghouse air samplings)[b]	*P. digitatum*	Kanetis et al. (2010)
					2012[c]	*P. italicum*	Adaskaveg *unpublished*

[a]Cross-resistance to imazalil
[b]Resistance only reported from laboratory mutants or in packinghouse air samplings, no practical resistance to date
[c]Resistance found at a single location, no practical resistance to date

Adaskaveg, J. E., and Förster, H. 2015. Evaluation of new postharvest fungicides for management of citrus decay. Chapter 28. *Postharvest Biology and Technology*.

	Thiabendazole (TBZ)	Guazatine (GZT)	Imazalil/ Pyrimethanil (IMZ/PYR)*	Pyrimethanil (PYR)*	2.4-D
Registered concentration	•1000 ppm	•1000 ppm	•500 ppm	•1000 ppm	•250 ppm
Pro's	•Green and blue mould •Latent pathogens	•**Sour rot** •Green and blue mould	•Green and blue mould drench mix table.jpg inhibition	•Green and blue mould •Latent pathogens (not registered)	•Calyx retention •Indirectly inhibit latent pathogens
Con's	•Precipitate •**High risk for TBZ resistance development**	•Residue loading unknown •Phyto risk •Only certain markets •Risk for resistance development	•**High risk for IMZ resistance development** •Residue loading suboptimal	•Residue loading suboptimal •Risk for resistance development	
Suitability / Caution rating	Red	Orange	Red	Orange	Green

* **These active ingredients or combinations are registered under specific trade names; please enquire from your supplier.**

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Standard drench mixture program

PAA - E.g., Hypercide, Deccocide, Citrocide®PLUS, etc.

- **Water sanitiser**
- Mainly to deactivate pathogen spores in the drench mixture.

- Inoculum accumulates if spores aren't killed.
- Can infect healthy fruit.

- Fast acting
- Important – High decay levels (e.g., sour rot outbreak) and susceptible citrus types (e.g., soft citrus).

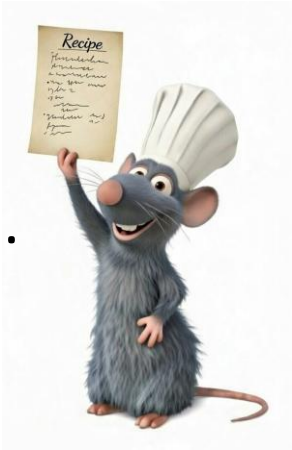
- Only effective if PAA is managed correctly and topped up.

Effective recipe

- The popularity of other chemical combinations has increased.
- Market restrictions, effectiveness, and agrochemical supplier recommendations.

- Keep in mind, this recipe is very effective:

- 2 Different fungicides (Different modes of action – Resistance prevention).
- Compatible, broad-spectrum water sanitiser.



What to remember when choosing chemicals

- **Purpose:**
  - Which pathogens are targeted?
  - Is it registered for the intended use?
  - Are there studies or trial results available?
- **Resistance risk:**
  - Modes of action (FRAC group)?
  - Is it already used in the packhouse? Resistance risk!
- **Compatibility:**
  - Is the sanitiser compatible with your other chemicals? Will it affect the fungicides?
- **Phytotoxicity:** Can it cause chemical burn, and under which circumstances?

Alternative fungicides

Active ingredient	Type	Target	FRAC	Mode of action	ppm
OPP (Ortho-Phenylphenol)	Fungicide	Green and blue mould; Rhizopus	**NC**	Disrupts microbial cell membranes & inhibits amino acid synthesis	1000 - 2000
Azoxystrobin *	Fungicide	Green mould and Brown rot	**11**	Inhibits fungal respiration – Stops spore germination, mycelial growth, etc.	1125
Fludioxonil	Fungicide	Green and blue mould	**9**	Interferes in protein creation (Fungal growth) & host infection	1000
Imazalil **	Fungicide	Green and blue mould	**3**	Sporulation inhibition	500

* Resistance risk – Used preharvest for CBS and Alternaria sprays.

