EXTENSION BRIEFS FOR AUGUST & SEPTEMBER 2015

H.F. LE ROUX & J.J. BESTER *Citrus Research International*

INTEGRATED PEST MANAGEMENT

CITRUS THRIPS T.G. GROUT

Suppressing citrus thrips populations on the spring growth flush will assist in lowering populations experienced at petal fall. On younger trees a methamidophos stem treatment is a useful option for this. An alternative may be an organophosphate that cannot be sprayed after petal fall but sprays should be completed before flowers open to reduce any impact on honey bees. If mealybug requires control, the organophosphate could be sprayed at full cover. These treatments will also reduce developing populations of citrus psylla. Avoid using abamectin at this time because it will be needed for citrus thrips control in summer and only three applications are permitted per season.

FALSE CODLING MOTH S.D. MOORE

It may be very tempting to neglect orchard sanitation in winter, as FCM levels are usually low and Valencias being harvested at this time are generally less susceptible to FCM than some of the earlier season cultivars. However, this would be a big mistake. It has been shown that Valencias can fulfil an over-bridging role for FCM from one season to the next. The most effective way in which to ensure the lowest FCM inoculum possible at the start of a season, is to diligently continue sanitising orchards until the previous season is truely over. Most importantly, growers must ensure that no fruit whatsoever remains on trees or on the orchard floor after harvesting is completed.

BOLLWORM S.D. MOORE

Depending on the region of the country, which influences temperature and blossom phenology, bollworm may begin invading orchards as early as September or even August. Growers should therefore begin weekly blossom inspections for bollworm eggs and larvae no later than early September. Particularly if a biological product, such as DiPel, Helicovir or Bolldex, is going to be used, sprays should be applied as soon as eggs begin to hatch. This can only be determined by vigilant and regular scouting but honey bee populations will benefit if sprays need to be applied during bloom because these products are harmless to bees.

CITRUS FLOWER MOTH S.D. MOORE

Moths of the citrus flower moth (also known as the lemon borer moth), Prays citri, are attracted to lemon blossoms. Growers should inspect these blossoms in spring to determine whether they are infested with larvae or pupae. These can be identified by their colouration, which is usually greenish and the association of webbing with pupation. Even if the damage to, and loss of blossom is not considered sufficiently severe to justify control measures, no intervention may allow the development of a second generation. It is the moths of this second generation which lay their eggs on the lemon fruitlets. Hatching larvae can potentially cause severe damage. It is therefore more effective to control the first generation. No plant protection products are registered for use against the lemon borer moth. However, there are a number of pesticides which are registered for other pests on citrus that are effective, including Bt (DiPel) and mevinphos.

CROP & FRUIT QUALITY MANAGEMENT

PAUL CRONJE & JAKKIE STANDER

GENERAL. It is important to keep managing and monitoring fruit pickers throughout the harvest season in order to reduce cull of export fruit, caused by picking injuries. Pruning of early-and mid-season cultivars should commence as quickly as possible after harvest to allow ample time for flower induction.

MATURITY INDEXING. Maturity indexing is done to predict the rate of change in fruit maturity in order to harvest fruit at a maturity that would maintain acceptable commercial shelf life. The aim is to define changes or rate of change in acids and sugars and to build up a database over a number of years for comparisons. Random sampling of fruit every week from each of ten representative trees should start 4 to 6 weeks before the expected harvest date. Titratable acidity is determined by titration with sodium hydroxide, sugar content (Brix) is determined using a refractometer, the sugar:acid ratio calculated and fruit colour should be read from a colour chart. All these data should be plotted on a graph in order to determine the optimal picking window. Growers should adhere to the time and temperature protocols for each citrus type to ensure optimal shelf life of the fruit (Cutting Edge No. 99). It is important to maintain good records of the maturity indicators over a number of years, in order to identify and possibly manipulate possible problems associated with internal and external quality parameters.

