Control of Sooty Blotch and Flyspeck of Apple with Captan, Mancozeb, and Mancozeb Combined with Dinocap in Dilute and Concentrate Applications

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ABSTRACT

Brown, E. M., and Sutton, T. B. 1986. Control of sooty blotch and flyspeck of apple with captan, mancozeb, and mancozeb combined with dinocap in dilute and concentrate applications. Plant Disease 70:281-284.

Sooty blotch (*Gloeodes pomigena*) and flyspeck (*Schizothyrium pomi*) symptoms were first observed an average of 30 days after the final captan spray during 1982–1984. In 1984, captan did not control sooty blotch or flyspeck when treatments were applied on a 14-day schedule. Sooty blotch symptoms were observed an average of 45 days and flyspeck an average of 60 days after the last mancozeb spray during 1982–1984. Flyspeck and sooty blotch control was considerably poorer when captan was applied concentrate (5× or 6×) as opposed to dilute; control was also poorer in some treatments in which mancozeb combined with dinocap (Dikar) or mancozeb was applied concentrate. In 1984, concentrate applications of mancozeb combined with dinocap did not control sooty blotch or flyspeck as well as concentrate applications of mancozeb.

Sooty blotch (*Gloeodes pomigena* Colby) (SB) and flyspeck (*Schizothyrium pomi* (Mont. & Fr.) von Arx) (FS), the most important summer diseases of apple in North Carolina, affect 5–10% of the fruit annually (15). Affected fruit are downgraded from fresh-market to processing or juice quality. Symptoms first appear on fruit from mid-June to the first of August. Control of SB and FS is achieved by fungicide sprays applied every 2 wk during the summer until harvest. The ethylene bisdithiocarbamate fungicides (EBDC) (zineb, metiram, and mancozeb combined with dinocap), captan, and folpet provide good control (2,3,6,7,19).

Residual activity of fungicides is recognized as important in controlling SB and FS. An increase in the severity of the two diseases noted in the early 1950s was attributed to the replacement of inorganic pesticides with less persistent, more specific organic pesticides (5). Lead arsenate and captan combinations gave better control of SB and FS than captan alone because of the residual activity of lead arsenate (19,21). Hickey (7) found that captan was slightly more toxic than zineb to the two pathogens in fungicide-amended agar tests; however, in the orchard, the residual activity of zineb was much greater than that of captan. When the final fungicide spray was applied 75 days before harvest, Drake (4), found no SB or FS on fruit treated with mancozeb combined with dinocap as opposed to 29% infection on fruit treated with captan.

Our initial studies were designed to determine the residual activity of captan and mancozeb on SB and FS incidence and severity. Both diseases are more prevalent in North Carolina than in northern apple-growing areas, and 100% of unsprayed fruit are affected. We reasoned that under high inoculum levels and favorable conditions for disease development such as occur in North Carolina, the residual activity of captan or the EBDC fungicides may be less than previously reported (4,7).

During these studies, we noticed that SB and FS were more severe in plots sprayed concentrate rather than dilute. Use of concentrate spray application has increased during the past 10–15 yr in North Carolina because growers have taken advantage of the increased savings in time, equipment cost, labor, and wear on equipment by spraying concentrate (1,17). Furthermore, studies have shown that 20% less material per hectare can be used when spraying concentrate without a reduction in fungicide deposition and apple scab, powdery mildew, or cedar apple rust control (14).

Therefore, this study was conducted to determine the residual activity of captan and mancozeb and the influence of concentrate applications of captan, mancozeb, and mancozeb combined with dinocap on the incidence and severity of SB and FS.

Paper 9687 of the Journal Series of the North Carolina Agricultural Research Service, Raleigh 276957610.

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This material is based on work supported by the USDA under Agreement 82-CRSR-21000.

Accepted for publication 18 June 1985 (submitted for electronic processing).

MATERIALS AND METHODS

Location. Fungicide tests were conducted at the Mountain Horticultural Crops Research Station (MHCRS), Fletcher, NC, and at Central Crops Research Station (CCRS), Clayton, NC. A block of 12-yr-old Golden Delicious trees was used in 1982 and 1983 at MHCRS. In 1984, two rows in a 16-yr-old block of Golden Delicious with overhead irrigation for evaporative cooling were used at MHCRS and a block of 5-yr-old Golden Delicious was used at CCRS.

