Development of a more effective post-harvest treatment for the control of post-harvest diseases of avocado fruit

Results from 2011

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ABSTRACT

The results from the work done in 2009 showed that 200 ppm prochloraz combined with 50 mM *HCl* was just as effective as the standard 810 ppm prochloraz. Based on the 2009 results, in 2010 the trials on both 'Fuerte' and 'Hass' were conducted using prochloraz EC and prochloraz SC formulations. The efficacy of other acids in combination with prochloraz was also investigated. The treatments were applied as either a 30s dip treatment or as a spray-on treatment on different sets of fruit. After treatment, fruit samples were taken for prochloraz residue analysis and others were stored for 28 days at 5.5°C before being ripened and evaluated for post-harvest disease incidence. There was no difference between the prochloraz EC and prochloraz SC formulations in terms of anthracnose and stem-end rot control on 'Fuerte' and 'Hass'. In terms of prochloraz residue, prochloraz EC resulted in slightly higher residues on the fruit compared to prochloraz SC. The method of application (dip *vs.* spray-on) also did not differ in the control of post-harvest diseases achieved. Results for prochloraz residue analysis showed that none of the treatments resulted in residues above 2.0 mg/kg. In 2011 trials were repeated on unsprayed 'Fuerte' and 'Hass' fruit. The results indicated that 200 ppm prochloraz + 50 mM *HCl* and 200 ppm prochloraz + 50 mM citric acid are as effective as 810 ppm prochloraz in terms of anthracnose and stem-end rot control on both 'Fuerte' and 'Hass' and leave less prochloraz residue on fruit compared to 810 ppm prochloraz. Based on the results from the work done from 2009 to 2011, 200 ppm prochloraz + 50 mM citric acid will be evaluated semi-commercially in 2012 to confirm the 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 (*HCl*) to the prochloraz solution in the pack house, the 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 *HCl* 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. The results indicated that there was no difference between the prochloraz EC and prochloraz SC formulations in terms of anthracnose and stem-end rot control on 'Fuerte' and 'Hass'. In terms of prochloraz residues, prochloraz EC resulted in slightly higher residues on the fruit compared to prochloraz SC. 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. The disease pressure was very low, which resulted in no significant difference between the treatments and the trial was repeated in 2011 using unsprayed fruit.

MATERIALS AND METHODS

Specific objectives for 2011

1. To determine the efficacy of hydrochloric acid (*HCL*), citric acid and different prochloraz concentrations for the control of post-harvest diseases on 'Hass' and 'Fuerte' fruit.
2. To do prochloraz residue analysis on fruit from the different treatments to determine compliance with MRL's.

In order to address objectives from above, fruit from unsprayed cultivars 'Fuerte' and 'Hass' were subjected to the treatments listed in **Table 1**. The treatments were conducted using the prochloraz SC formulation. These treatments were applied as a 30 s dip treatment (100 fruit per treatment). After treatment, fruit samples were taken for prochloraz residue analysis and others were stored for 28 days at 5.5°C before being ripened and evaluated for post-harvest disease incidence.

RESULTS

In none of the treatments a significant difference was observed in the post-harvest control of anthracnose and SER on 'Fuerte' fruit. All treatments did give significant better control of both diseases compared to the water treated fruit (Table 2). However, 200 ppm prochloraz alone was less effective in terms of anthracnose control, while it was as good as prochloraz 810 ppm in terms of stem-end rot control (Table 2). On Hass fruit, 810 ppm prochloraz, 200 ppm prochloraz + 50 mM *HCL* and 200 ppm prochloraz + 50 mM citric acid gave significant better control of anthracnose compared to water treated fruit, 200

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

Treatment	Prochloraz (SC) *HCl*, citric acid concentrations
1	Water treated fruit (control)
2	810 ppm prochloraz only
3	200 ppm prochloraz + 50 mM *HCl*
4	200 ppm prochloraz + 50 mM citric acid
5	200 ppm prochloraz only

Table 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 'Fuerte'.

	Treatments	% fruit free from anthracnose	% fruit free from stem-end rot
1	Water treated fruit	70a	47a
2	Prochloraz 810 ppm	91b	93b
3	Prochloraz 200 ppm+ 50 mM *HCl*	91b	90b
4	Prochloraz 200 ppm + 50 mM citric acid	91b	89b
5	Prochloraz 200 ppm only	88b	92b

ppm prochloraz alone was less effective compared to other treatments. In terms of stem-end rot, 810 ppm prochloraz, 200 ppm prochloraz + 50 mM *HCL* and 200 ppm prochloraz + 50 mM citric acid gave a significant better control compared to water treated fruit, 200 ppm prochloraz alone was again less effective compared to other treatments (Table 3). With regards to prochloraz residues on treated fruit in both 'Fuerte' and 'Hass' cultivars, all the treatments resulted in residue levels below the South African MRL of 2.0 mg/kg (Table 4).

FUTURE RESEARCH

In order to confirm results obtained in 2011, trials will be repeated semi-commercially using the following treatments: (1) untreated fruit, (2) prochloraz dip at 810 ppm (industry standard) and (3) prochloraz 200 ppm + 50 mM citric acid.

This trial will be done using 'Fuerte' and 'Hass' fruit. Each treatment will be evaluated using early season fruit and late season fruit of the different cultivars. Fruit samples and prochloraz solution samples from the prochloraz bath will be taken to determine how often the prochloraz bath must be changed. After treatment, fruit will be stored for 28 days at the recommended export temperature before ripening and evaluation for post-harvest disease incidence. Residue analyses from the different treatments will also be done to determine the MRL values on the fruit and to ensure it is within the allowed EU MRL of 5 mg/kg and the South African MRL of 2.0 mg/kg.

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

	Treatments	% fruit free from anthracnose	% fruit free from stem-end rot
1	Water treated fruit	72a	67a
2	Prochloraz 810 ppm	84b	83bc
3	Prochloraz 200 ppm + 50 mM *HCL*	83b	89bc
4	Prochloraz 200 ppm + 50 mM citric acid	84b	92c
5	Prochloraz 200 ppm only	74ab	79b

Table 4. Maximum residues levels of different treatments applied as a dip treatment to fruit of cultivar 'Hass' and 'Fuerte'.

	Treatment	Concentration (mg/kg)	Concentration (mg/kg)
		Hass	Fuerte
1	Water treated fruit	0.00	0.00
2	Prochloraz 810 ppm	1.90	0.92
3	Prochloraz 200 ppm + 50 mM *HCL*	0.47	0.19
4	Prochloraz 200 ppm + 50 mM citric acid	0.41	0.47
5	Prochloraz 200 ppm only	0.20	0.17

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