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IMPACT OF RAINFALL PRIOR TO HARVEST ON RIPE FRUIT QUALITY OF 'HASS' AVOCADOS IN NEW ZEALAND

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ABSTRACT

Three field trials (October 2002, December 2002 and February 2003) were conducted to determine the impact of different amounts of rain in the 24 hours preceding harvest on both susceptibility to handling damage and ripe fruit quality. In each trial a control sample of 200 fruit were harvested prior to the forecast rain event. Half of the fruit were picked directly into trays, while the remainder was jostled to simulate handling during the harvesting process. Further samples were then harvested after various periods of rain, and a final sample at least 24 hours after rain ceased. Fruit were coolstored for 28 days at 4-5°C, then ripened at 20°C and fruit quality assessed at eating ripeness. As little as 5mm of rain was sufficient to impact negatively on ripe fruit quality. Rain increased the susceptibility of fruit to handling damage, and facilitated the development of body rots. Jostling of fruit had a greater effect on development of stem end rots than on body rots. During prolonged periods of rain fruit quality may revert to that prevailing prior to the start of the rain event.

Key Words: handling damage, body rots, stem-end rots, lenticel

INTRODUCTION

In order to optimise export quality of New Zealand (NZ) avocados the Avocado Industry Council sets guidelines for harvest conditions, which include rainfall. The guidelines currently specify that fruit should not be harvested if more than 5mm of rain has fallen within the previous 24 hours, as this level of rainfall should be sufficient to increase fruit turgor. High fruit turgidity has been shown through *in vivo* experiments to increase the susceptibility of lenticels to handling damage (Everett *et al.*, 2001) that may lead to increased levels of postharvest rots. The level of rainfall required to impact on susceptibility to handling damage and ripe fruit quality under field conditions has not

been determined. Field experiments were conducted in the 2002/3 harvest season to determine the impact of different amounts of rain in the 24 hours preceding harvest on both susceptibility to handling damage and ripe fruit quality.

MATERIAL AND METHODS

Each trial was timed to coincide with a rain forecast that followed a 2-3 week dry period. There were 3 trials carried out in October 2002 (Trial A), December 2002 (Trial B) and February 2003 (Trial C). All fruit were harvested from a single orchard block in the Bay of Plenty region (37°S, 176°E), North Island of NZ. In each trial a control sample of 200 fruit were harvested prior to the forecast rain event. Half of these fruit were placed into trays and the remainder jostled in plastic bins using the method of Everett *et al* (2001) to simulate handling during the harvesting process. Further samples were then harvested after various periods of rainfall, recorded daily at 9.30 am, and a final sample at least 24 hours after it had ceased raining. Fruit were coolstored for 28 days at 4-5°C, then ripened at 20°C and fruit quality assessed at eating ripeness. Ripeness was determined by firmometer when the fruit reached a softness reading of 85 using a 300g weight or by hand feel after calibration to a firmometer. Fruit were assessed for disorders according to the Avocado Industry Council Fruit Assessment Manual (2001). Disorders were rated by assessing the percentage (scale 0 to 100) of the cut surface of the fruit or skin surface area that was affected by disorders. Green fruit were rated for peel damage (skin abrasions) and peel handling damage (diffuse grey patches spreading beyond individual nodules). Ripe fruit were cut longitudinally into quarters where the cut surface of ripe fruit was rated for stem end rot (discoloured flesh from the stem button down) and vascular browning. The under side of the peeled skin was rated for brown patches (body rot as circular brown coloured patches).

RESULTS AND DISCUSSION

Trial A

A light rainfall of 12mm in the 24 hours prior to harvest on the 17/10/02 increased both the incidence ($p<0.05$) and severity ($p<0.05$) of peel handling damage despite the minimal handling of the fruit (Table 1). After a further 24 hours even though there was no more rain, the incidence of unsound fruit increased in the control due to an increase in the incidence of body rots.

Jostling of fruit on the 11/10/02 prior to the rain event increased the incidence of unsound fruit relative to the control by 17%, mainly due to an increase in the incidence of body rots (Table 1). Although jostling significantly increased both incidence ($p<0.001$) and severity ($p<0.001$) of peel handling damage, jostling fruit either during or 24 hours after the rain event did not impact on ripe fruit quality. This may be related to the reduction in peel handling damage and severity.

Trial B

Jostling of fruit on 16/10/02 prior to the rain event increased the incidence and severity of peel handling damage and body rots relative to the control (Table 2). The proportion of unsound fruit increased by 27% as a result of jostling due to an increase in body rots. There was no effect of jostling on either stem-end rot incidence or severity.

In terms of rainfall, 5mm of rain falling in the 24 hours prior to harvest on 18/12/02 resulted in an increase in incidence and severity of both stem-end and body rots in jostled fruit as well as severity of peel handling damage (Table 2). The proportion of unsound fruit was increased more than 40%. However, a further 21mm rain in the following 24 hours resulted in an improvement in fruit

quality and decrease in the severity of peel handling damage, with a return to the incidence of unsound fruit prior to the rain on 17/12/02. After a further 24 hours of no rain fruit harvested on the 20/12/02 differed significantly from the fruit harvested prior to the initial rain event on 17/12/02 only in a higher incidence of body rots.