Fungicides tested. Fungicides tested were mancozeb (Dithane M-45 80WP), mancozeb combined with dinocap (Dikar 76.7WP) (a coordination product of 72% zinc ion and manganese ethylenebisditiocarbamate and 4.7% dinocap), and captan (Orthocide 50WP).

Determination of fungicide rate. The tree-row-volume concept (TRV) (18) was used to determine the volume of water necessary to provide dilute fungicide coverage of the trees. In 1982 and 1983, the block TRV at MHCRS was 3,086 L/ha. In 1984, the block TRV at MHCRS was 1,871 L/ha and the block TRV at CCRS was 1,169 L/ha. Dilute applications were made at 0.9 kg of formulation per 378 L of water. Trees receiving dilute sprays were wet to the point of drip.

The fungicide rates used in concentrate sprays were computed on the basis of the dilute applications. Twenty percent less material per hectare was used when spraying concentrate (14). In 1983, concentrate treatments were sprayed at 655 L/ha (5×), and in 1984, at 309 L/ha (6×).

Fungicide application. Treatments were applied in 1982 and 1983 with a Myers 2A36 airblast sprayer (F. E. Myers & Bros. Co., Ashland, OH) driven at 67 m/min, with 2,549 m^3/min air delivery and 177 km/hr airspeed. The pump operated at 1,390 kPa. Treatments were applied in 1984 with a Swanson DA500A airblast sprayer (Durand-Wayland, Inc., La Grange, GA) driven at 67 m/min. The sprayer produced 793 m^3/min air delivery with an airspeed of 217–233 km/hr. The pump operated at 862 kPa. Appropriate combinations of nozzle numbers and disc and core sizes were selected to deliver the volume of water determined by TRV. Two-thirds of the spray volume was delivered to the top one-third of the tree and the other one-third, to the bottom two-thirds of the tree.

In 1982, treatments were applied on 9 (pink), 23, and 30 April, 12 and 27 May, 8 and 24 June, 9 and 22 July, and 9 August. In 1983, treatments were applied on 10 (second cover) and 23 June, 8 and 21 July, and 4 and 19 August. In 1984, treatments at MHCRS were applied on 9 (petal fall) and 21 May, 7 and 21 June, 6 and 20 July, and 4 August, and treatments were applied at CCRS on 24 (first cover) April, 8 and 22 May, 5 and 19 June, 6 and 19 July, and 3 and 14 August. The residual activity of captan and mancozeb was also determined in plots in which treatments were discontinued 2 or 4 wk before the last cover spray. Treatments were discontinued on 22 July and 9 August 1982 and on 4 August 1983 at MHCRS. Treatments were discontinued on 3 August 1984 at CCRS.

Plot design and data collection. In 1982, fungicides were applied to two plots of five trees and data were collected from three trees selected at random within each plot. In 1983, treatments were applied to five trees, and three trees within each plot were chosen for data collection. In 1984 at MHCRS, treatments were applied to two plots of three to five trees and data were collected from two trees within each plot. In 1984 at CCRS, treatments were applied to two plots of five trees and two trees were chosen within each plot for data collection.

At MHCRS, 20 fruit per tree were chosen at random, tagged, and monitored throughout the season for disease incidence and severity. However, because of a late spring freeze in 1982, we were able to tag and monitor only 50 fruit selected at random within each five-tree plot. At CCRS, disease incidence and severity were determined on 20 fruit per tree selected at random on each sample date. Because of loss of fruit from white rot (*Botryosphaeria dothidea* (Moug. ex Fr.) Ces. & de Not.) and bitter rot (*Glomerella cingulata* (Stonem.) Spauld. & Schrenk), we were unable to monitor disease incidence and severity on the same fruit on each sample date as at MHCRS.

Fruit was evaluated for percentage of surface area covered with SB (severity), number of FS colonies (severity), and percentage of fruit affected with each disease (incidence) about every 2 wk from the onset of symptoms until 1 mo after harvest. Harvest dates were 16 September 1982, 20 September 1983, and 11 September (MHCRS) and 14 September (CCRS) 1984.

