Packhouse misting of prochloraz: Concentrations and other influencing factors

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ABSTRACT

Prochloraz is a postharvest product commonly used for the control of anthracnose on avocado fruit. An alternative misting system method was evaluated to determine the best application method of prochloraz. Results showed that the misting system does indeed ensures a more even residue level on the fruit throughout the day, whilst it also uses less chemical and there is hardly any waste disposal. However, prochloraz will not be available after 2022, since its registration will not be renewed. Therefore, the current methodologies and strategy to reduce anthracnose problems will have to be reviewed. It is envisaged that the strategy should include proper orchard sanitation, pruning to improve airflow in tree canopy, a spray programme with registered and effective fungicides at the correct time, proper control of insects, minimising wounds to fruit skin at harvest, i.e. cut rather than pull fruit, and a proper cold storage and supply-chain programme. In the packhouse, no other fungicide is available to effectively replace prochloraz at the moment.

INTRODUCTION

Prochloraz (Chronos 450 g/L SC – Adama) is registered as a postharvest treatment to control anthracnose (*Colletotrichum gloeosporoides*) at a concentration of 180 mL/100 L water + 0.2% HCl, while the EC formulation is registered as 1100 mL/100 L water as a spray-on treatment using a 1.6 L spray mixture per ton fruit applied with a low volume applicator (Van Zyl, 2011).

Although the allowed export default MRL for prochloraz was 5 ppm (DAFF, 2007) and might now increase to 7 ppm (EFSA, 2018; SANTE/10935/2018. Annex II), some importers in Europe require a lower MRL. When using the recommended concentrations, this lower MRL might be exceeded.

Additionally, discrepancies in residue analyses of fruit treated similarly throughout the season have been observed for no apparent reason. A study was initiated to determine reasons for these inconsistencies but the study ended with serious variation in the results, and it was realised that the application and sampling protocol had to be improved since both were part of the high variation in residue levels encountered (Daneel *et al*., 2016). Another study (Daneel *et al.,* 2017) followed to investigate factors that could possibly have an effect on residue levels of prochloraz on the fruit. Factors such as fruit size, cultivar and storage of fruit before packing, as well as the use of a sanitising agent in combination with prochloraz, with the prospect of reducing the concentration of prochloraz, and thus reducing excessive residue levels on the fruit, were evaluated. Results showed the highest residue levels were found on small size fruit, and cultivars varied in residue levels with 'Hass' having the highest residue level. Furthermore, standing over of fruit had little effect on residue levels although it was slightly higher on fruit packed one day after harvest. Adding a sanitation agent, Agrigold, in combination with prochloraz, resulted in higher residue levels (Daneel, 2015; Daneel *et al.,* 2017). Packhouses were visited and water samples were collected to test the potential of the turbidity meter in measuring concentrations of prochloraz (Daneel and Botha, 2013). However, because of impurities in the water, a more favourable practice would be to use a misting system for the application of prochloraz, as the concentration is made up fresh every day, it is not diluted throughout the day and a considerable lower amount of chemical is used.

Several packhouses have installed such a system, however, some fine-tuning is necessary to determine ideal concentrations of prochloraz as to ensure optimal residue levels on the fruit. Prochloraz is registered as a spray-on at 1100 mL/100 L water (Van Zyl, 2011). Spray on is however very different from misting and this concentration needs to be adapted for a misting system.

MATERIALS AND METHODS

Collection of fruit samples for residue analysis

On all occasions, randomly selected small fruit (size 22-24) was collected at the sorting and packing point of the pack line. For each sampling time, at least 36 fruit were collected which were subsequently divided into three batches which represented three replicates.

Fruit was placed in boxes when collected from the pack line. After drying, the fruit was packed in separate plastic bags, which were marked and closed. Thereafter fruit was transported to Labserve, Nelspruit, for analysis. Except for one occasion, fruit was delivered to Labserve on the same day. Fruit was kept at room temperature and never stored in the cold room.

Collection of fruit from different cultivars

Because fruit was collected throughout the day at different time intervals, fruit on the pack line during that time was selected and no specific testing was done for different cultivars.