** Resistance risk – Used in the packhouse for sporulation inhibition.

- **OPP**
- Very effective vs. green and blue mould when used in combination with other fungicides.

- **Azoxystrobin**
- The only registered post-harvest brown rot treatment.
- Most effective when used in the drench – Young infections.
- Curative action vs Phytophthora infections if treated within 12 hours post-harvest.

- **Caution!** Resistance risk.
- - Strobilurins used in the orchards for CBS and Alternaria sprays.
- Possible green mould-resistant populations in the orchard.
- Combine with chemicals from different FRAC groups.
- Annual resistance tests.

- Possible replacement for pyrimethanil rather than TBZ.

- **Fludioxonil**

- Has some sporulation inhibition properties – Interferes with spore germination.

- **Imazalil**

- Applied in the drench in some areas of the country (WC).
- **Strongly discouraged from using outside and again inside the packhouse.**

- **Resistance risk -** Resistant spores can develop during degreening.
  - IMZ-resistant spores move into the packhouse.

- **Cannot risk it -** Most packhouses use it several times on the line – Too **IMPORTANT**
- **If resistance? -** Replace imazalil for several seasons.
- - Stringent sanitation practices.

Disease	Causal organism	Days to first symptom at 25 ˚C
Green Mould	*Penicillium digitatum*	1-2 days
Blue Mould	*Penicillium italicum*	3 days

Sanitisers

- **Peracetic acid** – Excellent sanitiser.
- Fruit rind can burn if not managed correctly.
- Some use ½ the recommended dose for soft citrus or to be safe.

- **Potassium sorbate –** Excellent in combination with other chemicals.
- **Chitosan –** Keeps water cleaner for longer. Should be managed properly.
- **Stabilised glutaraldehyde**
- **Clove oil –** Excellent in combination with certain fungicides.

Sanitisers

- **Does it leave a residue?**
- **Is it compatible with my fungicides?**
  e.g. Chlorine does not discriminate; it breaks down any chemical.
- **Corrosivity?** PAA
- **Negatively affects the fruit?**
  - Phytotoxic? Burn or dehydrate? Susceptible cultivars?

ASK QUESTIONS

- Read the label and follow the instructions.

Sour rot control

- PAA and clove oil are excellent at deactivating *Galactomyces citri-aurantti* (sour rot pathogens) spores in the water.

- PAA effectivity is drastically reduced 24 hours post-application if not topped up.
- Regular measurement and topping up.

