South African Avocado Growers' Association Yearbook 1989. 12:10-12

Biocontrol of avocado postharvest diseases

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ABSTRACT

In South Africa biocontrol is a new approach to avocado postharvest disease control. In this report, the biological approach is evaluated against standard chemical control measures on a pre-and postharvest level. Antagonists Bacillus lichineformis and B subtilis effectively reduced stem-end rot, anthracnose and the Dothiorella/Colletotrichum fruit rot complex, when applied as field preharvest sprays, as well as packhouse postharvest dip treatments.

UITTREKSEL

Biologiese beheer is 'n nuwe benadering tot die beheer van na-oessiektes in Suid-Afrika. In hierdie verslag word die biologiese benadering vergelyk met standaard chemiese beheermaatreéls op beide 'n voor-en na-oesvlak. Antagoniste Bacillus lichineformis en B subtilis het stingelentbederf, antraknose en Dothiorella/Colletotrichum vrugtevrotkompleks effektief beheer as voor-oes veldbespuitingbehandelings sowel as na-oes pakhuisdipbehandelings.

INTRODUCTION

Reasonable control of various post-harvest diseases of avocado has been achieved through the use of preharvest sprays with compounds such as copper oxychloride (Kotzé, Du Toil & Du Randt, 1982). Although captafol gave better control (Darvis, 1981), it is slightly phytotoxic to the leaves (Kotzé, *et al,* 1982). Benomyl also gave effective control of anthracnose, but prolonged use has led to increased tolerance (Darvis & Kotzé, 1987). These funigcides, particularly CuOCI and captafol cause visible spray residues on fruit, which is difficult to remove (Denner & Kotzé, 1986). This resulted in rejection of 11, 5-19, 4 per cent of export fruit (Pieterse, 1986). More recently, postharvest fungicidal applications such as prochloraz successfully controlled postharvest diseases (Darvis, 1984). However, product clearance has not been given on the French market. Furthermore, general concern about possible adverse effects of pesticides on consumable items, makes it desirable to seek other control measures. One feasible alternative is biological control (Korsten, Bezuidenhout & Kotzé, 1988).

According to Wilson & Pusey (1985), encouraging results were obtained with biocontrol of postharvest diseases, despite the limited number of studies in this field. Thus far, success has been achieved with postharvest biocontrol of *Alternaría citrí* and *Geotrichum candidum* which cause fruit rot (Vapinder, Singh & Deverall, 1984), Rhizopus rot of peach (Wilson, Franklin & Pusey, 1987), and stone fruit brown rot, caused by *Monilinia fructicola* (Pusey & Wilson, 1984). On a preharvest level, blue mould on apples (Jansiewicz, 1987) and gray mould of strawberries, both caused by *Botrytis cinerea* (Bhatt & Vaughan, 1962), have been reduced through antagonists. Preliminary field trials with *Bacillus lichineformis* indicated that the antagonist could not compete with standard copper oxycholride treatments for the control of avocado postharvest diseases. However, effective control was achieved with fruit dip postharvest treatments under packhouse conditions. Before biocontrol agents can be adopted in commerce, it must yield consistent results, comparable with those achieved by chemical methods. Trials therefore repeated, using higher concentrations of the antagonists, more frequent applications and an integration of chemical and biological measures.

MATERIALS AND METHODS

Preharvest biocontrol

Field tests were conducted at Westfalia Estate on 15-year-old Fuerte trees with *B lichineformis* and/or *B subtilis* in treatments with or without copper oxychloride as described by Korsten *et al* (1988) (Table 1). In total, 1542 fruits were evaluated during the season, according to the procedures described by Bezuidenhout & Kuschke (1982).

