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CHEMICAL CONTROL OF BROWN ROT (SCLEROTINIA FRUCTICOLA) OF STONEFRUITS IN QUEENSLAND

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SUMMARY

During 1969–1972 various fungicides and fungicide schedules were tested at Stanthorpe for the control of brown rot (*Sclerotinia fructocola*) (Wint.) Rehm of stone fruit. Improved brown rot control was obtained in apricots, peaches and nectarines by four applications of benomyl (full bloom, 21 to 28, 7 to 14 and 1 to 3 days before harvest) and also by an increased number of applications of captan, captafol or chlorothalonil during the period from blossoming to harvest.

I. INTRODUCTION

In Queensland, as in New South Wales, Victoria, South Australia and Tasmania, brown rot (*S. fructicola*) is one of the most serious diseases of stone fruit.

Earlier work at Stanthorpe had shown the necessity to apply lime sulphur sprays at fortnightly intervals for a period of 2 to 3 months for brown rot control (Pont 1950). In 1953 thiram was found to be superior to ziram and lime sulphur. In 1954 captan was proved to be more efficient than thiram and ziram and the number of treatments was reduced by amending the schedule to include applications at 28, 14 and 1 to 3 days before harvest (Shea 1961). Blossom blight occurred rarely until this time and Shea considered that control measures were unwarranted. The control programme in Queensland was therefore originally based on the use of preharvest sprays alone whereas control recommendations in other States involved the application of fungicides during the blossoming and preharvest periods. In 1968 benomyl was found superior to captan for brown rot control in peaches (Burden, unpublished report Queensland Department of Primary Industries, 1968).

In the spring of 1968 a blossom blight epidemic occurred in stonefruit at Stanthorpe and following this further field trials were carried out. This paper reports the results of six field trials conducted during the three seasons 1969–1972 inclusive. These trials compared the performances of a number of fungicides at various rates of application using schedules which included applications during the blossoming and preharvest periods.

II. MATERIALS AND METHODS

The following fungicides were used—

Bayer 5191: nickel-(N, N^1-propylene-1, 2-bis(dithiocarbamate)) as a 50% wettable powder.

benomyl: methyl 1-(butylcarbamoyl) benzimidazole-2-ylcarbamate: as a 50% w/w wettable powder, Benlate†.

captafol: N-(1, 1, 2, 2, tetrachloroethylthio)-cyclohexene-4-ene-1, 2-dicarboxyimide: as an 80% w/w wettable powder, Difolatan†.

captan: N(trichloromethylthio) cyclohex-4-ene-1, 2-dicarboxyimide: as an 83% w/w wettable powder, I.C.I. Captan†.

carbendazim‡: methyl benzimidazol-2-ylcarbamate: as a 50% w/w wettable powder, Bavistin†.

chlorothalonil: tetrachloroisophthalonitrile: as a 75% w/w wettable powder, Daconil†.

dichlozoline: 3-(3, 5-dichlorophenyl)-5, 5-dimethyl oxazolidine-dione-2, 4: as a 50% w/w wettable powder, Sclex†.

dithianon: 2, 3 dicyano-1, 4-dihydro-1, 4 dithia-anthraquinone: as a 75% w/w wettable powder, Delan†.

lime sulphur: sulphur as polysulphides: as 20% w/v liquid, A.C.F.-Austral lime sulphur solution.

thiophanate-ethyl: 1,2-di-(3-ethoxycarbonyl-2-thioureido) benzene: as a 50% w/w wettable powder, Topsin†.

thiophanate-methyl: 1,2-di-(3-methoxycarbonyl-2-thioureido) benzene: as a 70% w/w wettable powder, Topsin M†.

thiram: bis(dimethylthiocarbamoyl) disulphide tetramethylthiuram disulphide: as an 80% w/w wettable powder, Thiotox†.

† registered name.
‡ proposed common name.