Effect of different prochloraz concentrations on residue levels

When prochloraz concentrations were increased in the fungicide tank to determine the effect on residue levels, fruit was collected 5-7 minutes after changing the concentrations to allow the pack line enough time to transport the fruit from the fungicide bath to the sorting and packing part of the pack line.

Comparison of three misting systems and residue analysis

Samples were collected from three different misting systems, which included two packhouses at Koeltehof, Hazyview, Mpumalanga Province and one packhouse at Bassan Packers, Tzaneen, Limpopo Province.

Residue analysis to determine MRL for prochloraz

Residue analysis was done by Labserve, Nelspruit, using the modified EN15662 method using a Shimadzu LCMS-8040 me Prominence HPLC. For each sampling three replicates were collected and analysed separately.

RESULTS

Collection of fruit samples for residue analysis

Variation in residue levels was overall smaller than previously observed when sampling in the fungicide bath.

Collection of fruit from different cultivars

No specific tests were conducted to compare residue levels of different cultivars since the samples were collected from fruit being packed at that stage. However, fruit collected included 'Fuerte', 'Hass' and 'Pinkerton', and no differences could be observed between the three cultivars concerning residue levels.

Effect of different prochloraz concentrations on residue levels

Changes in prochloraz concentrations were immediately visible in residue levels on the fruit. Whenever the concentration was increased, an increase in residue levels was observed while residue levels remained the same when concentration were not changed (Table 1). The higher residue level at 7:52 is probably due to an uneven distribution at the start of the system. This indicates that while the pack line is being started, the misting system should also be switched on to ensure that everything is wet when the first fruit arrives at the rollers.

Table 1. Residue levels of fruit treated with different prochloraz concentrations.

Sampling time	Prochloraz concentration (mL/100 L water)	Prochloraz residue levels (ppm)
7:52	450	3.180
8:40	625	2.196
9:15	700	3.748
10:18	700	3.656
10:32	700	3.700

Comparison of three misting systems and residue analysis

The three misting systems differed in numbers of nozzles, nozzle size and thus amount of solution sprayed on the fruit.

At Bassan Packers, residue levels were consistent throughout the day and between days, whilst only about 100 L of solution was used per day (Table 2). The residue levels observed were satisfactory within the limits for the export and local market.

Table 2. Residue levels for prochloraz for the three packhouses tested using similar concentrations in the fungicide tank.

	MRL (ppm)	Standard deviation (ppm)
Koeltehof A	3.254	0.452
Koeltehof B	1.259	0.137
Bassan packers	0.753	0.072

At Koeltehof, in both packhouses, nozzles had a higher capacity compared to Bassan Packers, thus more solution was sprayed onto the fruit resulting in higher residue levels. Although both systems are basically the same, residue levels in the older packhouse (Koeltehof A) were consistently higher. The pack line in Koeltehof A is moving slower and therefore more product is sprayed onto the fruit resulting in higher residue levels. Additionally, this system seemed to have regular blockages of the nozzles, resulting in more cleaning of the nozzles. This process caused high concentrations of prochloraz to drop onto the rollers, resulting in higher residue levels on the fruit.

Even if fruit was collected 30 minutes after cleaning the nozzles, residue levels were really high (ranging between 4.5 to 6.1), indicating a much longer effect than anticipated.

The layout of the misting system in Koeltehof A was different from the new packhouse, mainly because of positioning of the water tank and nozzle system on the pack line, resulting in longer pipes and more elbows. Additionally, no filter was installed between the fungicide tank and pump. The purpose of the filter is to prevent clogging, and in the absence of the filter much more blockages were experienced on this pipe line. Number of nozzles did not seem to have an effect on residue levels as long as the entire width of the pack line was covered.

DISCUSSIONS

The misting system seems to provide a method that supplies the chemical more evenly on the fruit, as well as having less fluctuation of residue levels, meaning fruit is also more evenly protected against anthracnose. For this trial, smaller size fruit were collected and analysed as previous trials showed that smaller fruit were more prone to higher residue levels (Daneel *et al.,* 2017).

The misting system seems to be efficient on most cultivars and no difference of residue levels on the different cultivars was observed. However, fruit that is not transported smoothly on the pack line due to either too small or too large size and/or of different shape, tends to get stuck on the rollers, resulting in higher residue levels due to longer exposure time.

