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CONTROL OF AVOCADO PRE-HARVEST DISEASES WITH *BACILLUS SUBTILIS* AND FUNGICIDE SPRAYS

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SUMMARY

Pre-harvest sprays with copper oxychloride and Bacillus subtilis *integrated with copper oxychloride significantly reduced black spot (BS) and sooty blotch (SB) at Omega Estate in 1992. The following year both copper oxychloride and* B. subtilis *on its own reduced the severity of BS at Omega but only the copper oxychloride was effective at Westfalia Estate. In 1993 SB was not monitored at Westfalia Estate due to a very low incidence, while at Omega copper oxychloride sprays significantly increased the disease and the* B. subtilis *treatment was ineffective.*

INTRODUCTION

Black spot (BS) caused by *Pseudocercospora purpurea* (Cke) Deighton (Darvas, 1982) is one of the most important pre-harvest fruit diseases of avocado *(Persea americana* Mill) in South Africa. Successful control of BS has been reported by Kotzé et al. (1982) and Darvas & Kotzé (1987) in the Nelspruit and Tzaneen areas respectively. However, disadvantages such as visible spray residue on harvested fruit (Denner & Kotzé, 1986), build up of pathogen resistance (Darvas & Kotzé, 1987) and growing international concern about environmental pollution have necessitated the search for alternative control measures.

Sooty blotch, so named because of the black epiphytic fungal growth enveloping the fruit is caused by *Akaropeltopsis* Batista & Peres sp. and was first described by Smith et al. (1985). Existing control measures including rinsing fruit in chlorine baths in the packhouse (Bezuidenhout, 1991).

Korsten et al. (1989) reported the successful control of avocado postharvest diseases through the use of pre-harvest bacterial sprays consisting of an antagonistic *Bacillus subtilis* isolate obtained from the avocado phylloplane. Pre-harvest application of *B. subtilis* to control pre-harvest diseases was reported by Thirumaladur & O'Brien (1977) and Baker *et al.* (1985) for charcoal rot in potato and bean rust respectively. More recently, Knudsen & Spurr (1987) effectively controlled *Cercospora aradicola* Hori on groundnuts in the field using mixtures of antagonistic *Bacillus* and *Pseudomonas* spp. In a previous report Korsten *et al.* (1992) showed that preharvest sprays with *B. subtilis* on its own, or integrated with copper oxychloride significantly reduced the severity of BS in

three field experiments. However, control was not as effective when compared with copper oxychloride on its own or with a copper oxychloride/benomyl combination. SB was reduced by *B. subtilis* integrated with copper oxychloride in one experiment only.

This paper presents further evidence on the effect of *B. subtilis* pre-harvest sprays on BS and SB monitored over 2 growing seasons.

TABLE 1. Treatment regimes for pre-harvest *B. subtilus* and copper oxychloride spray applications in 1992 at Omega, Burgershall.

Treatment	Concentration	Treatment date			
		Oct	Nov	Dec	Jan
Control	-	-	-	-	-
Chemical: Copper oxychloride	255 g a.i./100 ℓ	+	+	+	+
Integrated: Copper oxychloride	255 g a.i./100 ℓ	+			
B. subtilis	1 x 10^7 cells/mℓ	-	+	+	+

TABLE 2. Treatment regimes for pre-harvest *B. subtilus* and copper oxychloride spray applications in 1993 at Westfalia and Omega.

Treatment	Concentration	Treatment date			
		Oct	Nov	Dec	Jan
Wesfalia Estate (block 4)					
Control	-	-	-	-	-
Chemical: Copper oxychloride	255 g a.i./100 ℓ	+	+	+	+
Biological: *B. subtilis*	1 x 10^7 cells/m ℓ	+	+	+	+
Omega					
Control	-	-	-	-	-
Chemical: Copper oxychloride	255 g a.i./100 ℓ	+	+	+	+
Biological: *B. subtilis*	1 x 10^7 cells/mℓ	+	+	+	+

