A COMPARISON OF BENOMYL, THIOPHANATE-METHYL, AND CAPTAN FOR CONTROL OF STRAWBERRY FRUIT ROT[1]

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Abstract

Benomyl, thiophanate-methyl, and captan were tested in a 2-year trial to control gray mold fruit rot caused by Botrytis cinerea on the strawberry cultivars Cavalier and Redcoat. All treatments increased mean marketable yields and there was little difference among fungicides in the control of fruit rot. The maximum biological effectiveness of benomyl and thiophanate-methyl was attained with 1.68 kg/ha and 2.35 kg/ha, respectively, in 3 sprays.

Résumé

Au cours d'une experience de deux ans, on a étudié le comportement du benomyl, du methyl-thiophanate et du captane contre la moisissure grise produite par Botrytis cinerea, sur des cultivars de fraises Cavalier et Redcoat. Tous les traitements ont augmenté les rendements commercialisables moyens et on n'a constaté que peu de difference d'efficacité entre ces fongicides. L'efficacité biologique maximale du benomyl et du methyl-thiophanate a été obtenue aux doses de 1.68 kg/ha et 2.35 kg/ha respectivement, en trois pulvérisations.

The successful commercial production of strawberries necessitates a chemical control of gray mold fruit rot caused by Botrytis cinerea Pers. Infections occur mostly through the blossoms and latent infections often become established in the fruit (Jarvis 1962, Powelson 1960). Careful attention to methods and timing of fungicide spray applications improved the control of fruit rot (Bedard and Lechance 1970, Bennett 1972). strawberry cultivars may differ in their reaction to fungicides and those chemicals that give good control of fruit rot may not always increase the yield of marketable fruit (F'reeman 1966; Gourley 1963, 1968; Moore et al. 1965). Recently fungicides possessing systemic biological effectiveness have been evaluated as controls for strawberry fruit rot (Baltovski 1971; Bennett 1972; Borecka, Borecki and Millikan 1973; Branas 1971; Freeman and Pepin 1967, 1968; Garofalo 1971; Muller 1971; Tapio 1972).

The effects of benomyl, thiophanate-methyl, and captan were studied on Cavalier and Redcoat, two commercially important cultivars in eastern Canada. The results of a 2-year experiment of the efficacy and rate of application of these fungicides for the control of fruit rot are reported in this paper.

Materials and methods

The experimental design was a four-replicate, randomized-block split plot, with five fungicide treatments and a control as the main plots and two strawberry cultivars as the subplots, After harvest of the first fruiting year the plots were renovated by reducing the width of the matted rows from about 0.9 m to approximately 0.5 m with a rototiller.

The fungicide treatments were applied to the same plots in both years. The fungicides (active ingredient) and rate/2.25 kl of water per hectare and number of applications were as follows:

Fungicide	Proprietary product	Number of applications
Benomyl, 560.4 g	Benlate 50W	3
Thiophanate-methyl, 784.6 g	Cercobin-M 70W	3
Benomyl, 560.4 g	Benlate 50W	4
Thiophanate-methyl, 784.6 g	Cercobin-M 70W	4
Captan, 3362.5 g	Captan 50W	4
Control - unsprayed		

A blanket application of endosulfan (Thiodan 4 EC) at the rate 0.5 liter in 100 liter water was applied against insects at

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early bloom and again 1 week later. The first fungicide sprays were applied in both years on 20 May at which time a few blossoms had opened. On plots receiving three and four applications, sprays were applied at 12- and 10-day intervals, respectively, in each of the 2 years.

There were seven pickings in 1972 and six in 1973, beginning on 28 June and 27 June, respectively. Yields were recorded by weight and converted to metric tons/ha on the basis that each fruiting bed covered an area of 5.57 m^2. All fruit, including rotten berries, were harvested from each cultivar in each plot. The weight of sound fruit was recorded as marketable yield and that of infected fruit as preharvest fruit rot.

The effect of fungicide treatment on fruit size was determined at each picking by weighing 25 sound fruit from each cultivar in each plot.

greatest yields occurred with three sprays of benomyl or thiophanate-methyl, but these yields were not significantly greater than those from plots which received four applications of these same fungicides. In England, Bennett (1972) concluded that benomyl at 1.68 kg a.i./ha/season in 3 or 4 applications gave satisfactory control of fruit rot in Cambridge Favourite strawberries. Here the maximum biological effectiveness of benomyl and thiophanate-methyl was reached with 3 sprays of the fungicides.

All fungicides significantly reduced the amount of fruit rot and there were no differences among fungicides (Table 2). In 1973 the amount of fruit rot was Significantly greater than in 1972 only on unsprayed plots of cavalier.