Environmental data were monitored by a microcomputer-based weather data-acquisition system (22) located about 1 km from the MHCRS orchard and 0.1 km from the CCRS orchard.

RESULTS AND DISCUSSION

Environmental conditions were favorable for SB and FS development in 1982 and 1984; both growing seasons were characterized by frequent rains in June, July, and August (11–21 days per month at MHCRS). July and August 1983 were dry with 5 days of rain each month. In 1982 and 1984 at MHCRS, SB and FS symptoms first were observed on fruit in late June to early July on unsprayed trees. On 29 July 1982, about 85% of the fruit were infected with SB and FS, and on 27 July 1984, 25 and 65% of the fruit were infected with SB and FS, respectively. SB and FS symptoms were observed in mid-July on unsprayed fruit in 1984 at CCRS, and on 13 August, about 85% of the fruit were infected with SB and FS. SB and FS were not observed on unsprayed fruit at MHCRS in 1983 until late July; on 2 September, 76 and 44% of the fruit were infected with SB and FS, respectively.

The residual activity of captan and mancozeb against SB and FS varied within and between years (Figs. 1–3). These differences are probably attributable to differences in environmental conditions as well as inoculum levels. Although the residual activity of captan and mancozeb varied, there was a consistent difference between the two fungicides.

The residual activity of mancozeb against FS was 30–50 days longer than that of captan during the 3-yr study (Figs. 1–3). The incidence of FS was much less in all mancozeb treatments. Captan did not control FS in 1984 when applied on a 14-day schedule (Fig. 3). Twenty-five percent of the fruit were affected with FS 4 days after the last captan spray at MHCRS; more than 50% of the fruit were affected with FS 12 days after the final captan spray (14 August) at CCRS. In 1984, 1% of the fruit were affected with FS 4 days after the last mancozeb spray at MHCRS.

The residual activity of mancozeb against SB was 20–30 days longer than that of captan in 1982 and 1984, and disease incidence was less in the mancozeb plots (Figs. 1 and 3). Neither captan nor mancozeb completely controlled SB on a 14-day spray schedule in 1984. Five percent of the fruit were affected with SB 4 days after the last captan and mancozeb sprays at MHCRS. At CCRS, about 6% of the fruit in the captan plots were affected by SB 10 days after the 3 August deletion date. Symptoms of SB were noticed in captan and mancozeb plots at about the same time in the dry season of 1983 (Fig. 2). There was no difference in the incidence of SB in mancozeb or captan plots when the final spray was applied on 19 August,

