Preharvest application elicitors as an alternative to prochloraz

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ABSTRACT

Considerable postharvest losses, limiting the storage and marketability of fruit, are caused mainly by anthracnose (*Colletotrichum gloeosporioides* [Penz. & Sacc.]) and stem-end rot (including *Lasiodiplodia theobromae* [Pat.] Griffon & Maubl.). Currently, prochloraz® application is widely used in pack-houses to control anthracnose and stem-end rot during storage and transportation. As prochloraz® application is phasing out soon, a field trial was conducted between May and June 2019 on Lombard Farm, Tzaneen. Fruit sprayed with Methyl jasmonates (MeJa) at 0.1% or chitoplant® (CHP) at 1.5%, 2 weeks before harvest, reduced the postharvest disease incidence in inoculated fruit; anthracnose and stem-end rot were reduced to 20% in cv. Fuerte and both diseases were less than 20% in cv. Hass. In naturally infected fruit, cv. Fuerte and cv. Hass' fruit sprayed with 1.5% CHP or 0.1% MeJa at 2 weeks before harvest, had the lowest incidence of anthracnose (<5%) and stem-end rot in both cultivars. Overall, 0.1% MeJa and 1.5% CHP helped reduce the incidence of anthracnose and stem-end rot significantly and application two weeks prior to harvest is effective in controlling both postharvest diseases during storage, however, MeJa treatments seem to promote ripening.

INTRODUCTION

Non-systemic chemical fungicides, such as prochloraz®, are commonly used to control avocado fruit decay from anthracnose (*Colletotrichum gloeosporioides* [Penz. & *Sacc*.]) and stem-end rot (*Lasiodiplodia theobromae* [Pat.] Griffon & Maubl.) (Bill *et al.,* 2014). The acceptable maximum residue level (MRL) of prochloraz® in South Africa is set at 2 $mg.kg^{-1}$, however the European market and the rest of the global community is calling for a reduction in MRL levels due to the negative impact that fungicide residues have on human health (Mutengwe *et al*., 2016). Prochloraz® application is phasing out in 2020. A commercially registered pre-harvest product, chitoplant® (CHP), a water-soluble formulation listed as a basic substance in the European Union (EU No.1107/2009), has improved the postharvest quality of fruit crops, such as table grapes, sweet cherries and strawberries, through reduction of decay by acting as an external elicitor. Therefore, one approach is to replace prochloraz® application via pre-harvest application of CHP solution prior to harvest. The second problem associated with the industry is the application of 1-methylcyclopropene (1-MCP) for early season fruit causing uneven ripening (firmness) and poor fruit colouration in 'Hass' avocado fruit destined for the 'ready to eat' ripening programme (Nelson, 2010). Good appearance and the right firmness of the produce have a huge impact on consumers' willingness to purchase. The postharvest use of methyl jasmonates (MeJa) has been unexplored for South African avocados and these have the ability to alleviate chilling injury at quarantine treatment temperatures, and other disorders (Glowacz & Rees, 2016). Therefore, the objectives of the proposed research are to investigate the influence of commercially registered CHP / MeJa on postharvest decay control in i) inoculated fruit, cv. Fuerte and cv. Hass, and ii) on naturally infected fruit, cv. Fuerte, on postharvest decay, postharvest incidence and overall quality.

MATERIALS AND METHODS

The trial was carried out at Lombard Farm, Tzaneen, Limpopo. A complete randomised block design was used with five replicate trees per treatment. Fruit were sprayed with different dosages of CHP (0.5; 1 and 1.5%) and MeJa (0.1, 0.2 and 0.4%) at 2 and 4 weeks before harvest. At harvest, fruit were divided into two sets; the first set of the fruit was stored in a cold room (at 6.5°C for 28 days) at the Tzaneen Fruit Packers and the second set of the fruit was taken immediately to the laboratory for artificial inoculation trials.

Artificially infected

The second set of fruit was further subdivided into two sub-lots and inoculated with *C. gloeosporioides* and *L. theobromae* and incubated at shelf conditions (25°C). Ten triggered ripe fruit, selected according to a finger feel firmness score of 2 (1 = hard, 2 = semi-hard [triggered ripe], 3 = soft) were used per treatment. Fruit were subjected to the drop inoculation (surface inoculation without wounding) with prochloraz® dip (1000 mg L^{-1}) and an untreated


villa

fruit was included as control. To initiate infection, inoculated fruit were held at 25°C ambient temperature for 18 h before storage at 7.5°C for 14 days, after which disease incidence and severity were evaluated.

