Control of postharvest diseases in the orchard and after harvest

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Introduction

There are two major postharvest diseases of avocados, those that infect through the side of the fruit (body rots) and those that infect through the cut stem end (stem-end rots) (Figure 1).

Figure 1. Body rots infecting through the side of fruit (left) and stem-end rots infecting through the cut stem (left and right).

The pathogens that cause these two diseases can differ depending on the country in which avocados are grown. For the exporting countries: Mexico, Peru, Kenya, Chile, Colombia, Israel, Spain, South Africa, Dominican Republic, New Zealand, Brazil, Vietnam and Australia, and for those countries with high production for local consumption: United States of America (California and Florida), climates vary from tropical to temperate, from low to high rainfall, and from equitable to extreme climates, as categorised by the Köppen-Geiger classification system (Peel et al. 2007) and the annual average minimum and maximum temperatures (Anonymous, 2019a) (Table 1). Rainfall also varies between avocado growing countries, from negligible (Peru) to 2.8 m (Pácora, Colombia) (Anonymous, 2019a) (Table 1).

Table 1. Main avocado-growing regions and their climates according to the Köppen-Geiger climate classification[1] and annual average mean daily temperature, minima and maxima[2].

Region	Country	Köppen-Geiger climate(s)	Annual mean daily temperature (minima-maxima)	Rainfall (mm)	Main avocado growing regions
North America	California	Arid, Temperate	15.9 (5.9-25.8)	356	Ventura*, Santa Barbara, San Diego, Riverside, San Luis Obispo
	Florida	Tropical	25.0 (21-29)	1570	Miami-Dade*, Collier, Monroe
Latin America	Mexico	Temperate	24.2 (17.9-30.5)	1625	Michoacán*, Jalisco, Guerrero, Chiapas, Mexico State
	Chile	Arid, Temperate	14.6 (7.15-22.1)	262	Valparaiso, Coquimbo, Metropolitana*, O'Higgins (Mainly V Region)
	Peru	Arid, Tropical Temperate	24.2 (17.9-30.6)N 18.7 (14.5-23)	6 16	Lambayeque & Piura (N)*, La Libertad, Ancash & Lima*, Ica
	Colombia	Tropical, Temperate	14.3 (10.8-17.9)S 19.3 (14.3-24.4)U 16.4 (12.6-20.3)A 18.0 (13.7-22.3)P 18.5 (14.0-22.9)L	2380 2360 2764 2792 2397	Antioquia, Sansòn*(S), Urrao* (U), Caldas, Aguadas* (A), Pácora*(P), Salamina* (L) Valle del Cauca, Tolima

	Brazil	Temperate	18.5 (13.6-23.4)	1455	Sao Paulo*, Parana, Minas Gerais
West Indies	Dominican Republic	Tropical	26.2 (20.7-31.7)	1600	Elias Piña, Moca, Altamira, San Cristobal, San José de Ocoa, Mao, Montecristi, Dajabón*, Barahona, San Juan, La Romana, El Seibo, Baní, and Duvergé.
Africa	South Africa	Arid, Temperate	22.2 (14.1-30.2)	965	Limpopo*, KwaZulu Natal, Eastern Cape, Mpumalanga, Western Cape
	Kenya	Tropical, Temperate	20 (11.5-28.6)	1195	Meru, Embu, Muranga*, Nyeri Kiambu (highlands)
Europe	Spain	Arid, Temperate	18.4 (14.2-22.6)	357	Granada, Malaga*, Canary Islands
Middle East	Israel	Arid, Temperate	20.2 (14.9-25.5)	590	Coastal Plain* (from Rosh Hanikra to Gaza belt district), Jordan Valley and the Upper Galilee (Eastern Valleys)
Oceania	Australia	Temperate	20.6 (15.3-25.9)AT	1687	Western Australia, Perth (WA)*, Atherton Tablelands (AT)*, Queensland, Brisbane (Q)*, New South Wales, Victoria, South Australia
			21.5 (16.7-26.4)Q	1099	
			18.7 (13.4-24)WA	807	
	New Zealand	Temperate	16.2 (12.5-20)N	1080	Northland (N)*, Auckland, Bay of Plenty (BOP)*, Gisborne
			14.4 (9.9-19)BOP	1628	
Asia	Vietnam	Tropical	24.8 (20.2-29.4)	1806	Dak Nong*, Dak Lak, Lam Dong, Dong Nai

* Temperatures obtained for these representative regions.

1. Peel et al. (2007)

2. Anonymous (2019a)

Table 2. Records of pathogens in different countries.