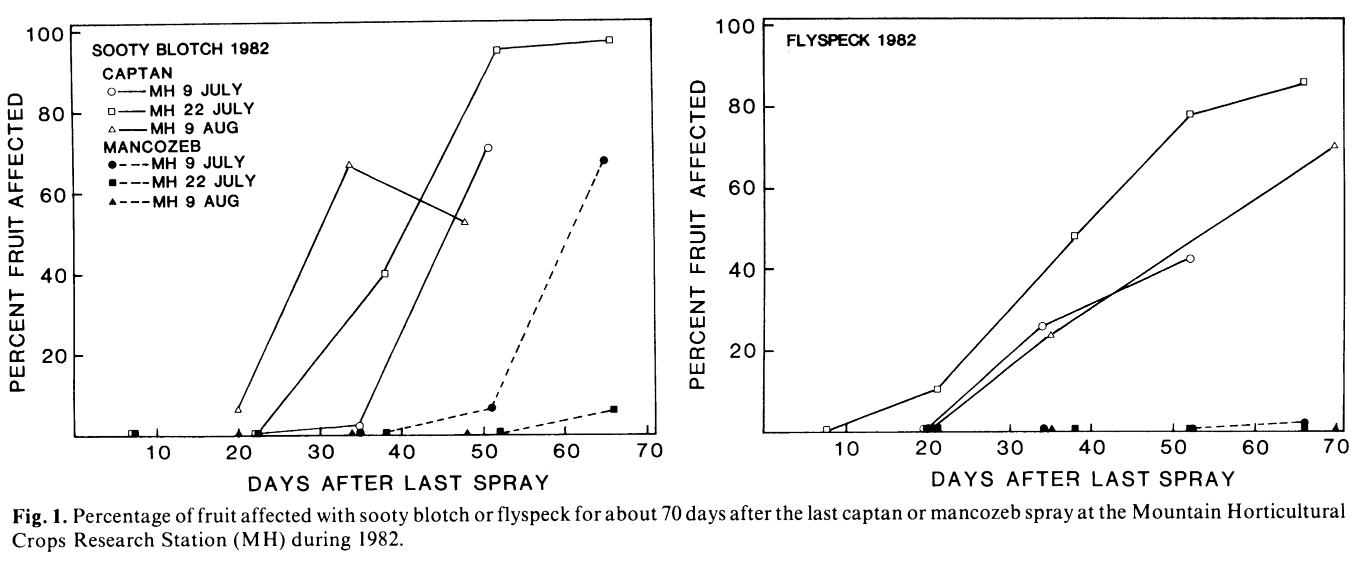

Fig. 1. Percentage of fruit affected with sooty blotch or flyspeck for about 70 days after the last captan or mancozeb spray at the Mountain Horticultural Crops Research Station (MH) during 1982.

but there was less SB in the mancozeb plot when the last application was on 4 August.

Reports of the residual activity of captan have been inconsistent in the literature (2–4,6,7). Our results indicate that in wet seasons, captan is ineffective in controlling SB and FS, and growers with an SB or FS problem should consider using an EBDC fungicide during the period from first cover until 3–4 wk before harvest. Because of the long residual activity of the EBDC fungicides, it may be possible to obtain satisfactory control of SB and FS by applying them every other cover spray or only during the late cover sprays, when disease pressure may be greater.

The incidence of SB was greater with concentrate applications of captan, mancozeb, or mancozeb combined with dinocap than with dilute applications, except with mancozeb combined with dinocap in 1983, when there was no difference between dilute and concentrate applications (Table 1). The severity of SB differed only between the captan treatments in 1983 and the mancozeb combined with dinocap treatment in 1984. In 1984, there were significantly more fruit affected in the mancozeb combined with dinocap concentrate treatment than in the mancozeb concentrate treatment ($P = 0.01$).

The incidence and severity of FS were greater when captan was applied concentrate than when applied dilute (Table 2). In 1984, the incidence and severity of FS were greater when mancozeb or mancozeb combined with dinocap was applied concentrate; there were significantly more fruit affected with FS when mancozeb combined with dinocap was applied concentrate than when mancozeb was applied concentrate ($P = 0.05$).

These results demonstrating poorer SB and FS control when treatments were applied concentrate differ from those in

Table 1. Incidence and severity of sooty blotch on Golden Delicious apples sprayed with captan, mancozeb, and mancozeb combined with dinocap in dilute and concentrate applications at the Mountain Horticultural Crops Research Station during 1983 and 1984

	1983[b]				1984[c]			
	Percent fruit affected		Severity[d]		Percent fruit affected		Severity	
Treatment[a]	1×	5×	1×	5×	1×	6×	1×	6×
Captan 50WP	53.3	96.7**[e]	1.5	4.7**	37.0	76.2*	2.3	4.9
Mancozeb 80WP	15.0	88.3**	2.4	6.7	7.5	39.5**	2.1	3.2
Mancozeb combined with dinocap 76.7WP	68.3	76.7	1.9	2.3	2.5	70.8**	0.8	4.0*

[a] Dilute rates for captan, mancozeb, and mancozeb combined with dinocap were 7.40 kg/ha in 1983 and 4.66 kg/ha in 1984; concentrate rates were 5.94 kg/ha in 1983 and 3.59 kg/ha in 1984.
[b] Last spray was on 4 August 1983; harvest was on 20 September 1983.
[c] Last spray was on 4 August 1984; harvest was on 11 September 1984.
[d] Severity = percent area covered on affected fruit.
[e] Significantly different from dilute application according to t test; * = $P = 0.05$ and ** = $P = 0.01$.

