FURTHER OBSERVATIONS ON THE EFFECTS OF ORCHARD FUNGICIDES ON STORED McINTOSH APPLES[1]

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Abstract

Sprays of captan, dodine, dichlone and phenylmercuric acetate were applied to McIntosh apples in two tests of 4- and 5-years duration. After 170 days storage, fruit sprayed with phenylmercuric acetate had a higher acid content than fruit sprayed with other fungicides. There were no differences among fungicide treatments in fruit firmness or sugar content. The best control of storage scab caused by Venturia inaequalis was obtained with dodine and the best control of Gloeosporium album rot with captan.

Introduction

Fungicides have usually been tested on apples to control diseases in the orchard and those that develop in storage. However, little attention has been given to their effects on quality of stored fruit. Eaves et al. (3) found that stored McIntosh apples from trees sprayed with phenylmercuric acetate (PMA) had higher acid contents than did fruit receiving other fungicides. They did not obtain differences in fruit firmness with the five fungicides used. Earlier studies showed that some fungicides increased the sugar content of apples (6). Garman et al. (5) in a comparison of several pesticides reported a lower acid content in fresh fruit receiving dichlone-lead arsenate sprays while captan-lead arsenate sprays tended to increase the acid content. They also found that apples sprayed with glyodin had a higher sugar content than apples sprayed with other fungicides.

Results of two tests, from 1959 to 1962 and from 1964 to 1968, on the long-term effects of fungicides on the performance of mature McIntosh apple trees have already been published (7, 9). This paper provides additional information from these two tests on the effects of these fungicides on storage rots and storage scab, acidity, firmness, and sugar content of stored McIntosh apples.

Materials and methods

The McIntosh apples used were treated as described in previous publications (7, 9). The treatments and rates of application per 100 gallons of water are listed in Table 1.

Treatments were randomized and applied to plots, each consisting of a row of six trees, in each of 4 blocks. Eight to 10 sprays, consisting of about an equal number of precover and cover sprays, were applied each year. At harvest 1 bushel of fruit obviously free of apple scab and insect injuries was picked at random from a tree in each plot, stored immediately at 0 C, and removed for examination after about 170 days. The number of fruit showing storage scab caused by Venturia inaequalis (Cke.) Wint. and rot was recorded and the cause of each rot was identified from fungal fruiting structures on the rotted areas, or after isolation on an agar medium. Ten apples from each sample were tested for hardness with a Magness-Taylor pressure tester. Titratable acidity was determined as before (4) and percent soluble solid was obtained with a refractometer and expressed as sucrose. Duncan's Multiple Range Test (2) was used to test for significant differences.

Results and discussion

In two tests on the effects of fungicidal sprays on stored McIntosh apples there were no significant differences between treatments in firmness of fruit or in fruit sugar content. No differences in firmness of fruit were obtained in an earlier test (3) which included two of the fungicides, PMA and captan, used here. In the 1959-1962 experiment the acid content of apples sprayed with the PMA-captan schedule was significantly higher ($P < 0.01$) than that of apples receiving the other treatments (Table 2). This confirms earlier findings (3) in which it was shown that precover sprays of PMA were associated with a high acid content of the fruit. With the other fungicides, captan, dodine, and dichlone, the acid content did not differ in the tests beginning in 1959 and 1964. Garman et al. (5) found that apples sprayed with dichlone-lead arsenate had a lower acid content, and fruit sprayed with captan tended to be more acid

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Table 1. Fungicide treatments applied to McIntosh apple trees in precover and cover sprays during 1959–62 and 1964–68

Treatment*	Chemical name	Rate (lb formulation/100 gal water) Precover	Cover
1959–62			
Captan 50-W	captan 50%	2.0	1.5
Cyprex 65-W	dodine 65%	0.75	0.75
Phygon XL	dichlone 50%	0.5	0.25
Erad - Captan 50-W	PMA† 10%	0.5 pint	0.0
	captan 50%	0.0	1.5
1964–68			
Captan 50-W	captan 50%	2.0	1.5
Cyprex 65-W	dodine 65%	0.5	0.5
Phygon XL -	dichlone 50%	0.5	0.0
Captan 50-W	captan 50%	0.0	1.5
Captan 50-W -	captan 50%	2.0	0.0
Phygon XL	dichlone 50%	0.0	0.25

* Sources of fungicides: Stauffer Chemical Co., New York, N.Y. (Captan 50-W); Cyanamid of Canada Ltd., Rexdale, Ont. (Cyprex 65-W); Naugatuck Chemicals, Elmira, Ont. (Phygon XL); Green Cross Products, Montreal, Que. (Erad Eradicant Fungicide).

† PMA = phenylmercuric acetate (Hg equivalent of formulation, 6%).

Table 2. Effect of orchard fungicidal sprays on the acid content of McIntosh apples stored at 0 C for 170 days

Fungicide	Malic acid (%) 1959	1960	1961	1962	Mean*
Dodine	0.29	0.39	0.33	0.34	0.34 a
Captan	0.33	0.38	0.30	0.33	0.33 a
Dichlone	0.32	0.41	0.37	0.33	0.36 a
PMA - captan	0.35	0.47	0.43	0.41	0.42 b

* Numbers followed by the same letter do not differ significantly at the 1% level.