Country	Average annual temperature (°C)	C.a.[1.]	C.g.	B. spp.	P.	L.t.	Reference(s)
New Zealand	14.4	+	+	+	+	-	Hartill (1991)
Chile	14.6	+	+	+	+	-	Anonymous (2019b); Valencia et al. (2019)
California	15.9	-	+	+	+	-	Twizeyimana et al. (2013a)
Spain	18.4	-	+	-	-	-	Plaza & Iglesias (1983)
Brazil	18.5	+	+	+	+	-	Zentmeyer (1961); Peres et al. (2002); Fischer et al. (2011)
Peru	18.7	-	+	-	+	+	Everett & Pushparajah (unpublished)
Kenya	20.0	-	+	-	-	-	Wasilwa et al. (2005); (Kimaru et al. 2018)
Israel	20.2	-	+	+	-	+	Zauberman et al. (1975); Eskalen et al. (2013)
Colombia	21.5	-	+	-	-	+	Garces (2019)
Queensland, Australia	21.5	+	+	+	+	+	Peterson (1978); Adkins et al. (2005)
South Africa	22.5	-	+	+	+	+	Darvas et al. (1987); Korsten et al. (1994)
Mexico	24.2	+	+	+	+	-	Campos-Martinez et al. (2016); Rojo-Baez et al. (2017)
Vietnam	24.8	-	+	-	-	-	Anonymous (2004)
Florida	25.0	-	+	+	+	+	Stevens & Piper (1941); Shetty et al. (2016)
Dominican Republic	26.2	-	+	-	-	-	Zentmeyer (1961)

[1.] C.a. = *Colletotrichum acutatum*, C.g. = *Colletotrichum gloeosporioides*, B spp. = *Botryosphaeria/Neofusicoccum* spp., P. = *Phomopsis* spp., L.t. = *Lasiodiplodia theobromicola*

These climates may affect the genera and/or species of pathogens that cause postharvest diseases. For example, *Colletotrichum acutatum* is a fungus that is more common on fruit grown in cool climates (Everett et al. 2007a), and *Lasiodiplodia theobromae* is more common in hot climates (Everett et al. 2016) (Table 2). In cooler climates, other members of the Botryosphaeriaceae fill the same niche as *L. theobromae,* i.e. *Neofusicoccum parvum* (syn. *Botryosphaeria parva*), *N. luteum* (syn. *Fusicoccum luteum*) and *B. dothidea* (Hartill 1991; Dann et al. 2013) (Table 2). *Colletotrichum gloeosporioides* apparently fills the *C. acutatum* niche in hot climates (Dann et al. 2013). All these fungi can be isolated from both stem-end rots and body rots. *Diaporthe* (syn. *Phomopsis*) is usually isolated from stem-end rots and not from body rots, unless the stem-end rot invades the entire fruit and it is difficult to ascertain the source of the rot when isolating. This fungus can be found on fruit grown in both cool and hot climates (Everett et al. 2007a; Everett et al. 2013). However, factors other than climate may be influencing the country specific distribution of postharvest pathogens of avocados such as effective border controls preventing new pathogens from entering.

Other pathogens are reported to cause postharvest rots in only a few countries, such as *Pestalotiopsis* in South Africa (Darvas & Kotze 1987) and Chile (Valencia et al. 2011), and *Alternaria* in California (Margosan & Smilanick 2000).

Presently, the taxonomic resolution of these fungi are undergoing changes, some of which have been based on genetic differences and may not be associated with meaningful biological differences. For example, there was no evidence provided for differences in the pathogenicity, host range or virulence of the 'phylospecies' (Everett 2014) that were resolved into new *Colletotrichum* species (Damm et al. 2012a; Weir et al. 2012).

The relevance of disease cycle data for different environments

It is important to understand the disease cycle of these postharvest pathogens for optimal on-orchard control. In particular, it is important to know the sources of inoculum, the criteria for infection and the timing of infection. Once these latter two factors are known, the timing of fungicide application can be optimised by developing weather based spray decision support tools.

Not a lot is known about the disease cycles of postharvest rot pathogens of avocados. Those that have been studied include *C. gloeosporioides* in Israel and Queensland (eastern Australia) and *B. parva* causing trunk cankers in California. These disease cycles need to be studied under different environmental conditions. For instance, in New Zealand the buds are an important source of overwintering inoculum for *C. acutatum* infecting apples (Everett et al. 2018), but in Norway they are not (Børve & Stensvand 2007, 2017). The hypothesis proposed to explain this difference was the difference in mean daily temperature between the two countries. In Norway temperatures were below a putative threshold of 15°C when buds were forming, but over this threshold during bud formation in New Zealand. This threshold was required to be exceeded for infection to take place in a series of laboratory and field studies in New Zealand (Everett et al. 2017).

For avocados, latent infection by *C. gloeosporioides* was demonstrated at least 6 months before harvest in Queensland (Coates et al. 1993a), and at least 3 months before harvest in Israel (Binyamini & Schiffmann-Nadel 1972), for a 9 month season in both environments. However, *C. gloeosporioides* wound-inoculated in avocados at monthly intervals from July to

harvest in February (a 15 month season) in the Bay of Plenty region of New Zealand did not cause rots (unpublished data). The mean daily temperatures in New Zealand are 6–7°C lower than those in Israel and Queensland (Table 2), perhaps accounting for this difference. While other factors may be involved, and further research is required to determine the infection criteria for *C. gloeosporioides* on avocado, it does demonstrate that disease cycle data may not be fully transferable to countries other than where the studies were conducted.