Trial C

This trial captured a prolonged rain period that was preceded by at least 4 weeks with no significant rainfall. The initial rain event of 10mm preceding harvest on 24/2/03 lead to a reduction in both incidence of stem end rots and unsound fruit relative to the control fruit harvested one month earlier under dry conditions (Table 3). While the interval between these two harvest dates is greater than desirable the observed reduction in stem end rot runs counter to an observed trend for incidence and severity of both stem-end rots and body rots to increase over this time of year (Pak, 2001).

Prolonged heavy rain had a limited impact on quality of the control fruit with no increase in the severity of brown patches or stem end rots, or in the incidence of unsound fruit or body rots, despite over 127 mm of rain falling over a two week period (Table 3). Quality of fruit harvested four days after the rain event on 7/3/2003 was better than that of fruit harvested on 22/1/2003 with a lower incidence of body rots and unsound fruit. Incidence and severity of peel handling damage followed a cyclic pattern with peaks on the 26/2/2003 and 3/3/2003.

Fruit that had been subjected to jostling also showed a cyclical pattern in peel handling damage. Low incidences and severities were observed for fruit harvested on the 27/2/2003 and 7/3/2003, which complemented the peaks observed in the control fruit (Table 3). The decreased incidence of unsound fruit on 27/2/2003 and 7/3/2003 is due to a decline in the incidence and severity of body rots. While body rots tended to reflect changes in peel handling damage, stem end rots were greatest in jostled fruit on 27/2/2003, when body rots were lowest.

Fruit harvested prior to rain on the 22/1/2003 and subjected to jostling had greater peel handling damage severity and incidence and a higher severity of body rots than the control (Table 3). Fruit harvested after the start of rain on the 24/2/2003 that were jostled had increased severity and incidence of stem end rots, body rots and peel handling damage with an increase of 27% unsound fruit. Continued rain prior to harvest on 26/2/2003 combined with jostling increased severity and incidence of body rots relative to the control, although there was no impact on stem end rots. Fruit harvested on the 27/2/2003 were less prone to deterioration of quality as a result of jostling, despite the continued rain, with no significant difference in incidence of body rots or unsound fruit relative to the control. The reduced impact of jostling on fruit harvested on the 27/2/2003 coincides with low levels of peel handling damage observed on this date. Ripe fruit quality was not significantly impacted by jostling 4 days after the end of the rain event on 7/3/2003. The combined results from Trial C suggest that harvesting fruit while wet increases susceptibility to handling damage and reduces ripe fruit quality but minimal handling of fruit limits the impact of prolonged rainfall on fruit quality.

The combined results of the trials indicate that rainfall in the 24 hour period prior to harvest can have a detrimental impact on ripe fruit quality. Rainfall within the first 24 hours of the commencement of a rain event appears to have the greatest impact on quality, since any negative effects appear to be ameliorated with continued rain. This may reflect the role of inoculum level in the development of opportunistic infections on fruit with increased susceptibility as a result of handling damage. Continued rainfall may deplete the reserve of inoculum available to infect fruit, hence the perceived improvement in quality. The base level of rots to which the fruit reverts following prolonged periods of rain or following a rain event may reflect the level of latent infections as opposed to opportunistic infections that occur at harvest.

Susceptibility of fruit to handling damage increases during a rain event, but the fruit recover within 24 to 72 hours. Rainfall sufficient to wet the soil makes fruit more susceptible to peel handling damage. This is probably the result of increased turgidity of cells beneath the lenticular cavity (Everett *et al,* 2001). The level of body rots that developed tended to reflect the susceptibility of fruit to peel handling damage, suggesting that peel handling damage may facilitate opportunistic infection.

CONCLUSIONS

As little as 5mm rain in the 24 hours preceding harvest is sufficient to negatively impact on ripe fruit quality. Susceptibility of fruit to handling damage increases during a rain event but fruit recover with 24 to 72 hours. Peel handling damage appears to facilitate the development of body rots with jostling influence body rots development to a greater extent than stem end rots. Rainfall over a 48 hour period or longer may ameliorate the negative effects of shorter rainfall events, possibly by depleting the level of inoculum available for fruit infection.

REFERENCES

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Table 1. Trial A: Effect of harvest date, rainfall (mm) in the 24 hours prior to harvest and handling treatment on severity and incidence of stem-end rots (SER), brown patches (BP), peel handling damage (PHD) and incidence of unsound fruit (incidence of ripe fruit with any disorders exceeding 5%). ANOVA table for effect of date and of handling treatment (control vs jostled) by date.