DEGREENING & POSTHARVEST RIND DISORDERS. The two publications "Common Defects Associated with Degreening of Citrus" by Andy Krajewski and Tim Pittaway and "Postharvest Rind Disorders of Citrus Fruit" by Paul J.R. Cronje are a must for any grower. Both are available from CRI. Contact Bella Thulare at 013 759 8000 or bella@cri.co.za.

PRUNING of early and late cultivars should be done as soon as possible after harvest.

All the following should be removed during pruning: old, broken and dead shoots/twigs; weak and entangled shoots crossing each other; and rootstock regrowth (water shoots). Removal of all dead wood is very important to reduce blemishes on the fruit and lower the inoculum of latent pathogens which cause postharvest decay, and is therefore part of orchard sanitation. Light levels of 30% of full sunlight are necessary for optimal photosynthesis and light also improves colour development. In dense trees, and especially older trees, light levels drop to below 30% inside the tree and adversely affect fruit set inside the canopy and fruit size, so at least one "window" cut should be made to allow for adequate light distribution to improve bearing wood within the tree. Increase in photosynthesis and light distribution will lead to increased fruit size and internal fruit quality, better fruit colour, increased rind condition and less variation in fruit quality within the canopy. Pruning can also be used as a thinning technique by pruning more heavily after a light crop if a heavy crop is expected and when the orchard has a history of alternate bearing. Pruning improves the light distribution and the quality of the bearing wood inside the tree. A follow up of regrowth management in the summer is critically important to maintain light management throughout the season. Proper pruning also improves spray penetration and effective control of pests and diseases, and is especially important for the effective control of phytosanitary pests and diseases. Pruning tools should always be sanitised with 10% Jik on a regular basis to prevent spreading of viral diseases, and should be done at least after each row, and definitely when moving from one orchard to another.

One or two PRE-BLOOM FOLIAR UREA applications (low biuret urea at 1%) should be applied for uniform flowering and fruit set, especially when leaf N levels are low and a light blossom is expected.

FRUIT SET treatments according to cultivar requirements need to be applied. Specific treatments include the application of gibberellic acid (GA) and girdling, especially for parthenocarpic cultivars that have a poor set. Girdling during full bloom improves set. A general guideline cannot be given as fruit set treatments differ by cultivar and, in many cases, by orchard depending on the previous crop load. Moisture stress should be avoided during full bloom, fruit set and early fruit growth.

GEINTEGREERDE BEMESTING

J.T. VAHRMEIJER

STIKSTOFBEMESTING VAN SITRUS

Aan die einde van die groei-seisoen

1. Blaar en grondmonsters moes aan die einde van die groei-seisoen geneem gewees het (Februarie tot Mei).

2. Resultate van die blaar- en grondontledings tesame met boordinligting (ouderdom van bome, onderstam, kultivar, verwagte opbrengs, ens.) word gebruik vir bemestingsaanbevelings.

Waar mikro-spuite of enige ander stelsel behalwe druppers gebruik word:

1. Begin met stikstoftoedienings in Julie met die uitsondering van die Wes-Kaap en Hartswater wat in Augustus begin.

2. Afhangende van die klei-inhoud van die grond word die stikstof tussen 1 en 4 toedienings verdeel.

Waar druppers gebruik word.

1. Begin met die stikstoftoedienings in Julie met die uitsondering vandie Wes-Kaap en Hartswater wat in Augustus begin.

2. Verdeel die volumes wat per maand aanbeveel is in ten minste weeklikse toedienings.

3. Stikstoftoediening geskied volgens die phenologiese stadium van die boord. As breë riglyn kan die volgende gebruik word:

Periode	Phenologie	N (% van totale toediening)
Julie	Seldifferensiasie en seldeling	25
Aug	Knopbreek, blom en vrugset	25
Sept	Vrugset en selgroei	25
Okt	Vrug-groei	15
Nov/Des	Vrug-groei	10

Blaarbespuitings:

1. Dien ureum toe as ŉ blaarbespuiting in Julie om vrugset te bevorder of na Oktober vir stikstof-aanvulling.

2. Die kritiese vereistes vir suksesvolle blaarvoeding is die kontaktyd wat die blare nat bly, druppelgrootte en die konsentrasie van die voedingselement in die spuit-oplossing.

