Development of a more effective post-harvest treatment for the control of post-harvest diseases of avocado fruit – Results from 2010

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ABSTRACT

Previous results showed that 200 ppm prochloraz combined with 50 mM H*Cl* was just as effective as the standard 810 ppm prochloraz in controlling post-harvest anthracnose and stem-end rot on avocado fruit of different cultivars. To confirm these results, trials were repeated on fruit from cultivars 'Fuerte' and 'Hass'. The treatments were conducted using prochloraz EC and SC formulations with all treatments applied as a dip or spray-on application. The efficacy of other acids in combination with prochloraz was also investigated. Results showed that application technique had no effect on the efficacy of the treatment and no difference could be observed between the prochloraz EC and SC formulations in terms of *C. gloeosporioides* and Botryosphaeriaceae control on 'Fuerte' and 'Hass' when applied at the same concentration, although the EC formulation resulted in slightly higher residues. No clear distinction was possible between different treatments with variable results with regards to post-harvest disease control on the different cultivars and further trials are therefore needed to clarify results.

INTRODUCTION

In South Africa anthracnose and stem-end rot as post-harvest diseases are major limiting factors in the production and export of avocados (Le Roux *et al*., 1985). The fungi causing these diseases include *Colletotrichum gloeosporioides* (anthracnose; ANT) and various species in the Botryosphaeriaceae (stem-end rot; SER) (Darvas, 1977; Darvas & Kotze, 1979). They occur as latent infections in the fruit and are therefore rather difficult to control with fungicides (Le Roux *et al*., 1985). Currently these diseases are controlled by a combination of pre-harvest fungicide applications and a post-harvest prochloraz dip in the pack house (Darvas, 1984). Despite the use of large amounts of fungicide, quality control results from the 2008 avocado season indicated that a substantial percentage of fruit were still lost due to ANT, SER or other body rots occurring on export fruit. This could indicate that the post-harvest application of prochloraz currently being used is not optimally effective.

Research has shown that during ripening, the pH of avocado fruit increases from pH 5.2 to pH 6.0 (Yakoby *et al*., 2000). It was furthermore found that under these pH values *pelB*, one of the virulence genes of *C. gloeosporioides*, was expressed more actively and that the pathogen enhances this process by excreting ammonia in the infected host tissue (Prusky *et al*., 2001; Yakoby *et al*., 2000; 2001). This change in the ambient pH of the host tissue at the infection site is therefore regarded as the cause for the activation of the latent *C. gloeosporioides* infections to cause necrotic lesions in the fruit (Prusky & Yakoby, 2003).

Alternaria alternata, an important post-harvest pathogen of mango acts in the same manner as *C. gloeosporioides* described above (Prusky *et al*., 2006). This characteristic of the pathogens was used in Israel to develop a more effective post-harvest treatment of mango fruit. It was found that by adding 50 mM hydrochloric acid (H*Cl*) to the prochloraz solution in the pack house, post-harvest decay caused by *A. alternata* was controlled significantly better (Prusky *et al*., 2006). This effect of the acidified prochloraz is due to the pH (1) directly affecting the germination of the pathogen conidia (Pelser & Eckert, 1977), (2) influencing the virulence of the pathogen (Prusky *et al*., 2004) and (3) affecting the toxicity of the fungicides used (Smilanick *et al*., 2005). Prusky *et al*. (2006) showed that by adding hydrochloric acid to the prochloraz solution, the solubility of the prochloraz is increased significantly. This means that in an acidified prochloraz solution a significantly lower concentration of prochloraz can be used, while the disease control obtained by this solution is significantly better.

To develop a protocol for the use of acidified prochloraz on avocado fruit for the control of post-harvest diseases, a study was initiated in 2009. Results from the first season indicated that applying acidified prochloraz post-harvest treatments as a dip application, resulted in more fruit free from ANT and SER compared to spray-on application, while applying 50 mM HC*l* combined with 200 ppm prochloraz was just as effective in controlling post-harvest diseases compared to the commercially used 810 ppm prochloraz dip (Mavuso & Van Niekerk, 2010). As follow-on to the trials of 2009, additional objectives were set in the 2010 season. These were (1) to compare the efficacy of acidified prochloraz EC formulation to acidified prochloraz SC formulation and (2) to determine if other acids could be used in the acidification of prochloraz.