The cultivars used were—

peach cv. Delicious Starking, maturing late December
peach cv. Elberta, maturing early February
peach cv. Kakamus, maturing late March
apricot cv. Trevatt, maturing late December
nectarine cv. Goldmine, maturing mid January

A randomized block design with four replications was used in each experiment and the plots consisted of a single tree in all cases.

Insecticides such as DDT or fenthion for fruit fly control and vamidothion for green peach aphid control were applied to all plots as required.

The sprays were applied at a pressure of 1 000 to 1 400 kPa using a small motor-powered spray with a hand-operated lance carrying two conical jets. Complete coverage of the tree and fruit was attempted and the sprays were applied until run-off occurred. The trees ranged in height from 3·5 to 5·0 m and each received 4 to 14 litres depending on its size. These spray volumes are equivalent to those applied in commercial high volume sprays of 1 to 3·4 kl/ha in Stanthorpe orchards.

The spray schedules used are given in the tables. In experiments 1 and 2, three blossom sprays were applied in some schedules. However, the petal fall sprays are not listed in Table 1 because they did not contribute to the control of blossom blight. In subsequent experiments blossom sprays were applied at early and/or full bloom.

Preharvest sprays were applied at 14-day intervals with final applications 1 to 3 days before harvest or in some cases 7 days before harvest. Where lengthy schedules were used, involving up to six preharvest applications, spraying began in late September or early October and continued at regular intervals terminating in the near-harvest application.

In experiment 5, rain fell the day before harvest preventing spraying with the fungicidal treatment. As this occurrence is typical of harvest conditions for stonefruit at Stanthorpe, the fruit were harvested on the due date, 28 February 1972, and then immediately dipped in aqueous suspensions of the fungicides (all benzimidazole chemicals) made up at the orchard spray concentrations under test. The fruit were dried before being packed and stored.

Disease incidence in the various experiments was assessed as follows—

Blossom blight was rated on blossom samples (experiments 1 and 2) and on blossom-bearing twig samples (experiment 6) harvested from each plot during late blossoming. The samples were incubated separately under moist, sterile laboratory conditions similar to the method of Ogawa *et. al.* (1968) and the number of infected flowers was recorded.

Twig blight was recorded in the orchard by counting the number of infected twigs in each plot (experiments 1 and 6).

The number of fruit developing brown rot before harvest was recorded in each plot (experiments 1 and 5).

To determine the incidence of postharvest rot, 100 mature fruit were harvested from each plot (all experiments). These were packed loosely in half-bushel volume-fill cases with paper liners and stored in a packing shed at ambient temperatures (15° to 28°C daily). Counts of brown rot arising from primary infections were made daily thereafter for 7 to 21 days and any diseased fruit removed.

III. RESULTS

The data for the various experiments are expressed as percentage blossom blight, number of blighted twigs, and percentage brown rot before and after harvest in Tables 1 to 4.

(a) CONTROL OF BLOSSOM BLIGHT AND TWIG BLIGHT. Blossom blight occurred only in experiments 1, 2 and 6. Twig blight occurred only in experiments 1 and 6.

In experiment 1, both lime sulphur applied at late full bloom and benomyl applied at full bloom or at early and full bloom controlled blossom blight ($P < 0{\cdot}01$, table 1). Captan applied at early and full bloom also controlled blossom blight ($P < 0{\cdot}05$) but was inferior to benomyl or lime sulphur. Similar results were obtained in experiment 2, but the variation was high due to frost damage. Twig blight, in experiment 1, was controlled by three blossom sprays of benomyl or captan or by one blossom spray of lime sulphur or benomyl, ($P < 0{\cdot}01$, table 2).

In experiment 6, benomyl (0·0125 to 0·05% a.i.) applied at full bloom completely controlled blossom blight and twig blight (Tables 1 and 2). Chlorothalonil (0·094%) was less effective than benomyl 4·1% of flowers and 0·8 twigs being blighted per plot. Untreated plots had 13·5% flowers and 8·8 twigs blighted per plot.