Om die loging van stikstof te beperk kan die volgende gedoen word:

1. Dien stikstof in die middel van of aan die einde van die besproeiingssiklus toe.

2. Voorkom ŉ oormaat van stikstof in die grondoplossing. Stikstofkonsentrasies wat hoër is as 150-200 mg/L het geen addisionele voordeel nie. Oormaat stikstof lei tot moontlike loging van die stikstof en moontlike probleme met vrugkwaliteit.

3. Stikstoftoediening moet verkieslik aan die einde van die groeiseisoen gestaak word sodat die stikstofinhoud in die grond gedurende die wintermaande kan afneem.

4. Die regte hoeveelheid water moet toegedien word tydens besproeiing. Dit is onvermydelik dat ŉ sekere hoeveelheid stikstof geloog word tydens besproeiing, maar oorbesproeiings versnel die proses en ŉ groot hoeveelheid stikstof kan verby die wortelsone geloog word. Reënval moet ook in ag geneem word tydens besproeiingskedulering.

NITROGEN FERTILSATION OF CITRUS

At the end of the growing season:

1. Leaf and soil samples should have been taken between February and May.

2. Results from the soil and leaf analyses with additional information such as tree age, tree vigour, expected yield rootstock, etc. are used to compile a fertiliser programme.

When micro-jets or any other system except drippers are used:

1. Start with nitrogen fertilisation in July with the exception of the Western Cape and Hartswater which should start in August.
2. Split the nitrogen application in one to four portions, depending on the clay content of the soil.

When drip irrigation is used:

1. Start with nitrogen fertilisation in July with the exception of the Western Cape and Hartswater which should start in August.
2. Split the volumes recommended per month into at least weekly applications. Ensure that the water and fertilisers do not penetrate deeper than the upper root zone (30-40 cm).

Periode	Phenologie	N (% van totale toediening)
July	Cell differentiation and start of cell division	25
Aug	Bud break, flowering and fruit set	25
Sept	Fruit set and cell growth	25
Oct	Fruit growth	15
Nov/Dec	Fruit growth	10

Foliar spray of nitrogen:

1. Spray the urea in July to improve fruit set and after October to supplement nitrogen.
2. The critical requirements for successful foliar sprays are contact time, droplet size and concentration of the nutrient element in the spray solution.

Four measures can be used to prevent or minimise the downward movement of nitrate:

1. Inject nitrate in the middle of, or late, in an irrigation event.
2. Avoid excessive concentrations of nitrate in the soil solution. Nitrate concentrations greater than 150-200 mg/L don't provide any additional benefit, and supplying more N fertiliser simply increases the risk of leaching by successive irrigation or rainfall events. Oversupplying N can also lead to fruit quality issues.
3. Complete the N supply programme by the end of the growing season to allow depletion of nitrate in the soil by winter.
4. Ensure that only the right amount of water is applied. Some movement of nitrate may be inevitable with each irrigation cycle, but overwatering is likely to speed up that process and move nitrate beyond the root zone. Allowing for expected rainfall when calculating the depth of water to apply will also help reduce the likelihood of leaching.

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GRONDGEDRAAGDE SIEKTES

M.C. PRETORIUS & JAN VAN NIEKERK

Aalwurms

Grond- en wortelmonsters kan in die lente getrek word en na die Diagnostiese Sentrum in Nelspruit gestuur word vir ontleding sodat die aalwurmpopulasie in die wortels bepaal kan word. Die resultaat sal dien as 'n bestuurshulpmiddel om 'n koste doeltreffende aalwurmbeheerstrategie daar te stel.