Aspects of the currently elucidated disease cycle for *C. gloeosporioides* can probably only be applied to countries with similar climates to Queensland and Israel. High rainfall does not appear to be necessary for infection to occur, in Israel where rainfall is low, significant amounts of rots are still reported to affect fruit. However, although the climate of different countries may affect when fruit are infected due to possible temperature thresholds (e.g. (Everett et al., 2017), information about inoculum sources is probably transferable as they are less likely to be affected by temperature.

Disease cycle for anthracnose caused by *C. gloeosporioides*

One study in Queensland found the most important inoculum source determined by collecting spores in rain traps was dead leaves entangled in the canopy, followed by infected fruit and fruit mummies still attached to the tree, and finally dead twigs (Fitzell 1987). Spores were not found from branch and trunk bark, or from green leaves (Fitzell 1987). In New Zealand, dead branches in the canopy and in the litter yielded fruiting bodies of *C. gloeosporioides* (Everett et al. 2003). In other studies in Australia, spores were released during rain events, and splashed or washed to infect fruit at all stages, from set to harvest (Peterson 1978; Coates et al. 1993a). Spores germinated, then formed an appressorium (a hard protective structure which can directly penetrate through avocado skin into the flesh) which adhered to the side of the fruit and inserted a short germ tube <1.5 μm into the avocado wax and cuticle (Coates et al. 1993b), upon which the germ tube ceased growth and became quiescent. Anti-fungal chemicals in the skin of 'Fuerte' avocados in Israel inhibit further growth (Prusky et al. 1982; Prusky et al. 1983; Prusky et al. 1991) until fruit are harvested. During subsequent ripening these chemicals are broken down, until when sub-fungitoxic levels are reached the appressorium resumes growth and penetrates into the avocado flesh to cause a rot (Prusky et al. 1991). Fungal fruiting structures are eventually produced in these rots and, if fruit remain in the orchard, are sources of inoculum for new infections.

Disease cycle for stem-end rots

A generalised disease cycle for the Botryosphaeriaceae and Diaporthaceae is derived from studies of avocado branch canker and fruit rots. Research has found fruiting structures on dead bark in New Zealand and California (Everett et al. 2003; Menge & Ploetz 2003), dead twigs in New Zealand (Hartill & Everett 2002), and cankers, rotten fruit and dead leaves in California (Horne & Palmer 1935). Recent studies in California showed cankers in twigs, branches or trunks were inoculum sources for fungi that were later shown to cause stem-end fruit rots (Twizeyimana et al., 2013b). Most infections of branches, twigs or trunks were through wounds, either from pruning, mechanical damage or weather events (Twizeyimana et al., 2013b, Valencia et al., 2019). Recent spore trapping studies showed that most Botryosphaeriaceous spores were released during rain events in winter, and that few spores were trapped during the dry California summer (Eskalen et al. 2013). Most spores from Diaporthaceous fungi were trapped in equal numbers during winter and autumn, also with

very few spores trapped during summer (Eskalen et al. 2013). Symptomless stems and branches were shown to be colonised by fungi that cause stem-end rots in New Zealand (*Botryosphaeria parva, Neofusicoccum luteum, Colletotrichum acutatum, C. gloeosporioides* and *Phomopsis*), and were described as phellophytes which inhabit the extra-cambial tissue under the cuticle (Hartill & Everett, 2002). Secateurs used to harvest avocados were shown to become contaminated with inoculum, and were a source of infection at harvest (Hartill & Everett, 2002). Avocado stem-ends were thus infected at harvest by spreading inoculum in the stem over the wound following cutting with secateurs, and also by spores released from the canopy during the disturbance caused by harvesting (Hartill & Everett, 2002). Naturally occurring stem-end rot fungi were shown to grow through the stem and into the flesh at a linear rate during coolstorage (Everett & Pak, 2002). Increasing the length of the stem at harvest decreased the incidence of stem-end rots, demonstrating clearly that infection occurred by contamination of the picking wound (Hartill et al., 2002)

Control in the orchard

Reduce inoculum

An obvious method to reduce inoculum in the orchard, and therefore reduce disease, is to remove inoculum sources. Dead leaves, dead twigs and branches, rotten or mummified fruit and cankers have been identified as inoculum sources for postharvest rots of avocado (Twizeyimana et al., 2013a, Eskalen et al., 2013, Hartill & Everett, 2002, Menge & Ploetz, 2003). Removal of these inoculum sources by raking or by means of a swing arm mower followed by mulching material in the inter-rows, or removal followed by burying or burning, are some methods that can be used to remove inoculum from under the trees. Knocking out dead branches followed by removal into the inter-rows has also been used as a method to reduce inoculum in the canopy (Everett et al. 2008b). The presence of mulch is important to sustain growth of avocado feeder roots, but reapplication of dead leaves, branches and twigs after grinding to a fine powder may be enough to reduce these as inoculum sources, but would need to be tested.

For black spot of apple, caused by *Venturia inaequalis*, fallen leaves under the canopy are the means by which this fungus overwinters and from which inoculum is released to start new epidemics the following spring. Hastening the decomposition of leaves by applying urea or by mulching has been shown to be effective in reducing inoculum (Sutton et al. 2000).