MATERIALS AND METHODS

B. subtilis (isolate B246), isolated from the avocado phylloplane and with *in vitro* inhibiting action against various avocado post-harvest pathogens, was cultured, harvested, lyophilised and stored as described previously (Korsten et al., 1988). Experiments were conducted at Waterval (block 4) at Westfalia Estate and at Omega near Burgershall. At each site, 20 mature Fuerte trees were randomly selected and treated as described in Tables 1 & 2. Five single tree replicates were used per treatment, and 100 ℓ of each treatment solution were sprayed with high volume ground sprayers, to full coverage per tree at each application date. Nu-Film 17 (Hygrotech Seed) was added to all treatment solutions at the registered rate of 0,02% (v/v). Fruit were harvested at random from each tree in April 1992 and in June 1993, and disease severity evaluated for BS on a 0-3 scale and for SB on a 0-4 scale as described by Lonsdale (1991). A Kruskal-Wallis transformation of data was performed before data were subjected to analysis of variance and treatment comparisons were made using

Duncan's multiple range test.

RESULTS

In 1992 at Omega BS and SB were significantly reduced by the integrated treatment only (Table 3). The following year, both the chemical and biological treatments significantly reduced BS, while SB remained unaffected by the biological treatment and was significantly increased by the chemical treatment (Table 5).

TABLE 3 Effect of copper oxychloride and/or *B. subtilis* field spray treatments on severity of black spot and sooty blotch at Omega in 1992.

Treatment	No. of fruit evaluated	Disease severity	
		Black spot	Sooty Blotch
Control	50	1,34 a	1,25 a
Chemical (copper oxychloride)	50	1,15 a	1,18 ab
Integrated	50	0,77 b	0,80 b
PR > F		0,0001	0,0001

Means within columns followed by the same letter do not differ significantly (P = 0,05), according to Duncan's multiple range test. Values represent mean disease severity.

TABLE 4 Effect of copper oxychloride and *B. subtilis* field spray treatments on severity of black spot and sooty blotch at Block 4 Westfalia Estate in 1993.

Treatment	No. of fruit evaluated	Disease severity	
		Black spot	Sooty Blotch
Control	50	1,67 a	-
Chemical (copper oxychloride)	50	0.82 bc	-
Biological *(B. subtilis)*	50	1.88 ab	-
PR > F		0,0044	-

Means within columns followed by the same letter do not differ significantly (P = 0,05), according to Duncan's multiple range test. Values represent mean disease severity.

TABLE 5 Effect of copper oxychloride and *B. subtilis* field spray treatments on severity of black spot and sooty blotch at Omega in 1993

Treatment	No. of fruit evaluated	Disease severity	
		Black spot	Sooty Blotch
Control	50	1,73 a	0.70 b
Chemical (copper oxychloride)	50	1.12 b	1.55 a
Biological *(B. subtilis)*	50	0.74 b	0.89 b
PR > F		0,0092	0.0299

Means within columns followed by the same letter do not differ significantly (P = 0,05), according to Duncan's multiple range test. Values represent mean disease severity.

No experiments were conducted at Westfalia Estate in 1992. The following year SB was not monitored due to its very low disease level and BS was significantly reduced only by the chemical treatment. However, the chemical and biological treatments did not differ significantly from each other (Table 4).

DISCUSSION

In a previous study (Korsten et al., 1992) it was demonstrated that biological control significantly reduced BS albeit not as effectively as chemical or the integrated treatments. These findings were partially reinforced in the present study in which BS was significantly reduced at Omega by the integrated treatment in 1992 and by the biological and chemical treatments in 1993. This is therefore the first study in which biological control of BS comparable to control achieved with a fungicide is reported. However, contrary to the previous years' findings only the chemical treatment significantly reduced BS at Westfalia Estate in 1993. In the present study chemical control of SB was not effective. Copper oxychloride sprays significantly increased disease level in one instance and had no effect on the other. Contrary to results obtained previously (Korsten et al., 1992) in which the integrated treatment significantly increased SB, it was the only treatment which significantly reduced SB in the present study. Variation in the effectiveness of biological and chemical treatments has been reported (Tronsmo & Ystaas, 1980; Kotze, Du Toit & Durand, 1982; Dubos, 1984) and can be due to any number of causes.

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