Table 1. Marketable yields in metric tons/ha

Fungicide and number of applications	Cavalier			Redcoat		
	1972	1973	Mean *	1972	1973	Mean
Benomyl (3)	14.4	22.3	18.4 a	17.4	21.5	19.5 a
Thiophanate-methyl (3)	13.9	21.1	17.5 ab	16.5	22.3	19.4 a
Benomyl (4)	13.1	19.4	16.2 ab	16.5	20.1	18.4 a
Thiophanate-methyl (4)	13.9	20.3	17.1 ab	16.8	20.3	18.6 a
Captan (4)	12.2	18.1	15.2 b	15.0	19.5	1.7.3 a
Control	8.3	11.6	9.9 c	13.3	14.2	1.3.7 b
L.S.D. years (P .01)	5.5			4.4		
(P .05)	3.9			3.1		

* Figures followed by the same letter do not differ significantly at the 5% level (Duncan's Multiple Range Test).

Results and discussion

All fungicide treatments significantly increased the mean marketable yields of Cavalier and Redcoat (Table 1). A significant difference between fungicide treatments occured only on Cavalier where plots that had received three applications of benomyl produced greater marketable yields than plots sprayed with captan. In 1973 yields of Cavalier were significantly greater than those in 1972 for all treatments, whereas yields of Redcoat were significantly greater in the second year than in the first year only for those treatments which received captan or three sprays of benomyl or thiophanate-methyl. For both cultivars the

Strawberry cultivars differ greatly in their susceptibility to fruit rot (Daubeny and Pepin 1973). In a trial conducted at Vineland Station, Ontario, for susceptibility to botrytis fruit rot, the cultivar Redcoat was rated 8 in a numerical range where 0 = resistant to 5 = very susceptible (C. L. Ricketson, unpublished data). In 1972 at Kentville, Redcoat had more Botrytis infection on blossoms and peduncles than any of the other 13 cultivars and selections examined (D. L. Craig, unpublished data). In this experiment the difference in yield between treated and non-treated plots may have been due partly to the loss of blossoms and peduncles prior to harvest.

Fungicides significantly increased the mean fruit size on Redcoat but not on Cavalier (Table 3). On Redcoat the mean weiqht of 25 fruit for three sprays of benomyl was significantly greater than that for four sprays of the same fungicide. Fruit size of both cultivars was significantly greater in the first than in the second crop year for all treatments which may have been the result of a heavier set of fruit the second year.

In England benomyl was phytotoxic to calyxes of Cambridge Favourite strawberries, and the amount of malformed fruit on Royal Sovereign was related to the dosage of fungicide applied per ha per season (Bennett 1969, 1972). In this experiment there was no visible evidence of phytotoxicity from any of the fungicides on either Cavalier or Redcoat. The maximum biological effectiveness of benomyl and thiophanate-methyl was attained with 1.68 kg and 2.35 kg, respectively, of fungicide was applied per ha per season. When a greater dosage of either fungicide was used yields were reduced and, although this effect was not significant, it was greatest in the second crop year for both cultivars.

Strains of B. cinerea have evolved which are tolerant of all benzimidazole compounds including benomyl and thiophanate-methyl (Norman 1973, Watson and Koons 1973). Also with these compounds there appears to be less decay of debris in plant rows (Norman 1973)

Table 2. Pre-harvest fruit rot in metric tons/ha

Fungicide and number of applications	Cavalier			Redcoat		
	1972	1973	Mean *	1972	1973	Mean
Benomyl (3)	1.8	2.1	2.0 a	1.5	2.1	1.8 a
Thiophanate-methyl (3)	2.6	2.6	2.6 a	1.8	1.8	1.8 a
Benomyl (4)	2.5	3.0	2.8 a	1.4	2.0	1.7 a
Thiophanate-methyl (4)	2.8	3.0	2.9 a	1.6	2.2	1.9 a
Captan (4)	1.9	2.2	2.0 a	1.8	2.3	2.0 a
Control	3.2	5.5	4.4 b	2.7	3.7	3.2 b
L.S.D. years (P .01)	1.7			NS		
(P .05)	1.2			1.02		

* Figures followed by the same letter do not differ significantly at the 5% level (Duncan's Multiple Range Test).

Table 3. Weight in grams of 25 ripe strawberry fruit

Fungicide and number of applications	Cavalier			Redcoat		
	1972	1973	Mean *	1972	1973	Mean
Benomyl (3)	214	194	204 a	255	212	233 a
Thiophanate-methyl (3)	214	204	209 a	242	214	228 ab
Benomyl (4)	221	196	208 a	239	210	224 b
Thiophanate-methyl (4)	227	195	211 a	243	217	230 ab
Captan (4)	208	191	199 a	245	215	230 ab
Control	212	202	207 a	231	196	214 c
L.S.D. years (P .01)	11			14		
(P .05)	8					

* Figures followed by the same letter do not differ significantly at the 5% level (Duncan's Multiple Range Test).

which creates a potential for massive production of inoculum. In this experiment there was a potential for greater inoculum production in the spring of the second crop year because it was observed that the debris and overwintered leaves carried an enormous residual infection of B. cinerea.