Although there is no data supporting the removal of inoculum sources as a strategy for controlling postharvest rots of avocados, it has been demonstrated to be effective in other pathosystems (Krauss & Johanson 2000; Tomescu 2002; Smith 2008).

Cutting out cankers, followed by application of a fungicidal pruning paste, are sensible precautions to aid disease control. Treating pruning wounds with fungicides should reduce infection of branches on the tree. An alternative that has not been tested is to use an air blast crop sprayer on the canopy to remove dead leaves and fruit. Treating pruning wounds with fungicides and removal of cankers has been demonstrated to reduce disease or inoculum in other pathosystems (Pitt et al. 2012; Latorre et al. 2013; Sosnowski & Mundy 2019), including botryosphaeria dieback of avocados in California (Twizeyimana et al. 2013b).

Nutrition

Improving nutrition has been shown to reduce postharvest fruit rots in New Zealand and Australia (Willingham et al. 2006; Everett et al. 2007a; Dann et al. 2016). The amount of calcium, magnesium and potassium was important in both countries, and nitrogen only in Australia (Willingham et al., 2006). The uptake of calcium was shown to be related to rainfall (Everett et al. 2007a), leading to a factorial field experiment which showed that both calcium applications and sufficient water uptake by the tree improved fruit quality (Everett et al. 2008b). In this study, removing dead branches in the canopy and raising the 'skirt' to reduce humidity did improve fruit quality for young trees (5–6 years old) (Everett et al., 2008b). However, this method was very labour intensive and was not effective for older trees (15–20 years old). Several years of management may be required to reduce inoculum in older trees.

Rootstocks

In Australia, grafting 'Hass' to Guatemalan or West Indian rootstocks such as 'A10' and 'Velvick' was shown to reduce postharvest rots of fruit from these trees compared with fruit from 'Hass' on Mexican rootstocks such as 'Duke 6' (Willingham et al. 2001b; Willingham et al. 2006; Dann et al. 2016).

Fungicide application

Eight applications of copper fungicides are recommended during the 18 month season in New Zealand and, every 28 days (or every 14 days for better control) for the 9 month season in Queensland (Willingham et al. 2001a). Application of benomyl during flowering reduced incidence of stem-end rots caused by *Diaporthe* in New Zealand (Everett et al. 1999b).

Prochloraz (Muirhead et al. 1982; Hartill et al. 1986; Fischer et al. 2011) or thiabendazole (Fischer et al. 2011) are the postharvest treatments reported to give good control of rots.

Biological control

To date, no biological control agents that are effective for pre and postharvest control have been identified due to inconsistent efficacy during field testing in New Zealand, Australia and South Africa (Coates et al. 1996; Havenga et al. 1999; Everett 2002; van Eeden & Korsten 2004; Everett et al. 2007b).

Spray decision support tools

There are currently no spray decision support tools readily available for postharvest rot fungi of avocados. To develop these tools, the infection criteria for each pathogen needs to be investigated. Additionally, host susceptibility can affect infection and also needs to be investigated. In combination with climate data (rainfall, humidity, leaf wetness and temperature), this information can be used to develop infection timing algorithms which can be validated and loaded onto suitable websites to allow easy grower access (Laurenson & Beresford 1996).

Postharvest handling

Impacts during postharvest handling can exacerbate postharvest rots (Everett et al. 2008a; Perkins et al. 2019). It is important to maintain good quality roading, to minimise damage during picking, placement in bins, transport to the packhouse, and to minimise drops and

impacts during packing. Short periods (24 hours) of high temperatures (25°C or higher) during picking while fruit were waiting in harvest bins for transport to the packing house were shown to decrease the rate of ripening after coolstorage and increase rots (Arpaia et al., 2018). Therefore placing bins in the shade while picking and removal to the coolstore immediately after filling would be a good practice in hot climates. Application of postharvest chemicals to the picking wound can reduce stem-end rots, as can sterilisation of secateurs between cuts (Everett 2002). Snap picking can reduce rots in arid climates (Woolf 1999), but worsen rots in humid climates (Hartill & Everett 2002). The time that avocados are coolstored is limited; for New Zealand fruit, it was shown both in laboratory experiments on detached fruit and in outturn monitoring that 28 days was the limit for storage (Dixon 2001; Everett & Pak 2002). After this time, the incidence of postharvest rots increased exponentially. Therefore, the time between picking and sale needs to be optimised by utilising efficient logistics. New technologies such as dynamic controlled atmosphere storage offer opportunities to increase the storage life of avocados (Burdon et al. 2008).

Conclusions

It is important that the disease cycle of postharvest avocado pathogens applicable to individual climates is known. In combination with infection criteria and host susceptibility, spray decision support tools can be developed to improve fungicide spray timing. Removal of inoculum sources in the orchard, improving the environment by using good nutrition and irrigation systems, using rootstocks shown to confer rot tolerance, reducing humidity under the canopy, careful handling during harvesting, transport and packing can all help improve avocado fruit quality. In addition, and most importantly, for the best possible disease control applications of fungicides in the orchard need to be applied regularly, followed by postharvest applications.