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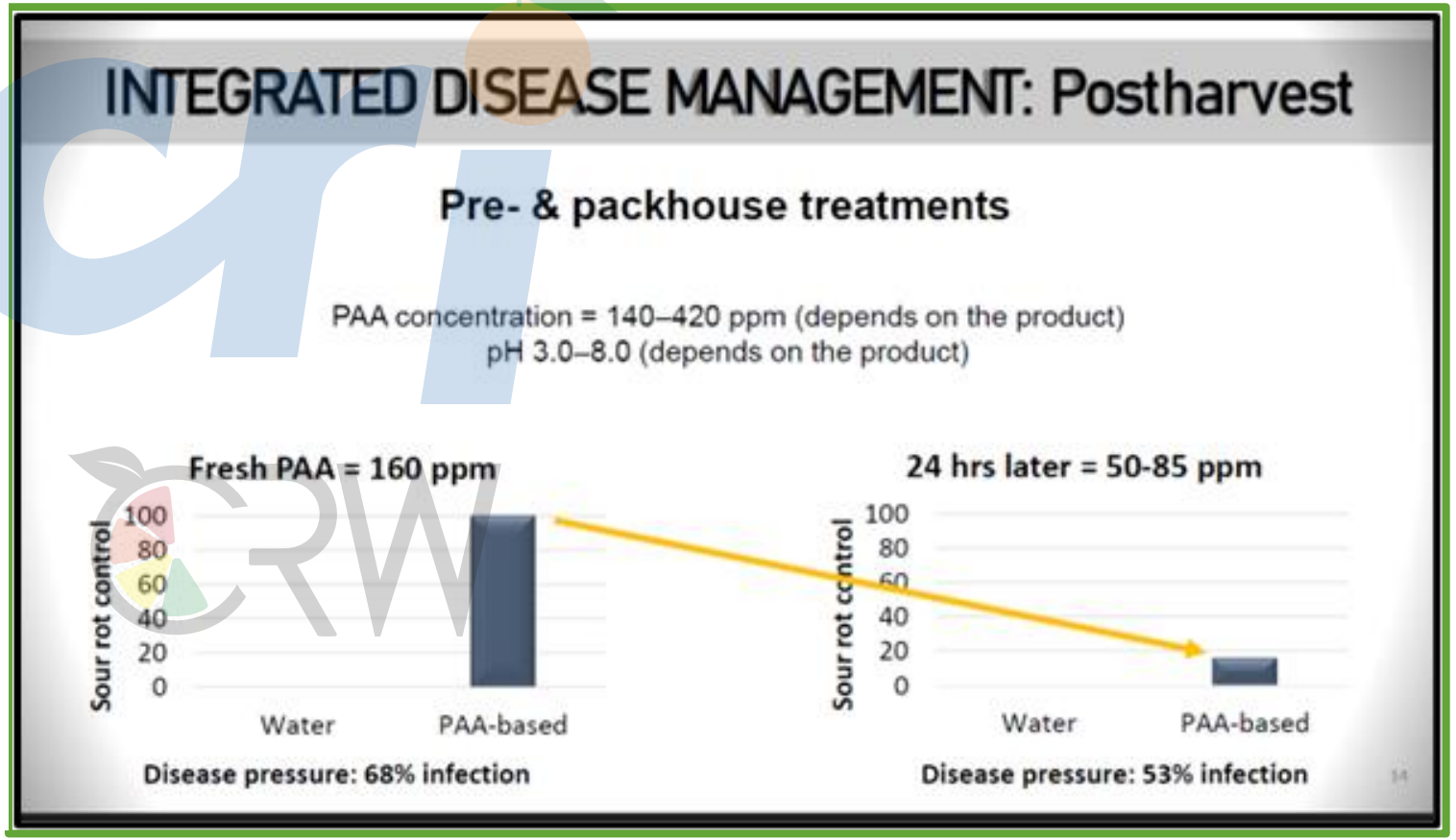
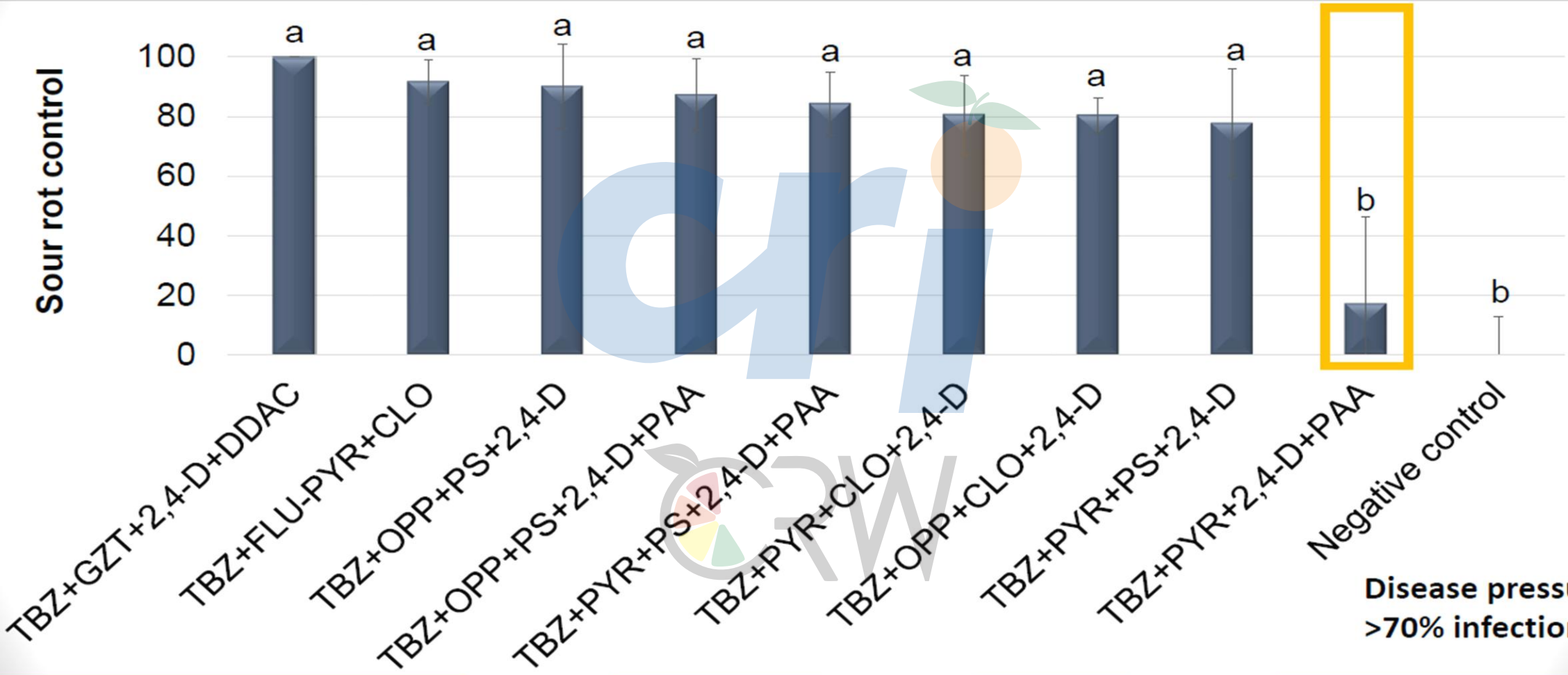