Natural infection

After harvest, fruit were stored in the cold room (at 6.5°C) for 28 days and afterwards allowed to ripen at 15°C to simulate market shelf conditions up to 5 days. At ready to eat stage, observations were recorded on the incidence and severity of anthracnose and stem-end rot. The number of days to ripen, the firmness as well as a uniform colour development for 'Hass' were recorded. Sixty replicate fruit were used per treatment.

RESULTS AND DISCUSSION

Anthracnose incidence in inoculated fruits

In cv. Fuerte, the incidence of anthracnose (after inoculation) was significantly reduced to 20% in fruit sprayed with 1.5% CHP at 2 weeks before harvest (Fig. 1A). The incidence of anthracnose (after inoculation) in fruit sprayed with 0.1% MeJa before 4 and 2 weeks of harvest was reduced to 30% and 20% respectively. Fruit dipped in prochloraz® at the pack-house showed 40% anthracnose incidence, compared to untreated fruit (90%). In cv. Hass, fruit sprayed with 0.1% MeJa at 4 and 2 weeks before harvest reduced the anthracnose incidence to more or less 20%, in comparison to all treatments (Fig. 1B), whereas CHP at 1.5 and 1.0% reduced the anthracnose incidence up to 40%. However, prochloraz® treated (control) revealed almost 50% anthracnose incidence. All the treatments included in this investigation were significantly different from the untreated fruit.

Stem-end rot incidence in inoculated fruit

In cv Fuerte, 1.5% CHP sprayed on the fruit, irrespective of the spraying time, reduced stem-end rot to 20% (Fig. 2A), and fruit treated with 0.1% MeJa at 2 weeks prior to harvest reduced the stem-end rot to 10%. The incidence of anthracnose in prochloraz® treated plants was similar to the untreated fruit and showed 40% incidence. In cv. Hass, no stem-end rot was recorded in fruit treated with 1.5% CHP, irrespective of the timing of spray, and in fruit treated with 1% CHP and 0.1% MeJa at 2 weeks prior to harvest and with the prochloraz® (Fig. 2B).

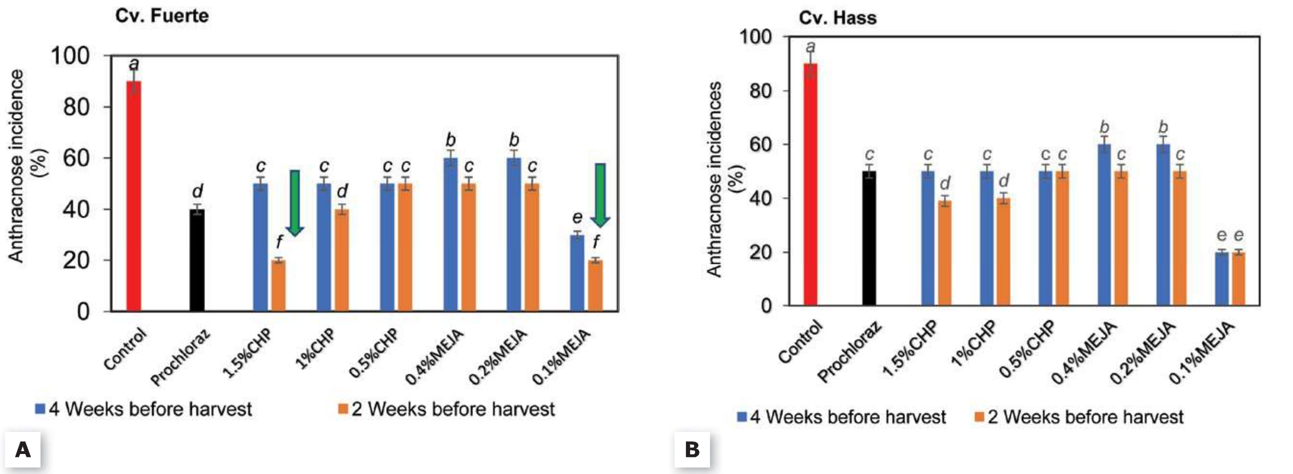

Figure 1: Incidence of anthracnose in avocado cultivars (A) Fuerte and (B) Hass in fruit sprayed with chitoplant (CHP) or methyl jasmonates (MeJa) at two or four weeks prior to harvest and inoculated after harvest with *Colletotrichum gloeosporioides*