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References

Adkins ME, Hofman PJ, Stubbings BA, Macnish AJ 2005. Manipulating avocado fruit ripening with 1-methylcyclopropene. Postharvest Biology and Technology 35(1): 33-42.
Anonymous 2004. 4.1 Avocado. Fruits of Vietnam. Bangkok, Thailand, Food and Agriculture Organization of the United Nations.
Anonymous 2019a. Climate-data.org.
Anonymous 2019b. Draft report for the review of biosecurity import requirements for fresh avocados from Chile. Canberra, Australian Government. Department of Agriculture and Water Resources. 149pp p.
Arpaia ML, Collin S, Sievert J, Obenland D, 2018. 'Hass' avocado quality as influenced by temperature and ethylene prior to and during final ripening. *Postharvest Biology and Technology* **140**, 76-84.
Binyamini N, Schiffmann-Nadel M 1972. Latent infection in avocado fruit due to *Colletotrichum gloeosporioides*. Phytopathology 62: 592-594.
Børve J, Stensvand A 2007. *Colletotrichum acutatum* found on apple buds in Norway. Plant Management Network. doi:10.1094/PHP-2007-0522-01-RS [accessed 12 November 2009].
Børve J, Stensvand A 2017. *Colletotrichum acutatum* occurs asymptomatically on apple leaves. European Journal of Plant Pathology 147(4): 943-948.

Burdon J, Lallu N, Haynes G, McDermott K, Billing D 2008. The effect of delays in establishment of a static or dynamic controlled atmosphere on the quality of 'Hass' avocado fruit. Postharvest Biology and Technology 49(1): 61-68.
Campos-Martinez A, Valle M, Flores-Moctezuma HE, Suarez-Rodriguez R, Ramirez-Trujillo JA, Hernandez-Lauzardo AN 2016. Antagonistic yeasts with potential to control *Colletotrichum gloeosporioides* (Penz.) Penz. & Sacc. and *Colletotrichum acutatum* JH Simmonds on avocado fruits. Crop Protection 89: 101-104.
Coates LM, Irwin JAG, Muirhead IF 1993a. The use of a benomyl-resistant mutant to demonstrate latency of *Colletotrichum gloeosporioides* in avocado fruit. Australian Journal of Agricultural Research 44(4): 763-772.
Coates LM, Muirhead IF, Irwin JAG, Gowanlock DH 1993b. Initial infection processes by *Colletotrichum gloeosporioides* on avocado fruit. Mycological Research 97(11): 1363-1370.
Coates LM, Cannon KT, Cooke AW, Dean JR 1996. Production, formulation and application of biological control agents for avocado anthracnose Final Report, HRDC Project AV504.
Damm U, Cannon PF, Woudenberg JHC, Crous PW 2012a. The *Colletotrichum acutatum* species complex. Studies in Mycology 73: 37-113.
Dann EK, Ploetz RC, Coates LM, Pegg KG 2013. Foliar, Fruit and Soilborne Diseases. In: Whiley AW, Schaffer B, Wolstenholme BN, Albert VA, Aluja M eds. The avocado: botany, production and uses. 2nd ed. Wallingford, CABI. Pp. 380-422.
Dann EK, Coates LM, Pegg KG, Dean JR, Cooke AW, Smith LA, Shuey L, Whiley AW, Hofman PJ, Marques R, Stubbings B 2016. Rootstock selection, nitrogen and calcium influence postharvest disease in avocado. In: Golding JB, Heyes JA, Toivonen PMA, Avanzato D, Erner Y, Harker R eds. Acta Horticulturae.
Darvas JM 1982. Etiology and control of some avocado fruit diseases, Pretoria, South Africa, University of Pretoria.
Darvas JM 1983. Pre-harvest chemical control of post-harvest avocado diseases in the 1981/82 season. Yearbook, South African Avocado Growers' Association 6: 48-49.
Darvas JM, Kotze JM 1987. Avocado fruit diseases and their control in South Africa. Yearbook, South African Avocado Growers' Association 10: 117-119.
Darvas JM, Kotze JM, Wehner FC 1987. Field occurrence and control of fungi causing post-harvest decay of avocados. Phytophylactica 19: 453-455.
Dixon J 2001. Development of fruit quality disorders in New Zealand avocados at outturn in the USA for the 2000-2001 and 2001-2002 seasons. New Zealand Avocado Growers' Association Annual Research Report 1: 31-40.
Eskalen A, Faber B, Bianchi M 2013. Spore Trapping and Pathogenicity of Fungi in the Botryosphaeriaceae and Diaporthaceae Associated with Avocado Branch Canker in California. Plant Disease 97(3): 329-332.
Everett KR, Stevens PS, Cutting JGM 1999a. Postharvest fruit rots of avocado are reduced by benomyl applications during flowering. Proceedings of the Fifty Second New Zealand Plant Protection Conference, Auckland Airport Centra, Auckland, New Zealand, 10-12 August, 1999: 153-156.
Everett KR, Stevens PS, Cutting JGM 1999b. Postharvest fruit rots of avocado are reduced by benomyl applications during flowering. Proceedings of the Fifty Second New Zealand Plant Protection Conference, Auckland Airport Centra, Auckland, New Zealand, 10-12 August 52: 153-156.
Everett KR 2002. Avocado fruit rots: a review of industry funded research. New Zealand Avocado Growers' Association Annual Research Report; avocadosource.com 2: 1-15.
Everett KR, Pak HA 2002. Patterns of stem-end rot development in coolstorage. New Zealand Avocado Growers' Association Annual Research Report; avocadosource.com 2: 1-9.
Everett KR, Rees-George J, Parkes SL, Johnston PR 2003. Predicting avocado fruit rots by quantifying inoculum potential in the orchard before harvest. 5th World Avocado Congress. 19-24 October, Granada-Malaga, Spain. pp. 601-606, vol 1. Viceconsejeria. Servicio de Publicaciones y Divulgacion. Pp. 601-606.
Everett KR, Owen SG, Cutting JGM 2005a. Testing efficacy of fungicides against postharvest pathogens of avocado (Persea americana cv. Hass). New Zealand Plant Protection 58: 89-95.
Everett KR, Owen SG, Cutting JGM 2005b. Testing efficacy of fungicides against postharvest pathogens of avocado (Persea americana cv. Hass). New Zealand Plant Protection, Volume 58, 2005. Proceedings of a conference, Wellington, New Zealand, 9-11 August 2005: 89-95.
Everett KR, Boyd LM, Pak HA, Cutting JGM 2007a. Calcium, fungicide sprays and canopy density influence postharvest rots of avocado. Australasian Plant Pathology 36(1): 22-31.
Everett KR, Timudo-Torrevilla OE, Pushparajah IPS 2007b. Evaluation of a new chemical and two biological control agents for postharvest rot control in avocados. New Zealand Avocado Growers' Association Annual Research Report; avocadosource.com 7: 73-78.
Everett KR, Hallett IC, Rees-George J, Chynoweth RW, Pak HA 2008a. Avocado lenticel damage: The cause and the effect on fruit quality. Postharvest Biology and Technology 48(3): 383-390.