The importance of fungicidal application during early blossoming for effective control has been stressed by other workers (Kable 1971; Wicks and Dry 1971). The results presented here show that, at Stanthorpe, the application of benomyl or lime sulphur at full bloom has been just as effective. This may be due to the short period of blossoming experienced in this locality (10 to 100% bloom may occur within 7 days) and also, possibly, because fully opened blossoms present a better spray target than do partially opened blooms.

(b) Fruit Rot Control. Pre-harvest rot developed in experiments 1 and 5 and postharvest rot in all of the five experiments under consideration. The fruit rot figures from these experiments have been summarized in Tables 3 and 4.

In experiment 1, the benomyl treatments and captan (nine sprays) gave the highest degree of control of pre-harvest brown rot ($P < 0{\cdot}01$, Table 3) and captan (nine sprays) was superior to captan (three or five sprays).

Benomyl 0·025% (five sprays) was the only treatment which effectively controlled brown rot ($P < 0{\cdot}05$, Table 4) in experiment 2.

Chlorothalonil 0·094% (seven sprays) and benomyl 0·025% (three sprays) gave best control of postharvest rot of apricots in experiment 3 and chlorothalonil was superior ($P < 0{\cdot}01$, Table 4) to benomyl 0·0125% (three sprays).

Benomyl 0·025% (three sprays) was the best treatment for the control of postharvest rot of nectarines, and was superior ($P < 0{\cdot}01$, Table 4 experiment 4) to chlorothalonil 0·094% (seven sprays), and to lime sulphur 0·17 to 1% (six sprays). The latter treatment was derived from Pont's long schedule recommendation involving the application of 1% lime sulphur 12 weeks before harvest decreasing to 0·17% lime sulphur a fortnight before harvest.

Experiment 5 showed that all the benzimidazole fungicides controlled preharvest (Table 3) and postharvest (Table 5) brown rot of peaches. In all cases, a schedule using three sprays and an immediate post-harvest dip gave a degree of control equivalent to that obtained with five sprays and a post-harvest dip of benomyl.

In experiment 6, benomyl treatments used at concentrations ranging from 0·0125% to 0·05% (Table 4), when applied on identical schedules, did not differ significantly in the amount of postharvest brown rot which developed on apricots. All benomyl treatments were, however, significantly better than chlorothalonil used on the same schedule ($P < 0{\cdot}01$, Table 4).

It is apparent from these results that benomyl will give improved brown rot control in peaches, nectarines and apricots. Carbendazim, thiophanate-methyl and dichlozoline, which are also benzimidazole fungicides, were as effective as benomyl for the control of peach brown rot and may be expected to control this disease in other stonefruits with equal efficiency. The protectant fungicides captan, captafol and chlorothalonil were also found to be of value for the control of brown rot of apricots and nectarines although they must be applied more frequently. This agrees with the result which Chandler (1968) obtained with captan on peaches.

In the work described here it was found that the concentation of benomyl need not exceed 0·0125% a.i. for the control of brown rot of apricots (maturing mid December). Benomyl at a concentration of 0·025% a.i. gave excellent control of brown rot in peaches (maturing late February). However, the same concentration of benomyl did not give the same degree of control of brown rot in one trial on nectarines maturing mid January or in another trial on peaches maturing late January but previously damaged by frost in September.

IV. CONCLUSIONS

Benomyl has proved an outstanding fungicide for the control of brown rot of stonefruit and has become the basis of a recommendation for improved control measures for this disease in the Stanthorpe district (Heaton 1972). The earlier recommendation of captan (Shea 1961) can be retained for early maturing stonefruit provided that blossom sprays are applied. Captafol can be substituted for captan if desired. A low rate of benomyl (0·0125%) may be used on apricots. The use of these less costly protectant fungicides on early maturing peaches and nectarines, and the use of a low rate of benomyl on apricots, have an economic advantage to growers.