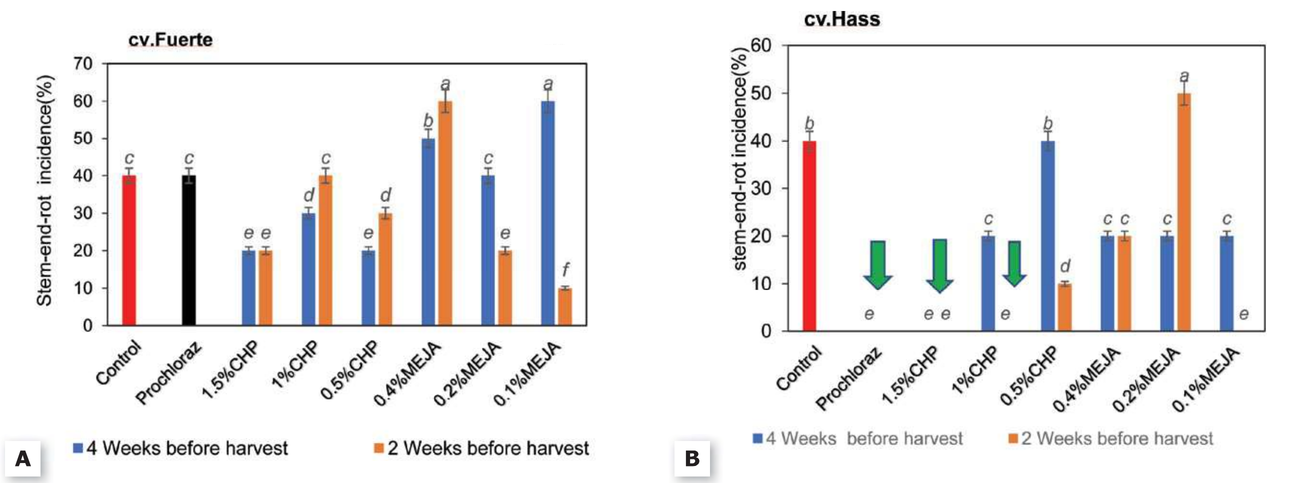

Figure 2: Incidence of stem-end rot in avocado cultivars (A) Fuerte and (B) Hass in fruit sprayed with chitoplant (CHP) or methyl jasmonates (MeJa) at two or four weeks prior to harvest and inoculated after harvest with *Lasiodiplodia theobromae*

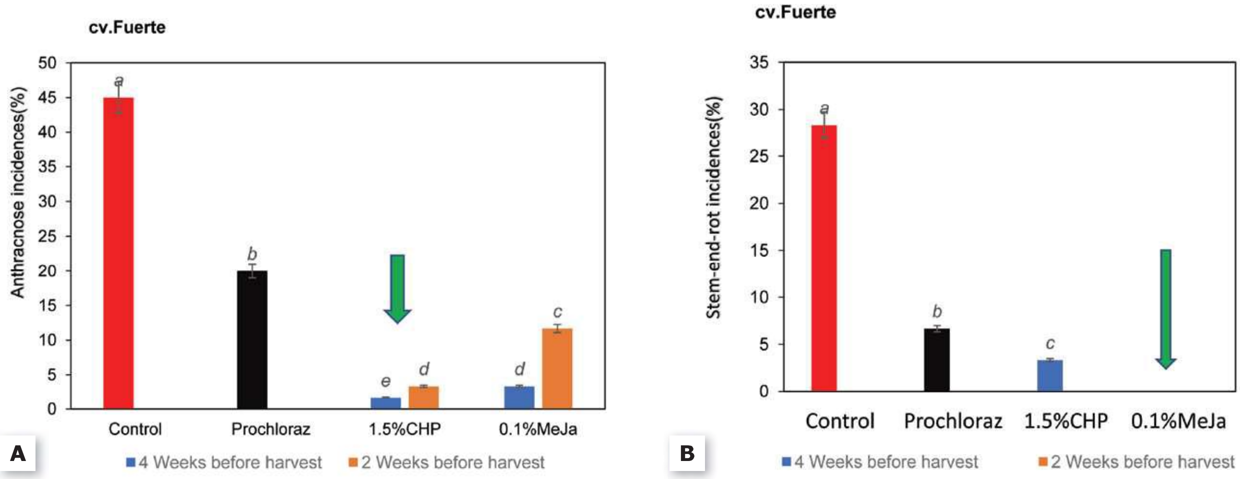

Figure 3: Incidence of (A) anthracnose and (B) stem-end rot in avocado cultivar Fuerte fruit sprayed with chitoplant (CHP) or methyl jasmonates (MeJa) at two or four weeks prior to harvest and thereafter harvest stored in cold storage for 28 days and held at the simulated market shelf condition for 5 days