Die gebruik van chemiese aalwurmdoders vir die beheer van die sitrusaalwurm word nie aanbeveel alvorens ten minste 30 mm reën geval het nie. Elke aalwurmdodertoediening behoort met 'n behoorlike besproeiing opgevolg te word om te verseker dat die middels deeglik deur die grondprofiel gewas word. ***Toedienings behoort slegs volgens etiketaanbevelings toegedien te word. Afwykings van die geregistreerde dosisse, om kostes te bespaar, lei tot oneffektiwiteit. Dit is belangrik om 'n program te volg, een aalwurmdodertoediening per seisoen is 'n mors van geld!***

Phytophthora

Phytophthora wortelvrot – die gebruik van fosfonaatprodukte is 'n uiters effektiewe en bekostigbare beheermaatreël wat suksesvol deur produsente gebruik word. Dit is van uiterste belang dat die etiket deeglik bestudeer word asook die waarskuwings voordat die produk gebruik word om effektiwiteit te verseker en fitotoksisiteit te voorkom. Indien kraagvrotletsels voorkom kan 'n stamverf of blaarbespuiting aangewend word, drie aanwendings per seisoen met 8 weke intervalle. Vir wortelvrotbeheer word drie blaarbespuitings, met 8 weke intervalle aanbeveel. Dit word sterk aanbeveel om nuwe aanplantings en nie-draende bome op 'n fosfonaatprogram van drie aanwendings per jaar, twee maande uitmekaar, te hou om gesonde wortel-ontwikkeling te verseker. Prosusente word gemaan om seker te maak dat bome nie oorbesproei word nie.

FRUIT AND FOLIAR DISEASES

G.C. SCHUTTE

Alternaria core rot

Alternaria core rot, also known as navel-end rot and black rot, occurs in all areas of southern Africa. The disease is most prevalent on those citrus cultivars such as navels and

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Clementines characterised by the presence of a secondary fruit called the fruit-navel, which varies in size and develops at the stylar end of the primary or main fruit. These fruitlets are extremely sensitive to environmental stress conditions during early stages of development and are therefore also prone to diseases such as navel-end rot and physiological disorders.

Alternaria core rot is linked to large fruit-navels or to the abnormal growth of the secondary fruit into primary-fruit locules, which lead to the formation of points of entry through which fungi can penetrate to form infections that remain quiescent until favourable conditions stimulate further fungal growth.

The style and stigma of navel blossoms are milky white at first and then turn light brown in colour and abscise cleanly. This happens one week after petals have dropped and young fruit are ± 8 mm in size. The two sets of stylar tissue present in the primary and secondary fruit locules can be injured during the blossom period if harsh weather conditions prevail for one or more days (hot days >25°C), and low relative humidity (<20%) followed by heavy dew during the evenings. This causes the outer or primary style to turn brown and dry out, while the inner or secondary style remains unaffected inside the outer style and continues to develop and swell in size to result in longitudinal cracks in the outer tissue. The longitudinal cracks enlarge as the orange increases in size. The inner ovary projects even more as the orange approaches maturity. This results in a large, irregular-shaped navel-end and creates an ideal site for *Alternaria* infections.

Score (50 ml/100 L water) and Folicur (80 ml/100 L water) are registered for control of the disease.

Botrytis on lemons

The role played by B*otrytis* and the damage that it can do to lemon fruit drop and the formation of ridging of the rind is still not clear. Damage can be caused during blossom on lemon petals when prolonged wetting and cool weather occur simultaneously. Producers in the Eastern Cape enlisted on the Adcon system can make use of their early warning forecasts for Botrytis. Benomyl is the most effective fungicide to control this fungus and should be sprayed at the balloon stage during blossom which can also form part of the black spot control programme.