Table 3. Percentage of apple fruits affected by storage scab following preharvest treatment with fungicides and storage at 0 C for 170 days

Fungicide	1959	1961	1962	Mean*
Dodine	0.2	1.7	0.3	0.7 a
Captan	19.0	19.9	5.6	14.8 b
Dichlone	46.6	19.5	16.4	27.5 b
PMA - captan	15.6	6.2	0.7	7.5 b

* Numbers followed by the same letter do not differ significantly at the 1% level.

than apples receiving other fungicides.

Storage scab appeared only on the 1959, 1961, and 1962 crops and control with dodine was significantly better ($P < 0.01$) than that with the other fungicides (Table 3). The incidence of early and late scab in the orchard for these years has already been reported (9). There was a positive correlation between the amount of late scab in the orchard and that in storage. In a previous test (8) cover sprays of dodine at the rate of 0.75 lb of 65% formulation per 100 gal were effective in preventing storage scab but sprays at a 0.5 lb rate were relatively ineffective. That test, which showed that regular cover sprays of dichlone and captan did not give good control of storage scab, agrees with the results in Table 3.

Rots in storage were caused almost entirely by Penicillium spp., Gloeosporium album Osterw., and Botrytis cinerea Pers. Analyses of the data on total fungal rots showed no significant differences among treatments. However, in the 1959–1962 test, there was a significant difference ($P < 0.05$) between treatments in rots caused by G. album (Table 4). The full schedule of captan gave the best control followed by PMA with captan

Table 4. Percentage of apple fruits affected by *Gloeosporium album* in storage folloying preharvest treatment with fungicides, 1959–1962

Fungicide	1959	1960	1961	1962	Mean*
Dodine	1.7	12.5	3.6	2.3	5.0 b
Captan	1.2	3.2	2.2	0.8	1.8 a
Dichlone	3.2	10.6	4.5	2.3	5.1 b
PMA - captan	0.4	7.7	3.8	1.8	3.4 ab

* Numbers followed by the same letter do not differ significantly at the 5% level.

Table 5. Percentage of apple fruits affected by *Gloeosporium album* in storage following preharvest treatment with fungicides, 1964–1968

Fungicide	1964	1965	1966	1967	1968	Mean*
Captan	3.2	0.0	1.5	0.2	0.3	1.0 a
Dodine	5.6	1.2	3.4	0.0	1.3	2.3 a
Dichlone - captan	3.4	0.3	1.7	1.0	0.1	1.3 a
Captan - dichlone	4.0	0.2	1.7	0.3	0.6	1.4 a

* Numbers followed by the same letter do not differ significantly at the 1% level.

in the cover sprays. From 1964 to 1968 the differences among treatments were not significant for G. album but when captan was used in the spray schedule, the incidence of rotting by this organism was less than with dodine (Table 5). Control of G. album probably accounted for the good control of fungal rots obtained with PMA and captan in a previous test (3). In Nova Scotia G. album causes the only apple storage rot of any significance where infection occurs while fruit is on the trees. It has been suggested that control with PMA may be due either to a reduction in the amount of inoculum in the orchard or to physiological changes in the fruit as indicated by the high acid content (3). Subsequent work (1) has shown that it is probably due to a reduction in the inoculum.

Literature cited

1. Burchill, R. T., and X. L. Edney. 1963. The control of Gloeosporium album rot of stored apples by orchard sprays which reduce sporulation of wood infections. Ann. Appl. Biol. 51:379-387.
2. Duncan, D. B. 1965. Multiple range and multiple F tests. Biometrics 11:1-42.
3. Eaves, C. A., J. F. Hockey, and R. G. Ross. 1958. Effects of orchard fungicides on stored McIntosh apples. Can. J. Plant Sci. 38:246-251.
4. Eaves, C. A., and J. S. Leefe. 1955. The influence of orchard nutrition upon the acidity relationships of Cortland apples. J. Hort. Sci. 30:86-96.
5. Garman, P., L. G. Kierstead, and W. T. Mathes. 1953. Quality of apples as affected by sprays. Conn. Agr. Exp. Sta. Bull. 576.
6. Hockey, J. F., and R. W. Ward. 1932. Studies in apple storage. I. The influence of fungicides on flavor and sugar content. Sci. Agr. 12:709-715.
7. Ross, R. G., A. D. Crowe, and R. P. Longley. 1969. Performance of McIntosh apple trees sprayed with captan, dodine or pre-cover and cover sprays of dichlone. Can. J. Plant Sci. 49:655-658.
8. Ross, R. G., and C. L. Lockhart. 1960. Influence of orchard fungicides on Gloeosporium album rot and storage scab of apples. Can. Plant Dis. Surv. 40:10-14.
9. Ross, R. G., and R. P. Longley. 1963. Effect of fungicides on McIntosh apple trees. Can. J. Plant Sci. 43:497-502.