THE CONTROL OF STRAWBERRY FRUIT ROT IN COASTAL BRITISH COLUMBIA

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Abstract

In a 2-year study several fungicides, including organic and inorganic compounds along with calcium and boron additives, were tested for control of gray-mold fruit rot of strawberries. Folpet, captan and thiram proved the most effective of the materials tested. In the first fruiting year marketable yields were increased by 96 to 119 per cent over the untreated plants by a spray schedule consisting of four sprays at approximately 10-day intervals beginning at first bloom. A single application of captan at full bloom resulted in only 37 per cent increase in sound fruit. In the second fruiting year yields in sprayed plots were increased by only 48 to 62 per cent even though the spray schedule continued through harvest. It is suggested that this apparent decrease in response was the result of an improved sanitary condition in the plot area. The addition of calcium chloride to the captan schedule appeared to have no beneficial effect, while the addition of boron resulted in a significant reduction in yield. The holding quality of the fruit was improved by the field sprays of folpet, thiram and captan. Fruit quality was affected slightly by captan, which reduced the sugar and total acid content of the fruit. Boron sprays tended to increase ascorbic acid content while calcium chloride decreased it. Polyram 80 (zinc activated poly (ethylene thiuram disulphide)) reduced ascorbic acid content.

Introduction

Gray mold of strawberries, caused by *Botrytis cinerea* (Pers.) Fr., causes a serious fruit rot most years in coastal British Columbia. The current control program is based upon protecting the blossom parts through the bloom period, the recommendation being that strawberries should be sprayed or dusted with captan at least three times, starting when the first blossoms emerge. This recommendation was based primarily on work conducted at Oregon State University (7,9). There has been no local investigation within recent years on the control of this fungus and, therefore, no factual evidence with which to convince the grower that the currently recommended control measures are necessary or even effective. Thus an experiment was started in 1962 to obtain information on the effectiveness of several fungicides including organic and inorganic compounds, along with boron and calcium additives, for the control of strawberry fruit rot. This paper reports the results obtained in the 2-year study.

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Methods

Siletz strawberries were planted in a Lynden silt loam at the Small Fruits Substation, Abbotsford, British Columbia in 1961. The experiment was laid out in a randomized block design with four replications. Each plot consisted of a single 50-foot row. The plants were grown by the matted row system and good grower practices were followed in establishing the plantation. The planting was sprinkler-irrigated when necessary. In the spring of 1962 the entire planting was cleaned up by removing the old dead leaves and cultivating lightly. A lime-sulphur spray, 1½ gal/100 gal was applied March 22 to all plots. On May 7 the planting received an application of 6-30-15 fertilizer at 500 pounds per acre.

1962 Trial

Treatments were applied as outlined in Table 1. The nickel chloride 10 and 30 lb/a and the mixture of nickel chloride 10 pounds plus potassium chloride 200 lb/a were applied with the fertilizer on May 7.

Control of pre-harvest infection was determined by weighing all infected berries from each plot at each picking. The 1962 crop was picked on July 5, 12, 19 and 25. In addition to weighing the infected fruit, the weights of marketable and cull fruit were also recorded. The size index of sound berries from each plot was determined at each picking. The effect of treatment on post-harvest fruit rot was determined from a random sample of one pound of sound berries picked on July 5 from each plot in each replicate. The berries were stored in shipping crates in a common storage shed and the percentage of sound berries was determined at 24, 48, and 90 hours after harvest.

1963 Trial

Folpet, captan and thiram were again tested in 1963, but instead of discontinuing the sprays a week before harvest, as in 1962, the treatments were continued through the picking period. Polyram 80 (zinc activated poly (ethylene thiuram disulphide)) 2 lb/a and copper 53 at 6 lb/a were added to the test. Since the variety Siletz is a relatively soft-fruited variety, boron and calcium were tested with the object of increasing the firmness of the fruit. Boron was applied as a fertilizer (Tronobar (14% boron) 35 lb/a) and as a spray (Solubor (20.5% boron) 2.5 and 25 lb/a) on May 3. Calcium was applied as a 0.4% calcium chloride spray on May 15, 24, 27 and 31 during bloom. Boron and calcium sprays were also combined with a full captan schedule. The complete spray schedules are listed in Table 3.

The 1963 crop was picked on June 17, 25, July 4 and 10. Data were recorded as in 1962 with the refinement that the effect of treatment on the post-harvest fruit rot was determined from the complete crop and not just a random sample of one picking. The percentage of sound berries was determined at 24, 48 and 72 hours after harvest.