POST HARVEST PATHOLOGY – WASTE PREVENTION

A. ERASMUS, K.H. LESAR & P.H. FOURIE

By this time of the citrus season all processes are in full motion. The strain of the season may be taking its toll on management and this may lead to poor management of critical control points. Below are a few suggested critical control points that should be well managed.

CRITICAL CONTROL POINTS FOR IMPROVED POSTHARVEST DISEASE MANAGEMENT

- Monitor the incidence of insect activity in the orchards and institute appropriate measures to reduce their populations, especially fruit fly and false codling moth numbers that could increase with hotter weather.
- Monitor orchard sanitation. Advise the orchard managers and producers if sanitation is being improperly managed or neglected, as this can also fulfil an overbridging role for FCM from one season to the next. The most effective way in which to ensure the lowest FCM inoculum possible at the start of a season, with associated fruit damage and decay, is to diligently continue sanitising orchards until the previous season is truely over.
- Monitor injuries to fruit during picking, handling and transport to the packhouse. Advise orchard managers and/or producers accordingly. Keep the time from harvest to the first fungicide treatment to a minimum
- Ensure that all fungicide applications are replaced frequently as per protocol and kept clean
- Keep the fruit dumping site where fruit will enter the packhouse as clean as possible
- Ensure proper removal of any rotten fruit before sanitising and treatment of the fruit
- Have a sanitation action (total loss chlorine spray) between fruit sorting and the first fungicide application
- Manage the concentration of imazalil in the fungicide dip tank by doing regular titrations
- Do not wax wet fruit – this could result in a severe risk to fruit quality
- Apply the correct amount of wax onto the fruit (i.e. 1.0 – 1.5ℓ per ton of fruit) and ensure even spread of the wax over the whole fruit
- Reduce the time from harvest to cold chain storage
- Packhouse sanitation should be a continuous process and not just a once a day or week activity
- Store fruit destined for the juicing factory as far away from the packhouse as possible and have them removed as soon as possible

Below is the same checklist for chemical application from last year with a few amendments.

CHECKLIST FOR CHEMICAL APPLICATION

Chlorine application

- Solution pH: 6 - 7
- Chlorine concentration: 75 – 100 ppm (free active chlorine)
- ORP: 800 mV

Fungicide dip tank

- Imazalil concentration: 500 ppm
- Solution pH: not higher than 6
- Exposure time: 1 – 3 minutes in a solution at pH3 or not longer than 45 seconds in a solution at pH6
- Maintain the concentration by following the advised imazalil top-up protocol

Optimisation of fungicide application in citrus packhouses, a journey to precision PART 2

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If this is the first time you are joining us on this journey, welcome and let us quickly bring you up to date. We are on a journey of revisiting research from the CRI-USPP post-harvest group where a lot of time was focused on fungicide application for the control of green mould. On the first part of this journey we learnt that the majority of South African citrus packhouses use a dip tank to apply the fungicide imazalil (IMZ). Imazalil is currently the most effective fungicide we have for the control of green mould *(Penicillium digitatum)*. We also discovered that the pH level of an IMZ sulphate solution influenced residue loading; much lower residue levels were loaded in the pH 3 solution compared to the pH 8 solution.

Fruit exposure time and residue loading

Now we explore the effect of fruit exposure time in an IMZ sulphate solution. Fruit were dipped for 15, 45, 90, 180 and 540 seconds in a 500 ppm IMZ sulphate solution at either 20 or 35°C. The solution pH level was also amended to 3 or 8. Only residue loading was investigated in this round. First of all, it was found that solution temperature had no effect at these two pH levels. The results can be seen in Figure 1. On this graph you will see a flat horizontal line for the IMZ sulphate solution at pH 3, this means that exposure time had no significant effect on residue loading. The residue level loaded after 15 seconds and 9 minutes was statistically similar (1.22 and 2.06 ppm, respectively). This is remarkable, especially when you compare that to the pH 8 solution. Here the residue increased from just below 4 ppm to just over 44 ppm! The red lights were starting to flash here when we considered the fact that many packhouses had solution pH levels of around 8, which is due to poor water quality. **Any packhouse with an IMZ sulphate solution pH of higher than 6 should limit fruit exposure time to less than 45 seconds to prevent exceeding the MRL of 5 ppm.**