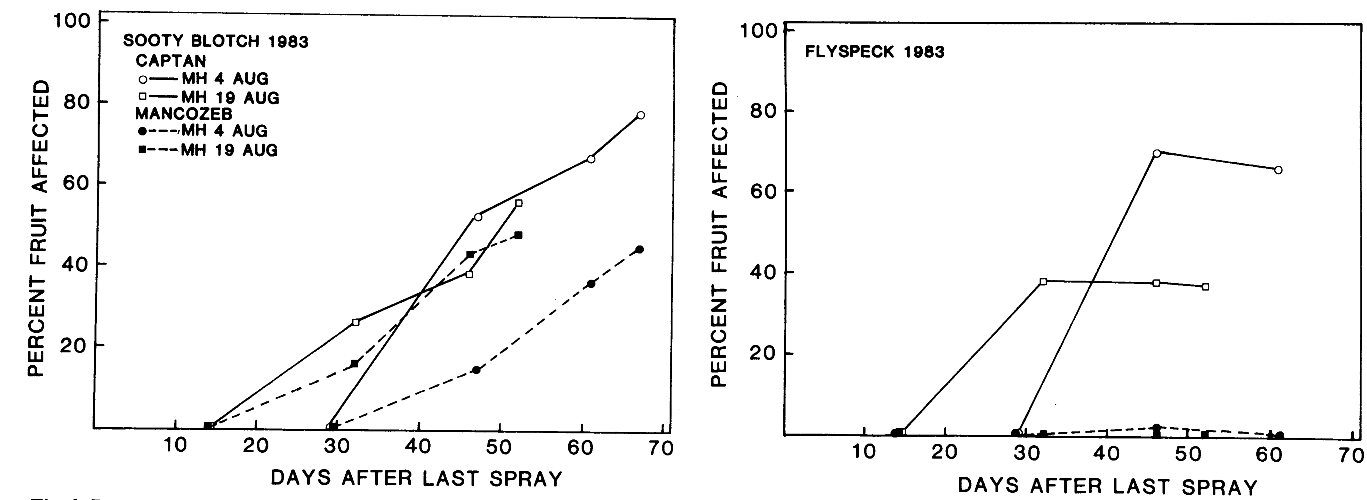

Fig. 2. Percentage of fruit affected with sooty blotch or flyspeck for about 60 days after the last captan or mancozeb spray at the Mountain Horticultural Crops Research Station (MH) during 1983.