Natural infection, number of days to ripe and fruit firmness after cold storage

Anthracnose

Figure 3A presents the level of anthracnose incidence in cv. Fuerte after cold storage. In cv. Fuerte, fruit sprayed with 1.5% CHP 2 or 4 weeks prior to harvest, demonstrated a significantly lower incidence (<5%), whilst the fruit treated with prochloraz® had around 20% anthracnose incidence. Fruit sprayed with 0.1% MeJa before 2 or 4 weeks prior to harvest showed around ≤15% anthracnose incidence. The untreated fruit showed the significantly highest anthracnose incidence of 45%. Therefore, it is interesting to note that in the highly decay sensitive avocado cv. Fuerte, the CHP at 1.5% 2 or 4 weeks prior to harvest reduced the anthracnose incidence by 40% when compared to the untreated control and by 15% when compared to prochloraz® treatment.

Stem-end rot

Figure 3B presents the level of disease incidence after cold storage. In avocado cv. Fuerte the incidence of stem-end rot was not noted after 1.5% CHP treatment 2 weeks prior to harvest. Similarly, fruit sprayed with 0.1% MeJa at 2 or 4 weeks prior to harvest also failed to show any stem-end rot symptoms after cold storage at the simulated market shelf condition.

Number of days to ripen in cultivars

In cv. Fuerte and cv. Hass, 0.1% and 0.2% MeJa sprayed fruit, irrespective of the spraying interval, reached the ready to eat stage in less than 3 days, i.e. about 50% of the fruit were at ready to eat stage on day 3 (Fig. 4). The CHP (0.55%, 1.0% and 1.5%) sprayed on fruit 2 weeks before harvest took longer to ripen, almost 4 days. The average number of days to ripen the untreated control fruit and the prochloraz® treated fruit were approximately 4 days.

Spraying fruit with chitoplant® in the form of a semi-permeable film on the surface of the fruit could reduce the respiration rate, water loss and delay ripening.

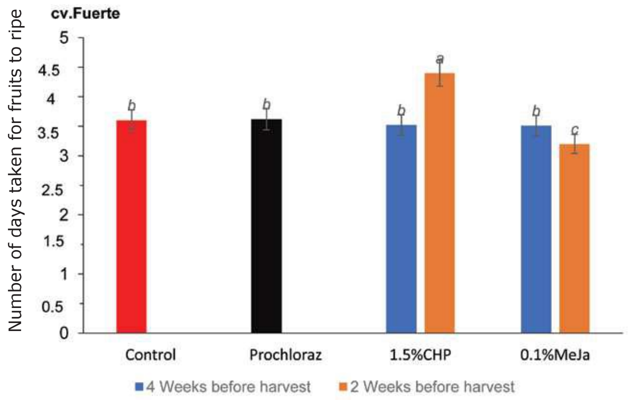

Figure 4: Number of days taken for avocado cv. Fuerte to ripen at the simulated market shelf condition

As a result of these events, it could have inhibited fungal fruit decay (Kanetis *et al*., 2017). Chitoplant and MeJa have been reported to preserve antioxidant content of fruit such as guava and mango (Jongsri *et al*., 2017; Nair *et al*., 2018). It is likely that these elicitors stimulate the activity of phenylalanine ammonia lyase, an enzyme involved in the synthesis of phenolics and flavonoids through the phenylpropanoid pathway (Martínez-Esplá *et al*., 2014). However, more than the phenolic compounds, the activation of PR proteins must be investigated to see the direct impact on improving the fruit health.

CONCLUSION

Preharvest elicitor treatments such as 0.1% MeJa and 1.5% CHP applied two weeks before harvest enabled a reduction in the incidence of anthracnose and stem-end rot to 20% or less during postharvest storage up to 28 days, and 5 days at the market shelf. MeJa treatments however appear to promote ripening. The trials will be repeated in 2020 to confirm the results.

Acknowledgements

The authors acknowledge the financial support provided by the Post-Harvest Innovation, Department of

Science and Innovation, and the South African Avocado Growers' Association. Trials were conducted at Lombard Farm, Tzaneen, South Africa.

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