TABLE 1

PERCENTAGE OF BLOSSOM BLIGHT IN PEACHES AND APRICOTS FOLLOWING VARIOUS FUNGICIDAL TREATMENTS

Treatment (% a.i.)	Spray Schedule*	Percentage Blossom Blight		
		Experiment 1 Peach cv. Starking Delicious	Experiment 2 Peach cv. Elberta	Experiment 6‡ Apricot cv. Trevatt
Benomyl 0·05% ..	F.B.			0·00
Benomyl 0·0375% ..	F.B.			0·00
Benomyl 0·025% ..	F.B.	0·43† a x	0·00† a	0·00
Benomyl 0·025% ..	E.B., F.B.	0·15 a x	0·06 a	
Benomyl 0·0125% ..	F.B.			0·00
Captan 0·1%	E.B.	11·32 b yz	4·31 b	
Captan 0·1%	F.B.	10·89 b yz	0·51 a	
Captan 0·1%	E.B., F.B.	8·62 b y	0·89 a	
Chlorothalonil 0·094%	F.B.			4·10
Lime sulphur 1·0% ..	L.F.B.	1·36 a x	0·06 a	
Untreated		18·02 b z	6·92 b	13·50

* E.B, (early bloom, 10%–50% petals open), F.B. (full bloom, 100% petals open), L.F.B. (late full bloom, 10% petals fallen).

† Inverse sine transformation used for analysis of variance. Treatment data followed by the same letter(s) a and b do not differ at P= 0·01 or by the same letter(s) x, y and z do not differ at P = 0·05.

‡ Not statistically analysed because of zero values.

TABLE 2

NUMBER OF BLIGHTED TWIGS IN PEACHES AND APRICOTS FOLLOWING VARIOUS FUNGICIDAL TREATMENTS

Treatment (% a.i.)	Spray Schedule*	Number of Blighted Twigs	
		Experiment 1 Peach cv. Starking Delicious	Experiment 6‡ Apricot cv. Trevatt
Benomyl 0·05%	1B.+1P.H.		0·00
Benomyl 0·0375%	1B.+1P.H.		0·00
Benomyl 0·025%	3P.H.	8·32† b	
Benomyl 0·025%	2P.H.	9·05 b	
Benomyl 0·025%	1B.+1P.H.		0·00
Benomyl 0·025%	1B.+2P.H.	0·20 a	
Benomyl 0·025%	3B.+2P.H.	0·00 a	
Benomyl 0·0125%	1B.+1P.H.		0·00
Captan 0·1%	1B.+2P.H.	3·82 ab	
Captan 0·1%	3P.H.	6·24 ab	
Captan 0·1%	3B.+6P.H.	0·50 a	
Captan 0·1%	3B.+2P.H.	2·61 a	
Chlorothalonil 0·094%	1B.+1P.H.		0·80
Lime sulphur 1%	1B.+1P.H.	1·24 a	
Untreated		9·04 b	8·80

* Number of bloom (B.) and preharvest (P.H.) sprays.

† $\sqrt{x + \frac{1}{2}}$ transformation used for analysis of variance. Treatment data followed by the same letter(s) do not differ at P= 0·01.

‡ Not statistically analysed because of zero values.

TABLE 3

PERCENTAGE OF BROWN ROT IN PEACHES BEFORE HARVEST FOLLOWING VARIOUS FUNGICIDAL TREATMENTS

Treatment	Spray Schedule*	Percentage Brown Rot of Fruit	
		Experiment 1 cv. Starking Delicious	Experiment 5 cv. Kakamus
Captan 0·1%	3B.+6P.H.	0·54† a	
Benomyl 0·025%	3B.+2P.H.	0·58 a	
Benomyl 0·025%	1B.+2P.H.	0·64 a	2·48 a
Lime sulphur 1%	1B.+1P.H.	6·56 b	
Captan 0·1%	3B.+2P.H.	11·48 bc	
Captan 0·1%	1B.+2P.H.	16·93 c	
Benomyl 0·025%	3P.H.	18·65 c	
Benomyl 0·025%	2P.H.	19·58 c	
Captan 0·1%	3P.H.	21·34 c	
Carbendazim 0·025%	1B.+2P.H.		1·52 a
Benomyl 0·025%	2B.+2P.H.		1·53 a
Thiophanate-methyl 0·07%	1B.+2P.H.		1·76 a
Dichlozoline 0·05%	1B.+2P.H.		1·82 a
Untreated		27·08 c	21·60 b

* Number of bloom (B.) and preharvest (P.H.) sprays.