MATERIALS AND METHODS

Objective 1

In order to compare prochloraz EC and SC as acidified post-harvest treatments, fruit from cultivars 'Fuerte' and 'Hass' were subjected to different treatments (**Table 1**). A hundred fruit were used for each treatment. The treatments were applied as a 30 s dip treatment to one set of fruit and as a spray-on treatment on another set of fruit. The spray-on treatments were applied using a custom built mini pack line with wax applicator at Westfalia Technological Services. After treatment, fruit samples were taken from treated fruit for prochloraz residue analysis (Scientific Analysis Laboratory, Bar Hill, Cambridgeshire, UK), while the rest of the treated fruit were stored for 28 days at 5.5°C before being ripened and evaluated for post-harvest disease symptom severity. Based on the severity of the symptoms, fruit were given a rating between 0 and 3, with 0 being fruit without any disease symptoms (clean fruit) and 3 being the most severe rating. After evaluation the percentage clean fruit for each treatment was calculated and statistically analysed using STATISTICA Version 6 (StatSoft, Inc., Tulsa, USA).

Objective 2

To address this objective the efficacy of other acids in combination with prochloraz was also investigated. In this investigation the trials was conducted using fruit from cultivars 'Fuerte' and 'Hass'. The different treatments applied are given in **Table 2**. Similar to the trial done in objective 1, treatments were applied as dip and spray-on applications to different sets of 100 fruit with residue analyses and evaluation also being done as above.

RESULTS

Objective 1

Results indicated that on 'Fuerte' and 'Hass' there was no difference in disease control efficacy when applying treatments as dip or spray-on application. Only the results from the dip application are therefore presented. The disease pressure on the 'Fuerte' fruit used were very low as evident from the high

Table 1. Acidified, non-acidified and acid alone treatments applied as dip or spray-on treatment to fruit of cultivars 'Fuerte' and 'Hass' for the control of the post-harvest diseases anthracnose and stem-end rot.

Treatment	Prochloraz (EC/SC) and HC*l* concentrations
1	Water treated fruit (Control)
2	50 mM HC*l* only
3	200 ppm prochloraz only
4	200 ppm prochloraz + 50 mM HC*l*
5	810 ppm prochloraz only

Table 2. Prochloraz, HCl, citric acid and food grade phosphoric acid combinations applied post-harvest as either a dip or spray-on treatment to fruit of cultivars 'Fuerte' and 'Hass' for the control of the post-harvest diseases anthracnose and stem-end rot.

Treatment	Prochloraz and acids concentrations
1	Untreated fruit
2	810 ppm prochloraz
3	200 ppm prochloraz + 50 mM HC*l*
4	200 ppm prochloraz + 50 mM food grade phosphoric acid
5	200 ppm prochloraz + 50 mM citric acid
6	50 mM HC*l*
7	50 mM food grade phosphoric acid
8	50 mM citric acid
9	200 ppm prochloraz

percentage clean fruit in the water treated fruit (**Figure 1**). No significant difference was observed between the different prochloraz treatments and the water treated fruit, although all the prochloraz treatments did result in higher percentages of clean fruit with regards to post-harvest diseases (Figure 1). The highest prochloraz residues resulted from the 810 ppm EC and SC treatments followed by the 200 ppm EC and SC treatments and then lastly the acidified 200 ppm prochloraz solution. However, all prochloraz EC treatments resulted in slightly higher residue levels, although not significantly higher than the SC formulation (Figure 1). In all treatments the residue was also lower than the 2.0 ppm maximum residue level (MRL) allowed for South Africa.

The disease pressure on the 'Hass' fruit used was much higher as evident from the low percentage clean fruit in the water treated fruit (**Figure 2**). Here the results indicate that the best treatment were the 200 ppm prochloraz EC treatment followed by the 200 ppm prochloraz SC treatment. The percentage clean fruit from these two treatments were noticeable higher than the clean fruit obtained with the other treatments (Figure 2).

Objective 2

Again no difference was found between the different application techniques and the results from the dip application are therefore discussed. The results on 'Fuerte' indicated that the best treatment was the commercial standard treatment of dipping in an 810 ppm prochloraz solution (**Figure 3**). The best acidi-