RESULTS: Pre-packhouse drench



PRE-PACKHOUSE DRENCH → Ca(ClO)2 → IMZ-S → 2,4-D+TBZ+IMZ-EC

Management of the chemicals

- Allocate the task of chemical measurement, mixing, and drench management to one person.
- Ensures correct application and consistency.

  - Limits mistakes.

- Use the same measuring jug or container - Contamination.

- Stopwatch or timer to keep time.
- Similar treatment period per bin/ batch.

- **Expensive to fill a drench tank – Cannot make mistakes**.

Making a drench mixture

1.) Fill the drench tank and start the pump to circulate the water.

2.) Mix the chemicals into the tank, according to their formulation – Ensures proper mixing.

SG – SC – EC – SL

,e.g. Deccomone/ 2,4-D (SG) - Thiabendazole (SC) – Pyrimethanil (SC) – Hypercide (SL)

3.) Turn on the pump.

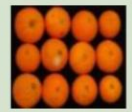
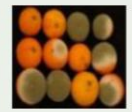
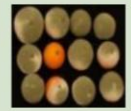
4.) Run the system for at least 10 -15 minutes before treatment – Uniform chemical mixing.

Managing a drench mixture

- **Ideal - Constant agitation** (Pump always on).
  - TBZ and PYR settle out when not agitated.
  - Difficult to resuspend TBZ.
  - This can reduce the concentration of the actives and result in less residue being loaded on the fruit.
- **Realistic -** Turn pump on **15 - 20 minutes before** treatment.
- Proper mixing is required after a night's standing.
- **MRL exceedance risk** – Highly concentrated sediment deposited onto the fruit.

- Each bin must receive 500L mixture/ minute.
- The mixture should be circulated every few minutes.
- All fruit inside bins should be completely covered in drench mixture.
- **No dry pockets should exist inside the bins.**
- Check for uniform wetness using tennis balls, carton disks, etc.
- A minimum contact time of 2-3 minutes is required for sufficient residue loading.