Whenever prochloraz concentrations were increased in the tank of the misting system, it very quickly resulted in higher residue levels on the fruit. It is therefore important to start with a concentration that has shown good results, such as 600 mL/100 L water, especially if fruit is packed for export to certain European supermarkets where the allowed MRL is only 0.8.

When one of the nozzles was cleaned because of blockage, residue levels also increased considerably as a high prochloraz concentration was released on the rollers. The higher MRLs were observed for a considerable time after cleaning the nozzles, since fruit was only collected 30 minutes after cleaning the nozzles, indicating a long after-effect. Cleaning should therefore be done when the pack line is not in operation with no fruit on the pack line. However, it is important to prevent blockages rather than fixing them by adding filters at each nozzle as well as adding a filter between the tank and the pump before the solution goes into the pipes.

It is also important to note than the person collecting the residue samples for the packhouse has not come in contact with prochloraz earlier that day, as samples could be contaminated.

The capacity of the nozzles is a driving factor in how much solution is deposited on the fruit. If the nozzle size is too high, too much solution is used, resulting in higher residue levels as well as too much solution being used throughout the day (of which a considerable amount is then wasted). Nozzles that are too small result in blockages, since prochloraz solution is relatively thick and becomes stuck inside the nozzle. Therefore, it is important to ensure that the nozzles are the correct size (about 0.75 mm) and preferably a filter should be used together with each nozzle.

The number of nozzles very much depends on the width of the packing line and should be determined accordingly, making sure that the spray covers the width of the pack line. A cover on top of the misting system is preferable to prevent drift.

Rollers or brushes are preferable above doughnuts, since doughnuts suck up the solution resulting in higher residue levels later in the day.

A misting system seems to be an improvement to the commonly used systems and could be installed in most packhouses without excessive costs. The advantages of such a system are the lower amount of prochloraz used throughout the day, reducing the costs of the chemical. Misting uses a much smaller amount of water compared to a bath and spray-on system. Immediately linked to this, less water and chemical have to be disposed of, resulting in a significantly lower ecological impact or foot-print. The solution applied is more accurate and remains the same concentration as it is an open system and once the solution is sprayed on the fruit, it is not recycled. It is very important to remember that the solution in the container has to stay in suspension at all times.

Table 3. Summarising characteristics of the misting system.

- Tank size: 100-400 L
- Pump: Peripheral pump of at least 4 Bar
- Return valve or circulation system inside tank: to ensure constant stirring of solution
- Filter: Between tank and pump
- Nozzles: 0.75-1.0 mm
- Small filters: positioned before each nozzle
- Number of nozzles: depending on pack line width
- Closed unit: can be made from metal or plastic
- Concentration: depends on ppm required but start with 600 mL/100 L water
- Use rollers or brushes on the pack line instead of doughnuts
- Unit should be positioned before dryers
- Clean tank and pipes regularly – when there is no fruit on the pack line

How long will prochloraz be available?

Currently a more pressing problem is the removal of prochloraz by 2022 as a chemical to control anthracnose on avocado fruit. In 2011, prochloraz was re-registered by BASF and Makhteshim Agan for a 10-year period (EFSA, 2011), but chances are very limited that this registration will be renewed.

Why will prochloraz be removed from the market?

Prochloraz is classified as an "Endocrine disrupting chemical" (EDC), which means prochloraz has an effect on the endocrine or hormonal system of animals, including mammals and humans. Hormones are chemical substances that affect diverse processes such as growth, reproduction, sexual characteristics to name some, at very low concentrations. Very small amounts can trigger very large responses in the body. Endocrine disruption or hormonal disruption implies that even very low concentrations can have an adverse effect on the organism exposed to it. Research has shown that EDCs have an effect mainly on reproduction, fertility, development, growth, metabolism and behavior (IPCS/WHO, 2013). Moreover, if we look around us, we cannot ignore that the number of people suffering from cancer, infertility, dementia, auto immune system disease etc. has considerably increased.