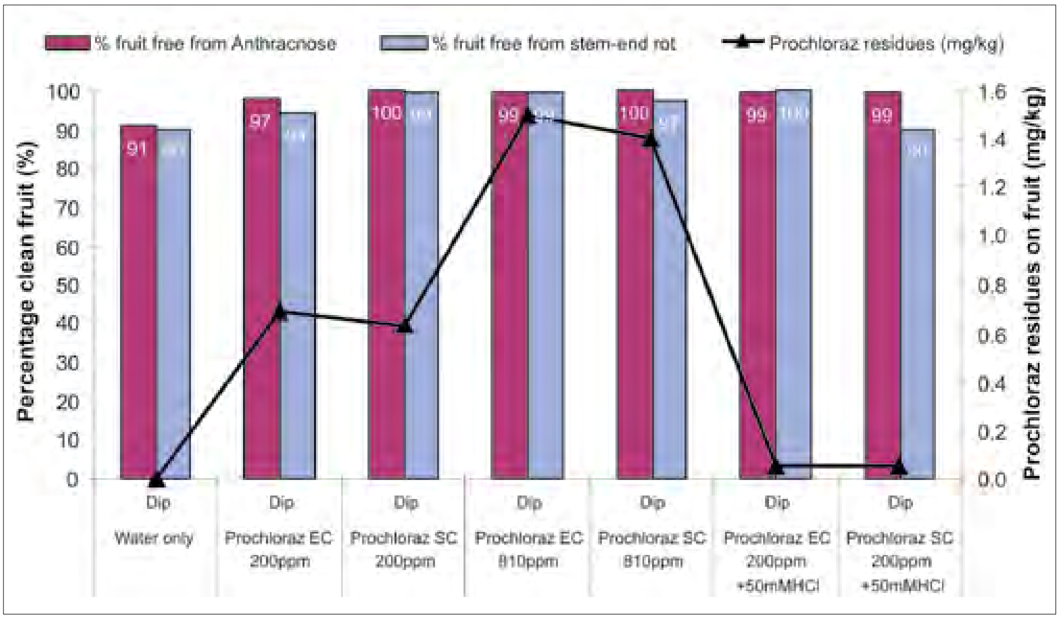

Figure 1. Average percentage fruit free from anthracnose and stem-end rot and prochloraz residues resulting from applying different post-harvest treatments as a dip to fruit of cultivar 'Fuerte'.

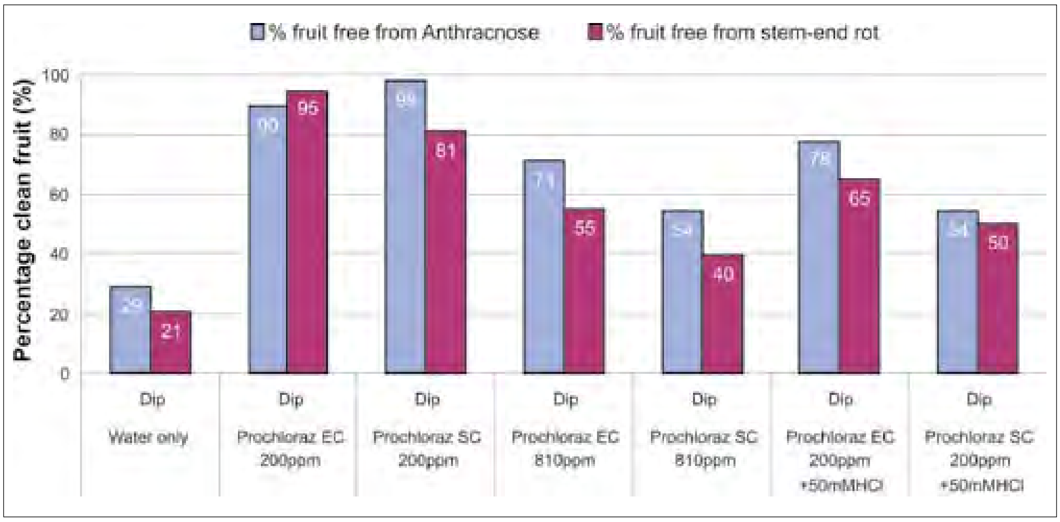

Figure 2. Average percentage fruit free from anthracnose and stem-end rot resulting from applying different post-harvest treatments as a dip to fruit of cultivar 'Hass'.

fied treatment was the 50 mM HC*l* combined with 200 ppm prochloraz, followed by the 200 ppm prochloraz acidified with citric acid. Both of the latter treatments compared very favourably with the commercial standard treatment with regards to clean fruit and were also better than the acid alone treatments or the non-acidified 200 ppm prochloraz treatment (Figure 3). In the case of 'Hass' the best treatment was the non-acidified 200 ppm prochloraz treatment, followed by the 50 mM citric acid treatment. Both these treatments were significantly better than the rest of the treatments, including the commercial standard treatment (**Figure 4**).

CONCLUSION

It was seen from the results that applying post-harvest treatments as a dip or spray-on made no difference to the levels of disease control achieved. Similarly, no difference in efficacy was observed between the prochloraz EC and SC formulations, although using the EC formulation in post-harvest treatments did result in slightly higher prochloraz residues on treated 'Fuerte' fruit. It must, however, be remembered that the SC formulation is the only one registered under Act 36 for use as a dip treatment on avocado fruit. With regards to acidification, the acidified treatments in some cases did give better control at lower prochloraz concentrations than the commercial treatment. Unfortunately, no single treatment stood out as being the best in controlling SER and ANT on both cultivars. Additional trials are therefore needed to confirm the results obtained in the previous seasons and arrive at a final recommendation to the industry.