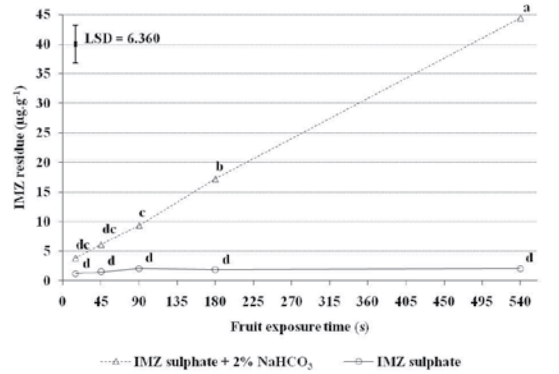

Figure 1. *Mean imazalil (IMZ) residue levels measured on Valencia oranges dipped for various exposure times in a 500 µg.mL^{-1} solution (at 20 and 35°C, mean data presented) of IMZ sulphate at pH 3 (solid line) or pH 8 (buffered with 2% $NaHCO_3$) (broken line). Data points followed by the same letter do not differ significantly (P = 0.05; LSD = 6.360)*

Comparing dip to spray application

We were curious to compare other application methods to the dip. The first method we investigated was the in-line spray application of an IMZ sulphate and EC (emulsifiable concentrate) formulation solution. We designed a lab spray applicator to deliver a fine mist of the solution to the fruit, but in such a volume that the solution does not start to run off. Here we looked at curative and protective action, where fruit was inoculated with green mould 24 hours before or ± 6 hours after treatment, respectively. Of course we also looked at residue loading. Half of the fruit was dipped for one minute in IMZ sulphate at pH 3 or 8, or in an IMZ EC solution (at 0, 250, 500 and 1000 ppm); the other half of the fruit was sprayed with these solutions (at 0, 1000, 2000 and 4000 ppm). For the spray application the residue loading did not differ so much between the differ- CONTINUED ON PAGE 58

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Wax application

- Fruit should be dry when they reach the wax applicator
- Wax load should be between 1.0 and 1.5 litres per ton fruit depending on manufacturers' recommendations

§ Over application can lead to MRL exceedance

§ Under application will lead to poor fruit quality and poor disease control

- The wax solution should be agitated continuously (24 hours a day, 7 days a week)

§ Thiabendazole tends to precipitate to the bottom of the wax drum and cannot be fully re-suspended

- Drying tunnels after the wax applicator should not be overheated

§ Obtain the optimal temperature for the specific wax from the wax manufacturer

§ The correct drying of the wax is crucial to ensure that the desired effect is gained

Table 1. *Mean imazalil (IMZ) residue levels measured on Valencia oranges and Eureka lemons dipped for 60s in or sprayed with 3 mL of various concentrations (0 – 1000 or 4000 μg.mL^{-1}, respectively) of IMZ sulphate at pH 3 or 8 (buffered with 2% $NaHCO_3$) or the IMZ EC formulation.*

IMZ concentration (μg.mL^{-1})	IMZ residue (μg.g^{-1})[a] IMZ sulphate (pH 3)	IMZ sulphate (pH 8)	IMZ EC
Dip			
0	0.05i	0.10i	0.05i
250	1.03hi	2.67ghi	2.94fghi
500	2.39ghi	8.00bcd	5.16defg
1000	4.82efg	18.34a	9.39b
Spray			
0	0.18hi	0.11i	0.18hi
1000	6.03cde	4.37efg	3.08fgh
2000	9.86b	8.69bc	5.73def
4000	19.03a	17.71a	10.78b