Together with prochloraz, 30 other pesticides are now listed as EDC (https://endocrinedisruption.org/; Sante, 2016; PAN, 2017). These chemicals are widely used in agriculture, and end up as residues in our food, exposing people to them on a daily basis. Moreover, the effects of prochloraz are combined with those of other EDCs resulting in an even more dangerous "cocktail" effect.

Although fruit send to the markets have prochloraz levels below the accepted MRL, these levels still have a significant effect on the person consuming it. Additionally, prochoraz is used on a wide range of fruit and vegetables, making the levels found in our bodies even higher because most people eat more than one fruit or vegetable per day. Considering this, it might therefore be better for our own health to start looking at alternatives for prochloraz.

What is the plan?

No other postharvest chemicals are available with the same efficacy against anthracnose, although several other products have been tested as a single application or in combination (Daneel *et al.,* 2016). Therefore, the different steps from flowering to the cold chain to reduce anthracnose incidence needs to be improved. Proper sanitation in the orchards by removing old branches and leaves will remove inoculum. Pruning to improve aeration in the tree will ensure that leaves and twigs can dry quicker after rain, reducing changes of spread and development of anthracnose. Chemical control against diseases like *Cercospera* will also control anthracnose. No additional spray is necessary, but it is important to ensure that the chemicals are sprayed correctly and timeously. At harvest, fruit must be treated with care at all times and damaged fruit (due to disease or insect damage, mechanical damage, sun burn) should not be brought into the packhouse as this is the fruit that will rot easily and infest other fruit. Rotten fruit on the pack line can infect the entire pack line by spreading spores everywhere. In the packhouse fruit must be handled softly. As soon as the cold storage starts, it should not be interrupted as this will also increase chances of anthracnose development. It might be interesting to investigate the possibilities of ozone and controlled atmosphere in the cold chain process. Other alternatives in the packhouse could be the use of anolyte water and/or nanotechnology, but this needs to be investigated.

REFERENCES

DAFF. 2007. MRL Status report – Avocado 2007 http://www.nda.agric.za/doaDev/sideMenu/foodSafety/doc/Avocado%20MRL%20Datasheet.pdf

DANEEL, M.S. 2015. Agrigold™, an alternative disinfectant with superior bactericidal efficacy. *International Journal of Postharvest Technology and Innovation* 5: 32-41.

DANEEL, M. & BOTHA, B. 2013. Developing a rapid method to determine the concentration of prochloraz in the fungicide bath in the mango pack house. *South African Mango Growers' Association Research Journal* 33: 30-32.

DANEEL, M.S., SIPPEL, A., DE BEER, M. & MLIMI, J. 2016. A look into the variability of prochloraz residues in the avocado industry. *South African Avocado Growers' Association Yearbook* 39: 92-98.

DANEEL, M.S., SIPPEL, A., DE BEER, M. & MLIMI, J. 2017. Prochloraz – a look into factors affecting the variability of residue levels on avocado fruit. *South African Avocado Growers' Association Yearbook* 39: 92-98.

EUROPEAN FOOD SAFETY AUTHORITY. 2011. Conclusion on the peer review of the pesticide risk assessment of the active substance prochloraz. EFSA Journal 2011; 9(7):2323. [120 pp.]. doi:10.2903/j.efsa.2011.2323. Available online: www.efsa.europa.eu/efsajournal.htm

EUROPEAN FOOD SAFETY AUTHORITY. 2018. Review of the existing maximum residue levels for prochloraz according to Article 12 of Regulation (EC) No 396/2005. EFSA Journal 2018; 16(8):5401.

UNITED NATIONS ENVIRONMENT PROGRAMME and the World Health Organization, 2013. State of the science of endocrine disrupting chemicals-2012.

PAN 2017. Pesticide action network Europe – Endocrine disrupting pesticides in European food. Brussels 2017

SANTE, D.G. 2016. Screening of available evidence on chemical substances for the identification of endocrine disruptors according to different options in the context of an Impact Assessment. Publications Office of the European Union, 2016

SANTE/10935/2018. Annex II. Pesticide residues and maximum residue levels (mg/kg)

VAN ZYL, K. 2011. The control of fungal, viral and bacterial diseases in plants. A CropLife South African Compendium. 1st ed. VR Print; Pinetown, South Africa.