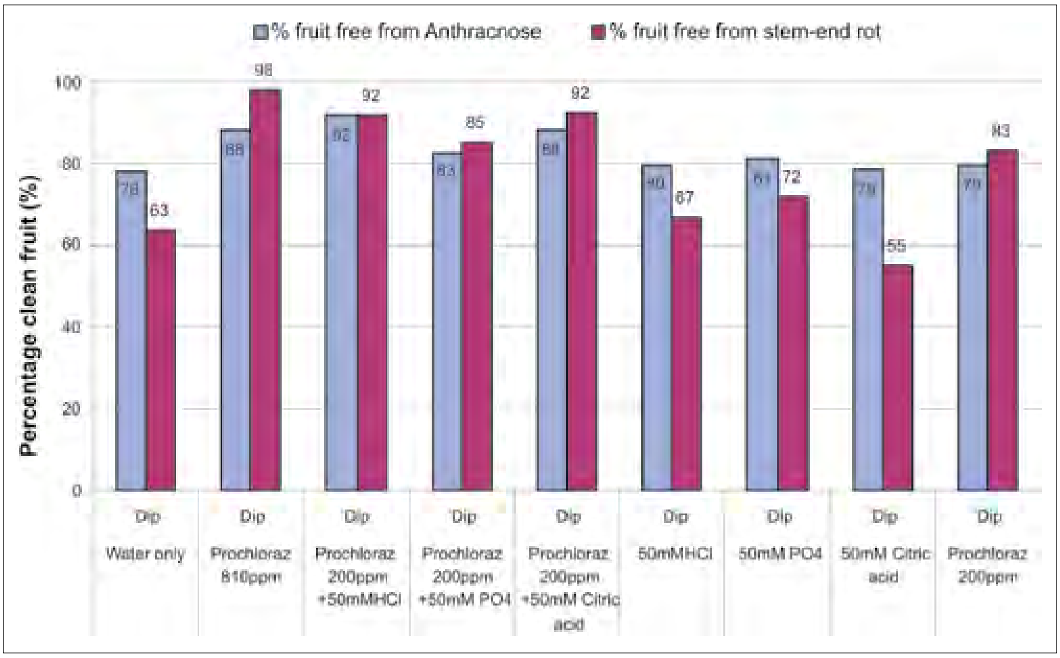

Figure 3. Average percentage fruit free from anthracnose and stem-end rot resulting from applying different post-harvest treatments as a dip to fruit of cultivar 'Fuerte'.

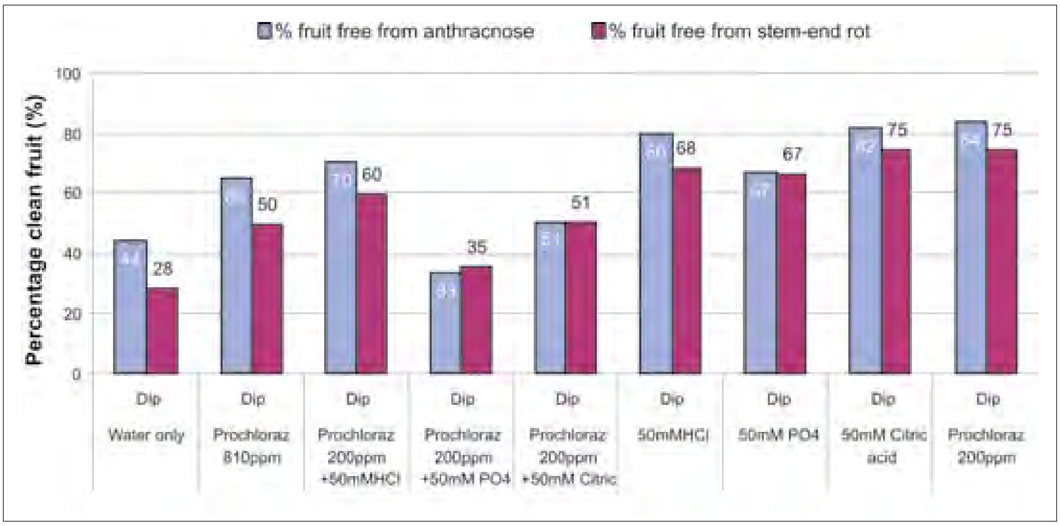

Figure 4. Average percentage fruit free from anthracnose and stem-end rot symptoms resulting from applying different post-harvest treatments as a dip to fruit of cultivar 'Hass'.

ACKNOWLEDGEMENTS

The authors wish to thank SAAGA for financial support and Westfalia Fruit Estate for materials, equipment, technical assistance and funding.

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