† Inverse sine transformation used for analysis of variance. Treatment data followed by the same letter(s) do not differ at P = 0·01.

TABLE 4

PERCENTAGE OF BROWN ROT IN PEACHES, APRICOTS AND NECTARINES AFTER HARVEST FOLLOWING VARIOUS FUNGICIDAL TREATMENTS

Treatment (% a.i.)	Spray Schedule *	Percentage Brown Rot of Fruit					
		Experiment 1 Peach cv. Starking Delicious	Experiment 2 Peach cv. Elberta	Experiment 3 Apricot cv. Trevatt	Experiment 4 Nectarine cv. Goldmine	Experiment 5 Peach cv. Kakamus	Experiment 6 Apricot cv. Trevatt
Benomyl 0·05%	1B.+1A.H.+2P.H.						2·94 a
Benomyl 0·0375%	1B.+1A.H.+2P.H.						1·66 a
Benomyl 0·025%	1B.+1A.H.+2P.H.						3·96 a
Benomyl 0·025%	1B.+2P.H.+P.H.D.					1·80 a	
Benomyl 0·025%	2B.+3P.H.+P.H.D.					0·19 a	
Benomyl 0·025%	2P.H.	41·60†bc	47·05 y				
Benomyl 0·025%	3P.H.	14·21 a	23·76 xy				
Benomyl 0·025%	1B.+2P.H.	12·33 a	39·12 xy	3·29 ab	24·30 a		
Benomyl 0·025%	3B.+2P.H.	7·02 a	10·62 x				
Benomyl 0·125%	1B.+2P.H.			26·44 bc	32·18 ab		
Benomyl 0·0125%	1B.+1A.H.+2P.H.						7·29 a
Captafol 0·1%	2B.+5P.H.			11·54 abc			
Captan 0·1%	3B.+6P.H.	17·06 ab	34·85 xy				
Captan 0·1%	3B.+2P.H.	42·27 bc	27·15 xy				
Captan 0·1%	1B.+2P.H.	66·76 c	21·92 xy				
Captan 0·1%	2B.+5P.H.				43·25 ab		
Captan 0·1%	3P.H.	68·67 c	17·06 xy				
Carbendazim 0·025%	1B.+2P.H.+P.H.D.					2·96 a	
Chlorothalonil 0·094%	2B.+5P.H.			0·32 a	57·79 b		
Chlorothalonil 0·094%	1B.+1A.H.+2P.H.						24·23 b
Dichlozoline 0·05%	1B.+2P.H.+P.H.D.					0·33 a	
Dithianon 0·075%+Bayer 5191 0·0375%	2B.+5P.H.				47·82 ab		
Lime sulphur 1%	1B.+1P.H.	70·58 c	16·40 xy				
Lime sulphur 0·17–1%	Long schedule (Pont, 1950)				58·63 b		
Thiophanate-ethyl 0·05%	2B.+5P.H.			14·26 abc	41·70 ab		
Thiophanate-methyl 0·07%	1B.+2P.H.+P.H.D.					0·54 a	
Thiram 0·12%	2B.+5P.H.			18·74 bc			
Untreated		93·43 d	47·30 y	50·36 c	88·55 c	71·00 b	71·02 c

* Number of bloom (B.), preharvest (P.H.), after hail (A.H.) sprays, and postharvest dip (P.H.D.).

† Inverse sine transformation used for analysis of variance. Treatment data followed by the same letter(s) a, b, c, and d do not differ at $P = 0{\cdot}01$ or by the same letters x and y do not differ at $P = 0{\cdot}05$.

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