Everett KR, Pushparajah IPS, Timudo-Torrevilla OE, Manning MA 2008b. Orchard treatments other than spray application of fungicides that reduce postharvest rots of avocados. New Zealand Avocado Growers' Association Annual Research Report; avocadosource.com 8: 93-98.
Everett KR, Timudo-Torrevilla OE, Hill GN, Dawson TE 2008c. Field testing alternatives to copper for controlling avocado fruit rots. New Zealand Plant Protection 61: 65-69.
Everett KR, Pak HA, Pushparajah IPS, Taylor JT, Astill MS, King DB, Chee AA 2011. Field evaluation of fungicides to control postharvest rots of avocados in New Zealand. New Zealand Plant Protection 64: 112-118.
Everett KR, Pushparajah IPS, De Silva N, Jia Y 2013. Systematic orchard survey to determine regional and seasonal variation of fruit quality in Michoacán avocados. . A Plant & Food Research report prepared for APEAM Michoacán Avocado Producers, Packers & Exporters Association. Milestone No. 49717. Contract No. 28909. SPTS No. 8303.
Everett KR 2014. Anthracnose and stem-end rots of tropical and subtropical fruit- new names for old foes. Chapter 5. In: Prusky D, Gullino ML eds. Post-harvest Pathology. Plant Pathology in the 21st Century, Contributions to the 10th International Congress, ICPP 2013 Switzerland, Springer International Publishing. Pp. 55-70.
Everett KR, Woolf AB, Burdon JN, Pushparajah IPS, Billing DP, Wohlers MW, Olsson SR, Feng J, Richards KK, Barefoot MD 2016. ProHass Avocado Multi-Year Fruit Quality Research. Years 1–3 Results. A Plant & Food Research report prepared for Asociación de Productores de Palta Hass del Perú- ProHass. Milestone No. 66530. Contract No. 29828. SPTS No. 12759.
Everett KR, Pushparajah IPS, Timudo-Torrevilla OE, Ah Chee A, Scheper RWA, Shaw PW, Spiers TM, Taylor JT, Wallis DR, Wood P 2017. Infection criteria, inoculum sources and splash dispersal of *Colletotrichum acutatum* causing bitter rot of apples in New Zealand. European Journal of Plant Pathology 152: 367-383.
Fischer IH, Tozze HJ, de Arruda MC, Massola NS 2011. Postharvest of 'Fuerte' and 'Hass' avocados: physical and chemical characteristics, damages and control of diseases. Semina-Ciencias Agrarias 32(1): 209-220.
Fitzell RD 1987. Epidemiology of anthracnose disease of avocados. South African Avocado Growers' Association Yearbook 10: 113-116.
Garces D 2019. Avocado stem end rot pathogens. Greenyard Fresh Colombia January: 6pp.
Hartill WFT, Manning MA, Allen DJ 1986. Control of postharvest diseases of avocado. Proceedings of the thirty ninth New Zealand weed and pest control conference. Pp. 158-161.
Hartill WFT 1991. Postharvest diseases of avocado fruits in New Zealand. New Zealand Journal of Crop and Horticultural Science 19(3): 297-304.
Hartill WFT, Everett KR 2002. Inoculum sources and infection pathways of pathogens causing stem-end rots of 'Hass' avocado (*Persea americana*). New Zealand Journal of Crop and Horticultural Science 30(4): 249-260.
Hartill WFT, Everett KR, Pak HA, 2002. Stem-end rots: the infection portal. *New Zealand Avocado Growers' Association Annual Research Report* **2**, 59-63.
Havenga W, De Jager ES, Korsten L 1999. Factors affecting biocontrol efficacy of *Bacillus subtilis* against *Colletotrichum gloeosporioides*. South African Avocado Growers' Association Yearbook 22: 12-20.
Horne WT, Palmer DF 1935. The control of *Dothiorella* rot on avocado fruits. Agricultural Experimental Station Bulletin. Berkeley, University of California.
Kimaru SK, Monda E, Cheruiyot RC, Mbaka J, Alakonya A 2018. Morphological and molecular identification of the causal agent of anthracnose disease of avocado in Kenya. International Journal of Microbiology 2018: 1-10.
Korsten L, Sanders GM, Grosse-Wieschede E 1994. Isolation and pathogenicity of avocado post-harvest pathogens from Westfalia and other avocado producing areas. Yearbook - South African Avocado Growers' Association 17: 46-48.
Kotze JM, Kuschke E, Durand B 1981. Pre-harvest chemical control of anthracnose and sooty blotch. Yearbook, South African Avocado Growers' Association 4: 69-70.
Krauss U, Johanson A 2000. Recent advances in the control of crown rot of banana in the Windward Islands. Crop Protection 19(3): 151-160.
Labuschagne N, Rowell AWG 1983. Chemical control of post-harvest diseases of avocados by pre-harvest fungicide application. Yearbook, South African Avocado Growers' Association 6: 46-47.
Latorre BA, Torres R, Silva T, Elfar K 2013. Evaluation of the use of wound-protectant fungicides and biological control agents against stem canker (*Neofusicoccum parvum*) of blueberry. Ciencia E Investigacion Agraria 40(3): 537-545.
Laurenson MR, Beresford RM 1996. Decision support software as a medium for technology transfer in plant protection. Proceedings of the Forty Ninth New Zealand Plant Protection Conference, Quality Hotel Rutherford, Nelson, New Zealand, 13-15 August, 1996.: 85-89.
Lonsdale JH, Kotze JM 1989. Chemical control of pre- and postharvest diseases of avocados. Yearbook - South African Avocado Growers' Association 12: 68-70.