[a]*Means followed by the same letter do not differ significantly (P = 0.05; LSD = 2.924)*

Table 2. *Mean green mould infection incidence (%) after 14 days of storage at 20°C rated on Valencia oranges and Eureka lemons inoculated with imazalil (IMZ) sensitive and resistant isolates of* P. digitatum, *incubated for 4-6 hours and then dipped for 60s in or sprayed with 3 mL of various concentrations (0 – 1000 or 4000 μg.mL^{-1}, respectively) of IMZ sulphate at pH 3 or 8 (buffered with 2% $NaHCO_3$) or the IMZ EC formulation.*

IMZ concentration (μg.mL-1)	Green mould infection incidence (%)[a] IMZ sulphate (pH 3) Sensitive	Resistant	IMZ sulphate (pH 8) Sensitive	Resistant	IMZ EC Sensitive	Resistant
Dip						
0	62.7b	50.2bc	51.5bc	47.3c	62.7b	50.2bc
250	4.2hij	48.6c	1.4j	18.1defg	0.0j	23.7de
500	4.2hij	16.7defgh	0.0j	8.3fghij	1.4j	7.0ghij
1000	0.0j	5.6ghij	0.0j	2.8ij	1.4j	1.4j
Spray						
0	77.9a	83.4a	58.5bc	59.8bc	77.9a	83.4a
1000	4.2hij	20.9def	1.4j	15.4defghi	1.4j	27.9d
2000	0.0j	22.3de	2.8ij	20.9def	0.0j	12.6efghij
4000	1.7j	8.4fghij	0.0j	15.4defghi	0.0j	5.6ghij

[a]*Means followed by the same letter do not differ significantly (P = 0.05; LSD = 13.0)*

ent formulation solutions; this was expected seeing that we sprayed to just before run off. In the dip solution there were differences between the pH 3 and 8 IMZ sulphate and the EC solution. The pH 8 solution tended to load much higher residue levels compared to the others at 500 and 1000 ppm. The big question was what level of green mould control we would get from these residue levels of which many were well over the MRL of 5 ppm! The residue results are shown in Table 1 and those of green mould control in Table 2. On the IMZ-sensitive isolate infections, excellent control was gained regardless of application method or residue level. Luckily, we also included an IMZ-resistant isolate and from here we learnt a thing or two. Firstly, we saw that residue levels as high as 19 and 17 ppm could not give complete control of the resistant isolate infections (8.4% and 15.4% infection, respectively), where low residue levels of around 2 ppm gave excellent control of sensitive isolate infections (mostly below 2% infection). Secondly, similar residue levels (i.e. ± 8 ppm) gave much better control in the dip treatments (8.3%) compared to the spray treatments (20.9%). **This showed us that residue level should not be the only way to measure the efficacy of a specific application, and that dip application was more effective than spray application.**

A first look at drench application

We have to remind you that at this stage (2008-2009) we were still very new to this field of citrus postharvest disease management and this was probably why we tried out so many different things. Therefore, we also evaluated the drench application, which is commonly used by packhouses, especially prior to degreening or delayed packing periods. To do the very first trials on drench application we devised a drench simulator. We drilled holes in the bottom of plastic lug boxes (very similar to milk crates) with closed sides; the holes were the same proportion as the openings in the bottom of wooden fruit bins. These boxes were then filled with fruit, stacked in groups of three and a specific IMZ EC solution was poured over the top crate which then ran through the middle and bottom crates. The aim here was to test the efficacy of a drench application where the fungicide solution showers over the fruit and runs through the fruit in the bin-stacks below the top crate. We calculated the volume of water that would resemble the industry-recommended 250 litres per orchard bin in our much smaller "bins". This amounted to 12.5 L per box and we added half and double that as extra treatments. In these trials we used the IMZ EC formulation, as it is registered for this use. Enough on the how, let's look at the results.