TABLE 1 Comparison of preharvest biocontrol with copper oxychloride sprays for the control of physiological and pathological disorders of Fuerte avocado fruit picked during the early season (06-05-88)

Treatments	External evaluation		Internal evaluation							
			Physiological			Pathological				
	No of fruit	Anthrac-nose	CD/C	VB	PS	VBB	Stem-end rot	Anthrac-nose	CD/C	Average ripening time
1) Nov and Jan: copper oxychloride	103	0.7961ab	1.19242a	0.5243ab	0.8058b	0.7476a	0.11650a	0.28155a	0.1068cb	5.13592de
2) Jan: copper oxychloride	95	1.0421a	0.7895b	0.3789cb	1.474a	0.3684c	0.14737a	0.23158ab	0.14737cb	5.4000bc
3) Nov: copper oxychloride Jan: *B lichineformis*	119	0.2437c	0.4118c	0.6891a	0,7227b	1.2857a	0.07563a	0.0504c	0.0084c	5.2437cd
4) Nov and Jan: *B lichineformis* and *B subtilis*	120	0.6167b	0.8583b	0.5417ab	0.7833b	0.3917c	0.10833a	0.21667ab	0.2333ab	5.4583ab
5) Nov, Jan, March and April: *B lichineformis*	100	0.3200c	0.4300c	0,6300ab	0.3900c	0.7900b	0.600a	0.1000cb	0.0900c	4.2000f
6) Jan and March: *B lichineformis* spore and vegetative forms	116	0.7845ab	0.7328b	0.2155c	0.9397ab	0.8966b	0.14655a	0.9483cb	0.01724c	4.9655e
7) Control: No spray	122	0.7705b	1.0164b	0.6475a	1.0820a	1.4426a	0.12295a	0.2541a	0.303028a	5.61475a
Total no of fruit	775									

VB = Vascular browning, PS = Pulp spot, VBB = Vascular bundle blackening, CD/C = Dothiorella/Colletotrichum fruit rot complex.
Values followed by the same letter do not differ significantly according to Duncan's multiple range test (P=0,001).
Values indicate mean disease severity.
Fruit were evaluated on a 0-10 scale, 0 being healthy and 10 indicating completely affected fruit.
Ripening was evaluated on a 0-10 scale, 0 being overripe, 5 ready to eat, and 10 still hard.

Postharvest biocontrol

B lichineformis, B cereus and *B subtilis* were further evaluated under commercial packhouse conditions at Westfalia Estate. Fruit was dipped into various antagonist suspensions (Table 2) as described by Korsten *et al* (1988). In total, 960 fruits were evaluated and analysed *as* described before.

TABLE 2 Comparison of preharvest biocontrol with copper oxychloride sprays for the control of physiological and pathological disorders of harvested Fuerte avocado fruit (10-01-88)

Treatments	External evaluation		Internal evaluation							
		Physiological					Pathological			
	No of fruit	Anthracnose	CD/C	VB	PS	VBB	Stem-end rot	Anthracnose	CD/C	Average ripening time
1) Jan: copper oxychloride	143	1.5105b	1.5385b	1.2378a	0.21678a	0.4266b	0.62738a	0.4545ab	0.16783ab	4.69231c
2) Nov: copper oxychloride Jan: *B lichineformis*	46	0.4783d	0.6304d	0.8478b	0.36957a	0.7174a	0.36957b	0.2174d	0.13043ab	5.68391a
3) Nov and Jan: *B lichineformis*	105	1.9238a	2.3429a	0.5619bc	0.4000a	0.4286b	0.16190cd	0.4381abc	0.2381a	4.74286c
4) Nov, Jan, March and April: *B lichineformis*	161	0.5714d	0.7764cd	0.6194bc	0.3806b	0.3881b	0.05590d	0.2919bcd	0.559b	4.70186c
5) Jan and March: *B lichineformis* spore and vegetative forms	134	1.1716c	1.0672c	0.441c	0.19876a	0.3665b	0.15672cd	0.2313cd	0.12687ab	5.07436b
6) Control: No spray	177	1.9774a	1.0395c	0.72881bc	0.27119a	0.4746b	0.33898bc	0. 5989a	0.07345b	4.9265b
Total no of fruit	767									

VB = Vascular browning, PS = Pulp spot, VBB = Vascular bundle blackening, CD/C = Dothiorella/Colletotrichum fruit rot complex.
Values followed by the same letter do not differ significantly according to Duncan's multiple range test (P=0,001).
Values indicate mean disease severity.
Fruit were evaluated on a 0-10 scale, 0 being healthy and 10 indicating completely affected fruit.
Ripening was evaluated on a 0-10 scale, 0 being overripe, 5 ready to eat, and 10 still hard.