Fruit Quality

Samples of fruit were quick-frozen and later analyzed in the laboratory for acidity, sugar and ascorbic acid as a measure of quality.

Results and Discussion

Of the 1962 treatments the folpet and thiram spray schedules gave the best control of gray mold as reflected in the increase in yield of sound fruit (Table 1). However, the results obtained from the lime-sulphur plus captan and the captan schedules were not significantly different from those obtained by the folpet and thiram schedules. The increased marketable yield for these four spray schedules ranged from 96 to 119 per cent over the unsprayed plots. This result is in agreement with Horn (3) who reported no significant difference between thiram, folpet and captan in rot control.

The single application of captan at full bloom resulted in only 37 per cent increase of sound fruit over the unsprayed plot. The additional three captan sprays resulted in a further 59 per cent increase in sound fruit. Thus, evidence is provided supporting the desirability of the full spray schedule. The fungicides dichlone, Dyrene and N-3684 (di-n-butyltin dimesylate) did not appear to be of sufficient efficacy to be considered further. The inorganic salts were but little better than no treatment.

Fruit size was affected by treatment; the trend was for fruit to be larger from plots treated with the more efficient fungicides. This result is in accord with findings of Powell (6) who reported that strawberry plants had benefitted nutritionally from captan and that fruit size was increased.

The data on post-harvest control of fruit rot show that there was little effect of treatment in the first 24 hours of storage (Table 2). The value of the folpet, thiram and captan spray schedules was, however, evident after 48 hours storage. The beneficial effect was still evident after 90 hours storage. Powelson (7) found that three pre-harvest applications of captan reduced rot incidence in the field, and also the amount of latent infection of marketable fruit. Powell (6) also reported that captan delayed the development of post-harvest rot.

The 1963 results again showed that folpet, captan and thiram were the most effective fungicides for fruit rot control (Table 3). There was not as great a difference in marketable fruit yields between treated and untreated plots as in 1962. It is well known that the severity of gray mold infection varies greatly with seasonal conditions. However, the weather pattern was not too different for the two years of this experiment and sprinkler irrigation was applied only as required. It is suggested, therefore, that much of the reduction in fruit rot in the second year can be attributed to an improved sanitary condition in the plot area as a result of the previous year's spray applications and the fact that all diseased berries were removed at each picking. It would be expected that the source of inoculum would be reduced significantly by such practices. Miller and Waggoner (5) on studying the dispersal of spores of *Botrytis cinerea* among strawberries reported that most spores were caught in periods of high humidity, regardless of rain or time of day. Only occasional spores were caught under other conditions. They suggested that most infections by *B. cinerea* originate from nearby primary inoculum and that microclimate afforded by dense strawberry foliage is more important than environmental conditions above the plants in determining incidence of

Table 1. Influence of various treatments on pre-harvest fruit rot of Siletz strawberries - 1962

Treatment (active ingredient) (sprays in 100 gal. water)	Dates of Application*	Rotted fruit	Sound fruit (mkt. yield)	Increase over unsprayed	Size index
		lb/plot	lb/plot	%	gm/25 fruit
Folpet 2½ lb/a	May 16,29, June 11,19	13.6 a	53.9 a	119	210 a
Thiram 2 lb/a	May 16,29, June 11,19	19.0 b	53.9 a	119	198 ab
Lime-sulphur 1½ gal + captan 1½ lb/a	May 16 May 29, June 11,19	22.0 bc	50.5 ab	104	197 ab
Captan 1½ lb/a	May 16,29, June 11,19	21.0 bc	48.1 ab	96	206 a
Dichlone ½ lb/a	May 7,29, June 11,19 July 10	19.9 bc	45.9 b	85	193 abc
Dyrene 1½ lb/a	May 16,29, June 11,19	20.9 bc	43.9 b	78	195 abc
Captan 1½ lb/a	May 29	28.3 e	33.8 c	37	192 abc
Nickel chloride 30 lb/a	May 7	29.6 e	29.6 cd	19	181 bc
N-3684 (di-n-butyltin-dimesylate) 2 lb/a	May 16,29, June 11,19	23.6 cd	27.4 cd	11	186 bc
Nickel sulphate 2 lb/a (spray)	May 7,29, June 11,19	24.0 cd	26.6 d	7	179 bc
Nickel chloride 10 lb + potassium chloride 200 lb/a	May 7	27.5 de	26.2 d	7	182 bc
Nickel chloride 10 lb/a	May 7	26.9 de	25.8 d	4	181 bc
Unsprayed	-	28.3 e	24.3 d	0	177 c
Mean		23.43	37.68		190.6
S.E. Mean		1.26	2.23		5.75