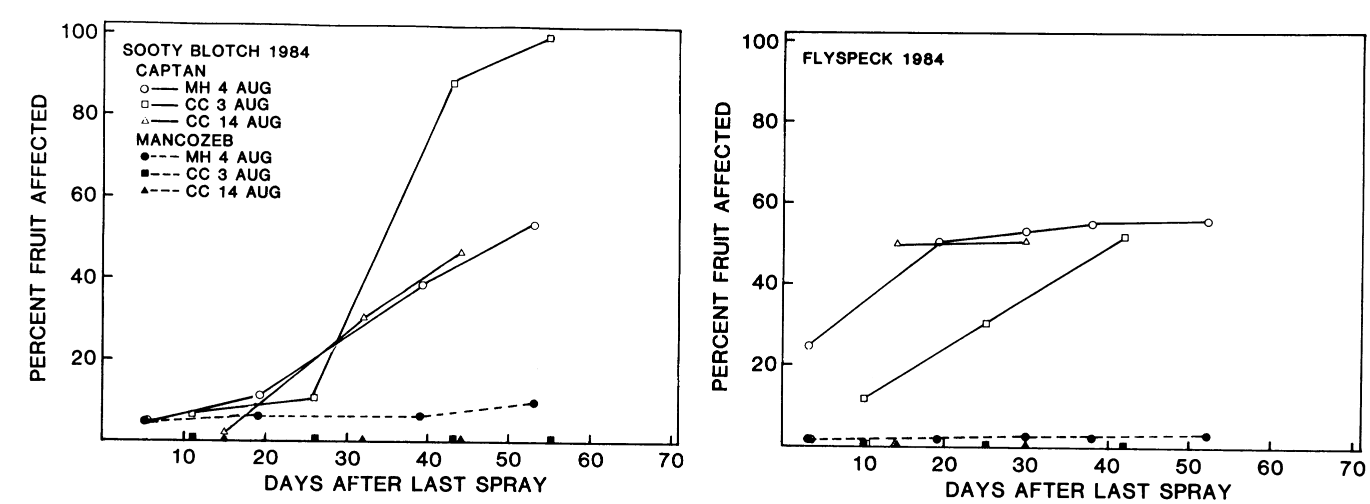

Fig. 3. Percentage of fruit affected with sooty blotch or flyspeck for about 55 days after the last captan or mancozeb spray at the Mountain Horticultural Crops Research Station (MH) or Central Crops Research Station (CC) during 1984.

Table 2. Incidence and severity of flyspeck on Golden Delicious apples sprayed with captan, mancozeb, and mancozeb combined with dinocap in dilute and concentrate applications at the Mountain Horticultural Crops Research Station during 1983 and 1984

	1983[b]				1984[c]			
	Percent fruit affected		Severity[d]		Percent fruit affected		Severity	
Treatment[a]	1×	5×	1×	5×	1×	6×	1×	6×
Captan 50WP	70.0	89.7*[e]	2.6	6.9**	56.2	90.0**	5.3	11.6*
Mancozeb 80WP	3.3	3.3	0.3	1.0	2.5	14.0**	0.4	2.9**
Mancozeb combined with dinocap 76.7WP	3.3	3.3	0.7	0.4	0.0	34.2**	0.0	3.8**

[a] Dilute rates for captan, mancozeb, and mancozeb combined with dinocap were 7.40 kg/ha in 1983 and 4.66 kg/ha in 1984; concentrate rates were 5.94 kg/ha in 1983 and 3.59 kg/ha in 1984.
[b] Last spray was on 4 August 1983; harvest was on 20 September 1984.
[c] Last spray was on 4 August 1984; harvest was on 11 September 1984.
[d] Severity = number of colonies on affected fruit.
[e] Significantly different from dilute application according to t test; * = $P = 0.05$ and ** = $P = 0.01$.

most tests comparing dilute and concentrate pesticide applications on various apple diseases, insects, and mites (8,9,11,13,16). Strider et al (16) found no difference in SB and FS control when fungicides were applied dilute (1×), 3×, 6×, or 10×. Krestensen (12) found that summer disease control on apple was good at concentrations up to 33×, but SB and FS control with concentrate applications was better in plots receiving lead arsenate or zineb in the last two cover sprays than in those receiving captan alone. Apple powdery mildew usually has been controlled equally well by dilute or concentrate applications (8,9,11). In one test, however, Hickey (10) found that powdery mildew control was poorer when mancozeb combined with dinocap was applied in 280 as opposed to 935 L of water per hectare. In addition, the response to certain growth regulators is significantly improved when they are applied dilute as opposed to concentrate (20).

The reduction in control of SB and FS that we observed in our concentrate applications (665 L/ha [5×] and 309 L/ha [6×]) may be due to poor fungicide coverage within fruit clusters and on the back side of fruit. We observed FS first on the inside of tightly clustered fruit. Our experience suggests that thorough coverage with spray deposits is essential for satisfactory control of SB and FS in North Carolina. Fungicide coverage within clusters or on the back side of fruit may be greater with dilute applications because larger spray droplets are more likely to penetrate fruit clusters and redistribute by drip or runoff.

The 20% reduction in fungicide rate also may have contributed to the poor control with concentrate applications; however, this is a standard recommendation throughout the United States and has not been reported to cause a reduction in deposition or disease control (14).

The decreased use of the inorganic pesticides, such as lead arsenate, has increased the importance of the residual activity in current fungicides for SB and FS control. Growers experiencing losses to SB and FS should consider using EBDC fungicides in their summer cover sprays and using less concentrated applications to achieve sufficient pesticide coverage.

ACKNOWLEDGMENT

We wish to thank L. Ray Pope for technical assistance and Rohm and Haas Co., Philadelphia, PA, for supplying the mancozeb and mancozeb combined with dinocap.

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