RESULTS

Preharvest biocontrol

Results of the 1988 field trial showed that higher concentrations of bacterial cells (10^8 cells/mℓ), more frequent applications of *B lichineformis,* mixtures of 6 *lichineformis* and *B subtilis,* as well as integrated spraying with copper oxychloride with application of *B lichineformis, were* more effective in controlling postharvest diseases than the standard commercial copper oxychloride spray programmes (Table 1). Control of the various postharvest diseases were persistant throughout the season. In contrast, diminishing protection by chemical treatments was observed later in the season (Table 2).

Postharvest biocontrol

Postharvest biocontrol was as effective as preharvest biocontrol, and higher concentrations of bacterial cells and mixtures of *B lichineformis* and *B subtilis* effectively reduced the various postharvest diseases (Table 3).

TABLE 3 Postharvest biocontrol of physiological and pathological disorders of Edranol avocado fruit with *Bacillus* antagonists

Treatments	External evaluation		Internal evaluation						
			Physiological				Pathological		
	No of fruit	Ripening	Ant	CD/C	VB	VBB	SE	Ant	CD/C
Control +	157	4.90446e	0.3376cd	0.7834cb	0.6433b	0.5860c	0.20382b	0.24841b	0.03822a
Control H_2O dip	131	5.00763de	1.3130a	1.0458a	0.8473b	1.229ab	0.38931a	0.41221a	0.0458a
Control + H_2O and chlorine dip	151	5.30464b	0.9139b	0.8808ab	1.1457a	1.0993b	0.42384a	0.44371a	0.01987a
Bacillus subtilis dip	110	5.1812bc	0.2636de	0.4182d	0.7364b	0.5364cd	0.16364b	0.16364cb	0.03636a
B cereus dip	140	4.96429de	0.1071e	0.5857cd	0.3571c	0.3214d	0.13571b	0.06429cd	0.02857a
B cereus + chlorine dip	153	6.30065a	0.085e	0.0588e	0.2614c	0.3529d	0.20915b	0.01961d	0.01307a
B cereus + *B subtilis*	118	5.10169cd	0.4831c	0.1780e	1.2203a	1.3559a	0.22034b	0.22034b	0.000a
	960								

VB = Vascular browning, PS = Pulp spot, VBB = Vascular bundle blackening, CD/C = Dothiorella/Colletotrichum fruit rot complex.
Values followed by the same letter do not differ significantly according to Duncan's multiple range test (P=0,001).
Values indicate mean disease severity.
Fruit were evaluated on a 0-10 scale, 0 being healthy and 10 indicating completely affected fruit.
Ripening was evaluated on a 0-10 scale, 0 being overripe, 5 ready to eat, and 10 still hard.

DISCUSSION

Preharvest biocontrol was more effective than the standard copper oxychloride commercial spray programmes, in reducing stem-end rot, anthracnose and Dothiorella/Colletotrichum fruit rot complex throughout the harvesting season. Postharvest biocontrol was also very effective in reducing post-harvest diseases, with the added advantage of being easier to apply and more cost effective. By optimising the application schedules, more effective control was achieved than during the previous season (Korsten. *et al,* 1988). Optimisation, according to Knudsen & Spurr (1987), will ensure that adequate population levels of the antagonists are maintained on foliar surfaces before pathogen arrival, multiplication or infection. Four applications of the antagonists during the fruit development season, were as effective in controlling stem-end rot and Dothiorella/Colletotrichum fruit rot complex as the combination of copper oxychloride and antagonist sprays. In addition, the four antagonist sprays gave sustained control of stem-end rot throughout the harvesting season. According to Blakeman & Fokkema (1982), integration of biological and chemical control could offer an effective solution, especially if the spectrum of activity of the chemical compound is considered with circumspection. The greater the specificity of action of a chemical against the pathogen which it aims to control, the more effective the integrated control system will be. Other fungicides can therefore be evaluated for superior performance in an integrated biocontrol programme.

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