Means not followed by the same letter are significantly different at the 5% level. (Duncan's Multiple Range test)

*May 16 - first floom, May 29 - full bloom, June 11 - after full bloom, June 19 - last spray before harvest. (first fruit ripe June 27)

Table 2. Influence of various pre-harvest treatment schedules on the post-harvest fruit rot of Siletz strawberries - 1962

Treatment (active ingredient) (sprays in 100 gal. water)	Dates of Application*	Percent sound fruit hours after picking		
		24	48	90
Folpet 2½ lb/a	May 16,29, June 11,19	88	70	9
Thiram 2 lb/a	May 16,29, June 11,19	91	62	11
Lime-sulphur 1½ gal/100 gal. + captan 1½ lb/a	May 16 May 29, June 11,19	79	67	8
Captan 1½ lb/a	May 16,29, June 11,19	74	72	8
Dichlone ½ lb/a	May 7,29, June 11,19, July 10	81	42	2
Dyrene 1½ lb/a	May 16,29, June 11,19	90	63	2
Captan 1½ lb/a	May 29	-	-	-
Nickel chloride 30 lb/a	May 7	78	29	2
N-3684 (di-n-butyltin dimesylate) 2 lb/a	May 16,29, June 11,19	83	24	1
Nickel sulphate 2 lb/a (spray)	May 7,29, June 11,19	74	27	0
Nickel chloride 10 lb + potassium chloride 200 lb/a	May 7	75	25	0
Nickel chloride 10 lb/a	May 7	80	25	0
Unsprayed	-	74	15	0

*See footnote Table 1

Table 3. Influence of various treatment schedules of pre-harvest fruit rot of Siletz strawberries - 1963

Treatment (active ingredient) (Sprays in 100 gal. water)	Dates of Application*	Rotted fruit lb./plot	Sound Fruit (Mkt. Yield) lb./plot	Percent Increase over unsprayed	Size Index gm/25 fruit
Folpet 2½ lb/a	May 15,24,31, June 7,14,21,29, July 5	10.8 a	67.4 a	62	256 a
Captan 1½ lb/a	May 15,24,31, June 7,14,21,29, July 5	9.9 a	62.9 a	51	252 a
Thiram 1½ lb/a	May 15,24,31, June 7,14,21,29, July 5	8.8 a	61.6 ab	48	261 a
Calcium chloride 0.4% + captan 1½ lb/a	Calcium chloride May 15,24,27,31, captan as above	10.8 a	60.5 ab	45	244 a
Boron spray ½ lb + captan 1½ lb/a	Boron May 3, captan as above	9.5 a	54.3 bc	30	253 a
Boron spray 5 lb/a + captan 1½ lb/a	Boron May 3, captan as above	8.7 a	50.4 cd	21	247 a
Polyram 80W 2 lb/a	May 15,24,31, June 7,14	19.8 bc	45.3 de	9	238 a
Copper 53 6 lb/a	May 15,24,31, June 7,14,21,29, July 5	18.5 b	42.2 ef	1	238 a
Unsprayed	——	22.9 bc	41.7 ef	0	238 a
Calcium chloride 0.4%	May 15,24,27,31	20.7 bc	40.6 ef	0	241 a
Boron fertilizer 5 lb/a	May 3	23.1 c	38.2 ef	0	243 a
Boron spray 5 lb/a	May 3	23.0 bc	35.6 f	0	239 a
Mean		15.55	50.6	-	245.7
S.E. Mean		1.90	2.69		6.44

Means not followed by the same letter are significantly different at the 5% level. (Duncan's Multiple Range test).

*May 15 first bloom, May 24-31 full bloom, June 17 first picking.