Margosan DA, Smilanick JL 2000. 15. Fungi isolated after harvest from decayed California avocado fruit. California Avocado Commission. 2000 Avocado Research Symposium. avocadosource.com. Pp. 4 pp.
Menge JA, Ploetz RC 2003. Diseases of Avocado. In: Ploetz RC ed. Diseases of Tropical Crops. Wallingford, UK, CAB International. Pp. 35-71.
Muirhead IF, Fitzell RD, Davis RD, Peterson RA 1982. Post-harvest control of anthracnose and stem-end rots of Fuerte avocados with prochloraz and other fungicides. Australian Journal of Experimental Agriculture and Animal Husbandry 22(118/119): 441-446.
Peel MC, Finlayson BL, McMahon TA 2007. Updated world map of the Köppen-Geiger climate classification. Hydrol. Earth Syst. Sci. 11: 1633-1644.
Peres NAR, Kuramae EE, Dias MSC, Souza NLd 2002. Identification and characterization of *Colletotrichum* spp. affecting fruit after harvest in Brazil. Journal of Phytopathology 150(3): 128-134.
Perkins ML, Joyce DC, Coates LM 2019. Possible contribution of impact injury at harvest to anthracnose expression in ripening avocado: a review. Scientia Horticulturae 246: 785-790.
Peterson RA 1978. Susceptibility of Fuerte avocado fruit at various stages of growth to infection by anthracnose and stem-end rot fungi. Australian Journal of Experimental and Animal Husbandry 18: 158-160.
Pitt WM, Sosnowski MR, Huang RJ, Qiu Y, Steel CC, Savocchia S 2012. Evaluation of Fungicides for the Management of *Botryosphaeria* Canker of Grapevines. Plant Disease 96(9): 1303-1308.
Plaza JLdl, Iglesias MC 1983. Effects of waxing on quality of Hass avocados stored in a controlled atmosphere. Efectos del encerado sobre la calidad del aguacate "Hass" conservado en atmosfera controlada. Primer Congreso Nacional II: 1011-1019.
Prusky D, Keen NT, Sims JJ, Midland SL 1982. Possible involvement of an antifungal diene in the latency of *Colletotrichum gloeosporioides* on unripe avocado fruits. Phytopathology 72(12): 1578-1582.
Prusky D, Keen NT, Eaks I 1983. Further evidence for the involvement of a preformed antifungal compound in the latency of *Colletotrichum gloeosporioides* on unripe avocado fruits. Physiological Plant Pathology 22(2): 189-198.
Prusky D, Plumbley RA, Kobiler I 1991. The relationship between antifungal diene levels and fungal inhibition during quiescent infection of unripe avocado fruits by *Colletotrichum gloeosporioides*. Plant Pathology 40(1): 45-52.
Rojo-Baez I, Alvarez-Rodriguez B, Garcia-Estrada RS, Leon-Felix J, Sanudo-Barajas A, Allende-Molar R 2017. Current status of *Colletotrichum* spp. in Mexico: taxonomy, characterization, pathogenesis and control. Revista Mexicana de Fitopatologia 35(3): 549-570.
Shetty KG, Rivadeneira DV, Jayachandran K, Walker DM 2016. Isolation and molecular characterization of the fungal endophytic microbiome from conventionally and organically grown avocado trees in South Florida. Mycological Progress 15(9): 977-986.
Smith BJ 2008. Epidemiology and pathology of strawherry anthracnose: A North American perspective. Hortscience 43(1): 69-73.
Sosnowski MR, Mundy DC 2019. Pruning Wound Protection Strategies for Simultaneous Control of *Eutypa* and *Botryosphaeria* Dieback in New Zealand. Plant Disease 103(3): 519-525.
Stevens HE, Piper RB 1941. Avocado diseases in Florida. Circular of the United States Department of Agriculture 582: 46pp.
Sutton DK, MacHardy WE, Lord WG 2000. Effects of shredding or treating apple leaf litter with urea on ascospore dose of *Venturia inaequalis* and disease buildup. Plant Disease 84(12): 1319-1326.
Tomescu A 2002. Chemical and cultural control of pathogenic fungi in tomato crops. In: Paroussi G, Voyiatzis D, Paroussis E eds. Proceedings of the Second Balkan Symposium on Vegetables and Potatoes. Pp. 521-526.
Twizeyimana M, Forster H, McDonald V, Wang DH, Adaskaveg JE, Eskalen A 2013a. Identification and Pathogenicity of Fungal Pathogens Associated with Stem-End Rot of Avocado in California. Plant Disease 97(12): 1580-1584.
Twizeyimana M, McDonald V, Mayorquin JS, Wang DH, Na F, Akgul DS, Eskalen A 2013b. Effect of Fungicide Application on the Management of Avocado Branch Canker (Formerly *Dothiorella* Canker) in California. Plant Disease 97(7): 897-902.
Valencia AL, Torres R, Latorre BA 2011. First Report of *Pestalotiopsis clavispora* and *Pestalotiopsis* spp. Causing Postharvest Stem End Rot of Avocado in Chile. Plant Disease 95(4): 492-492.
Valencia AL, Gil PM, Latorre BA, Rosales IM 2019. Characterization and Pathogenicity of Botryosphaeriaceae Species Obtained from Avocado Trees with Branch Canker and Dieback and from Avocado Fruit with Stem End Rot in Chile. Plant Disease 103(5): 996-1005.
van Eeden M, Korsten L 2004. Effect of additives and copper fungicide on *Bacillus subtilis* to control avocado (*Persea americana* Mill.) fruit diseases. South African Avocado Growers' Association Yearbook 27: 11-16.
Wasilwa LA, Njuguna JK, Kirigua V, Waturu CN, Stafne RA, Wasilwa LA, Morelock TE 2005. Impact of anthracnose on avocado production in Kenya. Hortscience 40(4): 1103-1104.