Date	Rain	Handling	Severity			Incidence			
			SER	BP	PHD	SER	BP	PHD	Unsound
11/10/02	0	Control	0	0.10	0.14 a	0	2 a	12 a	2 a
17/10/02	12	Control	0.02	0.12	0.48 b	2	8 a,b	29 b	9 a,b
18/10/02	0	Control	0.04	0.19	0.29 a,b	4	13 b	22 a,b	16 b
ANOVA		**Date**	**ns**	**ns**	**p=0.003**	**ns**	**p=0.014**	**p=0.012**	**p=0.002**
11/10/02	0	Jostled	0.01	0.29	4.12 a	1	14	99 a	19
17/10/02	12	Jostled	0.03	0.18	2.48 b	3	11	88 a,b	14
18/10/02	0	Jostled	0.11	0.31	2.84 b	6	18	71 b	24
ANOVA		**Date**	**ns**	**ns**	**p=0.002**	**ns**	**ns**	*******	**ns**
ANOVA		**handling*date**							
		11/10/02	ns	ns	***	ns	p=0.002	***	***
		17/10/02	ns	ns	***	ns	ns	***	ns
		18/10/02	ns	ns	***	ns	ns	***	ns

*** p<0.001, ns not significant. Values within the same section of column (jostled/control) with the same letter are not significant at p=0.05 according to the Tukeys' HSD test.

Table 2. Trial B: Effect of harvest date, rainfall (mm) in the 24 hours prior to harvest and handling treatment on severity and incidence of stem-end rots (SER), brown patches (BP), peel handling damage (PHD) and incidence of unsound fruit (incidence of ripe fruit with any disorders exceeding 5%). ANOVA table for effect of date and of handling treatment (control vs jostled) by date.

Date	Rainfall	Handling	Severity			Incidence			
			SER	BP	PHD	SER	BP	PHD	Unsound
16/12/02	0	Control	0.03	0.07	0.1	2	15	2	16
16/12/02	0	Jostled	0.09 a	1.32 a	3.0 a	5 a	42 a	94	43 a
18/12/02	5	Jostled	1.15 b	3.07 b	4.9 b	38 b	79 b	99	86 c
19/10/02	21	Jostled	0.20 a	0.78 a	3.2 a	7 a	43 a	96	47 a,b
20/12/02	0	Jostled	0.20 a	1.73 a	3.3 a	8 a	56 a	99	61 b
ANOVA		**Date**	*******	*******	*******	*******	*******	**ns**	*******
ANOVA		**Handling by date**							
		16/12/02	ns	***	***	ns	***	***	***

*** p<0.001, ns not significant. Values within the same section of column (jostled/control) with the same letter are not significant at p=0.05 according to the Tukeys' HSD test.

Table 3. Trial C: Effect of harvest date, rainfall (mm) in the 24 hours prior to harvest and handling treatment on severity and incidence of stem-end rots (SER), brown patches (BP), peel handling damage (PHD) and incidence of unsound fruit (incidence of ripe fruit with any disorders exceeding 5%). ANOVA table for effect of date and of handling treatment (control vs jostled) by date.

Date	Rain	Handling	Severity			Incidence			
			SER	BP	PHD	SER	BP	PHD	Unsound
22/1/03	0	Control	0.25 a,b	2.0 a	0 a	14 a	56 a	0 a	60 a
24/02/03	10	Control	0 a	1.0 a,b	0 a	0 b	42 a,b	0 a	42 b
26/02/03	17.5	Control	0.24 a,b	1.2 a,b	0.2 b	12 a	50 a,b	17 b	54 a,b
27/02/03	23	Control	0.31 b	0.3 b	0 a	13 a	34 b	0 a	43 b
3/03/03	77	Control	0.14 a,b	1.5 a,b	0.2 b	8 a,b	46 a,b	13 b	47 a,b
7/03/03	0	Control	0.10 a,b	1.4 a,b	0 a	5 a,b	37 b	2 a	38 b
ANOVA		**Date**	**p=0.04**	**p=0.005**	***	**p=0.002**	**p=0.018**	***	**p=0.018**
22/1/03	0	Jostled	0.31a,b	4.6 a	3.6 a	11 a	64 a	98 a	66 a
24/02/03	10	Jostled	0.10 b	2.3 b	4.7 a,b	6 a	78 a,b	100 a	79 a,b
26/02/03	17.5	Jostled	0.20 a,b	3.2 a,b	5.1 b	10 a	83 b	99 a	84 b
27/02/03	23	Jostled	0.50 a	0.5 c	1.4 c	24 b	38 c	61 b	48 c
3/03/03	77	Jostled	0.28 a,b	3.5 a,b	3.5 a	14 a,b	66 a	93 a	68 a
7/03/03	0	Jostled	0.05 b	0.6 c	1.1 c	3 a	40 c	66 b	43 c
ANOVA		**Date**	**p=0.002**	***	***	***	***	***	***
ANOVA		**handling by date**							
		22/1/03	ns	p=0.004	***	ns	ns	***	ns
		24/02/03	p=0.017	***	***	p=0.013	***	***	***
		26/02/03	ns	***	***	ns	***	***	***
		27/02/03	ns	p=0.024	***	p=0.045	ns	***	ns
		3/03/03	ns	p=0.002	***	ns	p=0.004	***	p=0.003
		7/03/03	ns	ns	***	ns	ns	***	ns

*** $p<0.001$, ns not significant. Values within the same section of column (jostled/control) with the same letter are not significant at $p=0.05$ according to the Tukeys' HSD test.