Fruit Coverage

Residues	Green mould control	
Same (0.5 – 1 ppm)	Highest (12%)	
Same (0.5 – 1 ppm)	Intermediate (32%)	
Same (0.5 – 1 ppm)	Lowest (48%)	

When to replace the mixture?

- Drench mixture gets dirty – Dirt and organic material settle to the bottom.
- Gradual deactivation of chemicals.
- Spore load increases – Sanitiser can only do so much.
- UV breaks down chemicals.
- Water evaporates.

- Chemicals stripped from the system by the fruit and bins.
- Automatic dosers – Keeps the mixture at the correct concentration

  BUT cannot control other factors.

- Ineffective chemical treatment and sanitation = Increased risk of decay.

When to replace the mixture?

Reservoir size	1000 L	Discard drench mix after 60 tons of fruit or 150 bins
	2000 L	Discard drench mix after 80 tons of fruit or 200 bins
	3000 L	Discard drench mix after 120 tons of fruit or 300 bins
Flow rate	1 bin	250 L per minute
	2 bin stack	500 L per minute
	3 bin stack	750 L per minute
Exposure time	per stack	1 to 3 minutes

- Replace the drench mixture when the recommended number of bins has been treated.
- Most packhouses keep the same mixture for a week.
- Do residue analysis tests to see how many bins can effectively be tested before replacement is really necessary.

- Ineffective chemical treatment and sanitation = Increased risk of decay.

How to prolong the lifespan

Reduce debris in the tank

- A grid or net over the drench tank to catch plant material.
- Easy removal.

Effective filtration system

- Removes organic material, dirt, and other impurities.
- Recirculating system – Lasts longer.

Sanitation

- Managing the sanitiser ensures that spores are deactivated even near the end.

Smaller tank size

- Less water and chemicals are used. Managed more efficiently.
- But, more effort is required.

Top-up of chemicals

- Important, especially for sanitisers (like PAA).
- Automatic dosing systems
  - Correct concentration of chemicals is dosed after each batch of bins is drenched.
- Regardless, frequent concentration measuring is needed is possible.
- Residue analysis tests.
- Automatic dosers should be serviced often to limit incorrect dosing.

Other considerations

- Your drench tank should be covered.

- Limits exposure to the elements.
    - UV rays break down chemicals.
    - Debris can fall in.
    - Rain will dilute the mixture.

How to know if your drench treatments are working

- Your residue analysis reports show that you load above the minimum effective level, but below the MRL.

- Low decay levels post-degreening and down the line.
- Diseased fruit had bombed out, but not infected neighbours.
- No heaps of calyxes under the drop plates.
- PAA levels are kept consistent – Test strips indicate

Take home message

- The drench is the first postharvest chemical treatment that the fruit receives
  - Give your fruit the best possible start to their long journey.

It is expensive to make a drench mixture, so do it right.

- Run trials first before any new chemical is incorporated into the program or a big change is made to your existing protocol.
- It is easy to manage.

Additional resources

- Citrus academy: Citrus packhouse series.
- **CRI postharvest factsheets 2025:** https://www.citrusres.com/document-library/
- **Cutting edges:**
  - **No. 56** – Pre-packhouse and Packhouse chemical treatments.
  - **No. 136** – Recommendation for the pre-packline drench.
  - **No. 177 –** Pre-packhouse treatment recommendations.
  - **No. 341 –** Post-Harvest decay warning.
  - **No. 348 –** Intensive management of critical control points in the packhouse.

- Van der Merwe (2024) Evaluation of fludioxonil and azoxystrobin for the postharvest control of Phytophthora brown rot on citrus. 72-92.
- Kellerman et al. (2014) - Thiabendazole residue loading in dip, drench and wax coating applications to control green mould and chilling injury on citrus fruit. 78 – 87 (96).
- Kellerman et al. (2018) - Postharvest dip, drench and wax coating application of pyrimethanil on citrus fruit: Residue loading and green mould control. 115 – 129 (103).

Thank you!

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