Table 4. Influence of various pre-harvest treatment schedules on the post-harvest fruit rot of Siletz strawberries - 1963

Treatment (active ingredient) (sprays in 100 gal. water)	Dates of Application*	Percent sound fruit hours after picking (means of 4 harvests) 24	48	72
Folpet 2½ lb/a	May 15,24,31, June 7, 14,21,29, July 5	97	77	48
Captan 1½ lb/a	May 15,24,31, June 7,14,21,29, July 5	96	67	45
Thiram 1½ lb/a	May 15,24,31, June 7,14,21,29, July 5	95	87	54
Calcium chloride 0.4% + captan 1½ lb/a	Calcium chloride May 15,24,27,31; captan as above	96	77	48
Boron spray ½ lb/a + captan 1½ lb/a	Boron May 3, captan as above	96	79	45
Boron spray 5 lb + captan 1½ lb/a	Boron May 3, captan as above	97	76	42
Polyram 80W 2 lb/a	May 15,24,31, June 7,14	91	56	15
Copper 53 6 lb/a	May 15,24,31, June 7,14,21,29, July 5	92	37	8
Unsprayed	—	91	52	10
Calcium chloride 0.4%	May 15,24,27,31	92	50	13
Boron fertilizer 5 lb/a	May 3	92	45	8
Boron spray 5 lb/a	May 3	93	47	6

*May 15 - first bloom, May 24 - 31 full bloom, first picking June 17.

Table 5. Influence of various treatment schedules on total acid, sugar and ascorbic acid content of Siletz strawberries - 1963

Treatment/a*	Total Acidity (% citric)	Treatment/a*	Sugar (%)	Treatment/a*	Ascorbic acid (mg./100 gm)
Polyram 80W 2 lb	.95 a	Boron spray 5 lb	8.31 a	Boron spray 5 lb	35.63 a
Copper 53 6 lb	.95 a	Calcium chloride 0.4%	8.27 ab	Unsprayed	34.12 ab
Thiram 1½ lb	.94 a	Polyram 80W 2 lb	8.20 ab	Boron spray 5 lb + captan	34.02 ab
Boron fertilizer 5 lb	.94 a	Copper 53 6 lb	8.20 ab	Boron spray ½ lb + captan	33.96 ab
Calcium chloride 0.4%	.94 a	Thiram 1½ lb	8.18 ab	Thiram 1½ lb	33.27 abc
Folpet 1½ lb	.93 ab	Boron fertilizer 5 lb	8.18 ab	Boron fertilizer 5 lb	32.95 abc
Boron spray 5 lb	.93 ab	Unsprayed	8.13 ab	Folpet 1½ lb	31.85 bcd
Calcium chloride + captan	.93 ab	Folpet 1½ lb	8.12 ab	Copper 53 6 lb	31.72 bcd
Unsprayed	.92 ab	Boron spray 5 lb + captan	8.09 ab	Captan 1½ lb	31.42 bcd
Captan 1½ lb	.92 ab	Calcium chloride + captan	8.05 ab	Calcium chloride .04%	31.19 bcd
Boron spray ½ lb + captan	.90 b	Captan 1½ lb	7.99 ab	Polyram 80W 2 lb	30.98 cd
Boron spray 5 lb + captan	.90 b	Boron spray ½ lb + captan	7.89 b	Calcium chloride + captan	29.84 d
Mean	.93		8.14		32.58
S.E. Mean	.01		0.12		0.88

Means not followed by the same letter are significantly different at the 5% level (Duncan's Multiple Range Test).

*Treatment schedules as Tables 3 and 4

gray mold. Jarvis (4) states that the primary aim in control must be the eradication of the over-wintering stages of the pathogen and the reduction in potential sites for saprophytic colonization at the time of flowering and fruit development. He further states that good plantation hygiene is therefore of great importance, and must include attention to many details such as weed control and the removal of strawberry debris. There would appear to be no advantage to lengthening the spray schedule by spraying during harvest. Yields of sound fruit from plots treated with Polyram 80 (zinc activated poly (ethylene thiuram disulphide)) at 2 lb/a were not different from the untreated plots. Stall (8) found *Botrytis* more prevalent on tomato plants sprayed with zinc sulfate or nabam-zinc sulfate than on unsprayed plants. Cox and Winfree (1) found the same effect with gray mold on strawberries and suggested that an excess of zinc in the plant tissue might increase susceptibility to the disease.

The addition of calcium chloride to the captan schedule appeared to have no beneficial effect, while the addition of boron resulted in a yield reduction. These treatments had no apparent effect upon fruit firmness. Eaves and Leefe (2) reported that highly significant increases in firmness of Sparkle strawberries were associated with calcium sprays.

Fruit quality was affected to some extent by the treatments. Captan tended to reduce the sugar and acid content of the fruit (Table 5). Boron sprays tended to increase ascorbic acid content while calcium chloride caused a reduction. Of the fungicides only Polyram caused a significant reduction in the ascorbic acid content. The holding quality of the fruit was proved again in 1963 by the field sprays (Table 4).

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