In terms of residue loading (Table 3) increasing the volume did not have a substantial effect, but control gained from increasing the volume (Table 4) was always better. Another hint that residue loading alone is not always an indicator of disease control efficacy. Even loading a residue of ± 2 ppm did not always result in complete control of the sensitive infections, which would have been the case with a dip application. The resistant isolates could not be controlled; even at residue levels close to 4 ppm.

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Table 3. *Mean imazalil (IMZ) residue levels (μg.mL-1) measured on Minneola soft citrus, Eureka lemons and Valencia oranges drenched with different volumes (6.25 – 25.00 L) of 500 μg.mL-1 IMZ EC.*

Drench volume (litre)	IMZ concent-ration (μg.mL-1)	IMZ residue (μg.g-1)[a]		
		Mineola	Lemon	Valencia
12.50	0	0.00g	0.06g	0.02g
06.25	500	1.56f	2.92b	1.72ef
12.50	500	1.65ef	3.80a	2.19cd
25.00	500	1.99de	3.90a	2.47c

[a]*Means followed by the same letter do not differ significantly (P = 0.05; LSD = 0.409)*

Table 4. *Mean green mould infection incidence (%) rated on Minneola soft citrus and Valencia oranges after 14 days of storage at 20°C inoculated with imazalil (IMZ) sensitive and resistant isolates of* P. digitatum, *incubated for 4-6 hand then drenched with different volumes (6.25 – 25.00 L) of 500 μg.mL-1 IMZ EC.*

Drench volume (litre)	IMZ concent-ration (μg.mL-1)	Green mould infection incidence (%)[a]	
		Sensitive isolate	Resistant isolate
12.50	0	91.7a	92.6a
06.25	500	9.3d	69.0b
12.50	500	6.0de	65.3bc
25.00	500	1.9e	56.9c

[a]*Means followed by the same letter do not differ significantly (P = 0.05; LSD = 0.48)*

Other information gained at this leg of the journey

The fact that the resistant isolate is less fit than the sensitive isolate was shown in most of our untreated inoculated fruit. The resistant isolate fruit in most cases had lower infection levels compared to those inoculated with the sensitive isolate. This is an indication that the resistant isolate needs IMZ to survive in a specific environment, if the selection pressure from IMZ is removed, the sensitive isolates will slowly take over as they compete much better for food and space than the resistant isolates. This is just another fact that should urge packhouses to implement a diligent sanitation regime, as well as to alternate fungicides with different modes of action.

Another interesting fact to see was that infection levels on untreated Valencia fruit were always lower than those on any other citrus type. This was an indication that Valencia fruit were more resistant to green mould than other citrus types. This explains why we tend see less decay problems on Valencia fruit than on other citrus types on the market.

During the next leg of the journey we will have a closer look at pH level, fruit exposure time and IMZ formulation in dip applications.

What we have learnt on this part of the journey:

- Fruit exposure time in a pH 3 IMZ sulphate solution had no significant effect on residue loading
  - The opposite was true in a pH 8 solution, but this should not be considered for practical implementation as the MRL was quickly exceeded
- Even though lower residue levels were loaded in a dip treatment compared to a spray treatment, dip treatment still gave better green mould control
- Drench application was also not as effective as dip application.

A word of caution. Don't increase the pH of your IMZ sulphate solution to 8! In Part 3 we discover that pH 8 is not the way to go. Always follow the recommendations given by CRI and always read the product labels.

Most of this work was published in a scientific article; please contact Arno Erasmus at arno@cri.co.za if you are interested in reading it.

The publication where more detail on this leg of the journey can be found:

Erasmus, A., Lennox, C.L., Jordaan, H., Smilanick, J.L., Lesar, K., Fourie, P.H., 2011. *Imazalil residue loading and green mould control in citrus packhouses.* Postharvest Biol. Technol. 62, 193-203.

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