Foliage diseases were not observed on any of the fungicide treated plots and leaf scorch, caused by the fungus Diplocarpon earliana (Ell. & Ev.) Wolfe, was the only foliar disease that occurred on unsprayed plants.

conditions were ideal for the development of gray mold fruit rot of strawberries when, coincidently in both years, rain fell on 11 days during the spray seasons, 28 May to 28 June, and on 6 days over the harvest periods, 27 June to 17 July.

Benomyl at 1.68 kg/ha and thiophanate-methyl at 2.35 kg/ha per season in 3 sprays beginning when the first blossom opened gave satisfactory control of fruit rot. Increasing the number of sprays or the amount of fungicide applied per ha per season did not enhance the control of fruit rot or increase yields of the strawberry cultivars cavalier and Redcoat.

Literature cited

1. Baltovski, Branko. 1971. A contribution to the study of chemical control of Botrytis cinerea on strawberries. Zast Bil; a 22 (114): 221-226. Abstr. in Biol. Abstr. 56:39232. 1973.

2. Bedard, R., and R. O. LaChance. 1970. Control of gray mold disease of strawberry. Phytoprotection 51:72-77.

3. Bennett, Margery. 1969. Field control of strawberry fruit rot (Botrytis cinerea Fr.) by fungicides. J. Hort. Sci. 44:81-89.

4. Bennett, Margery. 1972. Field control of strawberry fruit rot (Botrytis cinerea Fr.) by fungicides (11). J. Hort Sci. 47:321-327.

5. Borecka, H., Z. Borecki, and D. F. Millikan. 1973. Recent investigations on the control of gray mold of strawberries in Poland. Plant Dis. Rep. 57:31-33.

6. Branas, J. 1971. Remarques sur la pourriture grise. Rogres. Agric. Vitic. 88:223-226. Abstr. in Rev. Plant Pathol. 51:548. 1972,

7. Daubeny, H. A., and H. S. Pepin. 1973. variations in fruit-rot susceptibility of strawberry cultivars and selections as indicated by a postharvest screening technique. Can. J. Plant Sci. 53:341-343.

8. Freeman, J. A. 1966. A comparison of dicholfluanid, dichloran and DAC 2787 with captan for fruit rot control in strawberries. Can. Plant Dis. Surv. 46: 126-128.

9. Freeman, J. A., and H. S. Pepin. 1967. A systemic fungicide (fungicide 1991) for the control of gray mold and powdery mildew in strawberry and raspberries. Can. Plant Dis. surv. 47: 104-107.

10. Freeman, J. A., and H. S. Pepin. 1968. A comparison of two systemic fungicides with non-systemics for control of fruit rot and powdery mildew in strawberries. Can. Plant Dis. Surv. 48:120-123.

11. Garofalo, F. 1971. Tests on the anti-Botrytis activity of benlate of strawberry crop. Riv. Ortofloro fruttic. Ital. 55:124-129.

12. Gourley, C. O. 1963. Fungicidal control of fruit and foliage diseases of strawberry in Nova Scotia. Can. J. Plant Sci. 43: 462-468.

13. Gourley, C. O. 1968. Fungicidal control of Botrytis cinerea on four strawberry varieties. Can. J. Plant Sci. 48:267-272.

14. Jarvis, W. R. 1962. The infection of strawberry and raspberry fruits by Botrytis cinerea Fr. Ann. Appl. Biol. 50:569-575.

15. Moore, M. H., Kirby, A. H. M., and Bennett, Margery. 1965. Experiments on controlling strawberry Botrytis rot by spraying. Proc. 3rd Brit. Insecticide Fungicide Conf. (Brighton) 1965, pp. 116-120.

16. Muller, H. W. K. 1971. Gray mold, Botrytis cinerea control in strawberries with systemic fungicides. In Hort. Abstr. 42:607, no. 5649, 1972.

17. Norman, R. 1973. In The Grower 80:277.

18. Powelson, R. L. 1960. Initiation of strawberry fruit rot caused by Botrytis cinerea. Phytopathology 50: 491-494.

19. Tapio, Eeva. 1972. Fungicidal control of strawberry gray mold (Botrytis cinerea Pers.). Ann. Agric. Fenn. 11: 85-93. Abstr. in Biol. Abstr. 56:22109. 1973.

20. Watson, A. G., and C. E. Koons. 1973. Increased tolerance to benomyl in greenhouse populations of Botrytis cinerea. Phytopathology 63: 1218-1219.