Weir BS, Johnston PR, Damm U 2012. The *Colletotrichum gloeosporioides* species complex. Studies in Mycology 73(1): 115-80.
Willingham SL, Pegg KG, Coates LM, Cooke AW, Dean JR, Langdon PWB, Beasley DR 2001a. Field management of avocado postharvest diseases. In: Ben-Arie R, Philosoph-Hadas S eds. Acta Horticulturae.
Willingham SL, Pegg KG, Cooke AW, Coates LM, Langdon PWB, Dean JR 2001b. Rootstock influences postharvest anthracnose development in 'Hass' avocado. Australian Journal of Agricultural Research 52(10): 1017-1022.
Willingham SL, Pegg KG, Anderson JM, Cooke AW, Dean JR, Giblin FR, Coates LM 2006. Effects of rootstock and nitrogen fertiliser on postharvest anthracnose development in Hass avocado. Australasian Plant Pathology 35(6): 619-629.
Woolf AB 1999. Summary of New Zealand and Californian experience with 'snap' picking In: Arpaia ML, Hofshi R eds. Avocado Brainstorming. Riverside, California, USA, University of California. Pp. 161-162.
Zauberman G, Schiffmann-Nadel M, Fuchs Y, Yanko U 1975. The biology and pathogenicity of fungi causing post-harvest rot of avocado fruit- La biologie et la pathogenicite des champignons causant les pourritures de l'avocat apres la recolte. Fruits 30(7/8): 499-502.
Zentmeyer GA 1961. Avocado diseases in the Americas. Ceiba 9: 61-79.