Effect of Fungicides on McIntosh Apple Yield and Quality: A Five-Year Study Under Hudson Valley Conditions, 1949-1953

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Contents

Cover picture shows section of McIntosh orchard near New Paltz, N. Y., used for this experiment. The trees were spaced 32 x 36 feet and were about 20 years old in 1949, when the experiment was begun. The orchard was in permanent sod which was mowed but undisturbed by cultivation during the experiment.

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EFFECT OF FUNGICIDES ON McINTOSH APPLE YIELD AND QUALITY: A FIVE-YEAR STUDY UNDER HUDSON VALLEY CONDITIONS, 1949–1953

D. H. Palmiter and R. M. Smock

Abstract

EIGHT different fungicide treatments, previously established for control of apple scab *(Venturia inaequalis)*, were applied in conjunction with a uniform insecticide program to McIntosh apple trees in a protective spray schedule in the Hudson Valley over a period of five years (1949–53) to determine their effect upon yield and quality of fruit.

The fungicide treatments included (1) Micronized wettable sulfur, (2) Micronized plus lime, (3) Everett flotation sulfur paste, (4) Everett flotation in pre-cover sprays followed by Fermate (ferbam) in the cover applications, (5) Crag Fruit Fungicide 341 (glyodin), (6) Fermate, (7) Phygon XL (dichlone) in pre-cover sprays followed by Fermate in the cover applications, and (8) Tag Fungicide 331 in pre-cover sprays followed by Fermate in the cover applications.

An average of five timely applications of the fungicides alone at full strength during the period from the dormant to the petal-fall stage of development, followed by six applications in combination with arsenate of lead, proved sufficient to give excellent control of scab, averaging less than 3 per cent scab for the five-year period.

The all-season Fermate treatment proved to be the safest fungicide used in this test on McIntosh, but the use of sulfur in the early applications showed little difference in production of quality fruit.

Everett flotation sulfur paste followed by Fermate in the cover applications was superior to an all-season sulfur schedule in producing better yields and higher quality of fruit.

Addition of lime to Micronized wettable sulfur improved disease control, fruit size, color, and yield, and reduced spray injury.

Phygon and Tag did not show to advantage in the protective spray schedule since their main value probably lies in their eradicative action.

Marked differences in time of fruit maturity were evident among the plots treated with various fungicides. While there was some variation from year to year, wettable sulfur and Crag 341 tended to ad-

vance maturity; whereas Fermate, Phygon followed by Fermate, and Tag followed by Fermate tended to delay maturity.

Firmness tests made from storage did not show any striking effects of treatment that were not apparent at harvest time. There was a suggestion of more storage scald on the Fermate-sprayed fruits as compared with the other treatments in certain years.

While the cost per acre for the organic fungicides was greater than for sulfur materials, the use of Fermate alone or in combinations increased the production of U. S. No. 1 fruit sufficiently to justify the added cost.

Introduction

It was evident from previous work that ferbam sprays increased the yield and quality of apples as compared with wettable sulfur.[1] The purpose of the experiment reported here was to confirm these results and compare the effects of certain other fungicide treatments on apple yield and quality when used on the same trees over an extended period of time. The fungicides tested had all been established as good apple scab control materials, hence scab infection caused by *Venturia inaequalis* was not the primary interest of this study.

The fungicide treatments tested in combination with arsenate of lead as the main insecticide included (1) Micronized wettable sulfur, (2) Micronized plus lime, (3) Everett flotation sulfur paste, (4) Everett flotation in pre-cover sprays followed by Fermate (ferbam) in the cover applications, (5) Crag Fungicide 341 (glyodin), (6) Fermate, (7) Phygon XL (dichlone) in pre-cover sprays followed by Fermate in the cover applications, and (8) Tag Fungicide 331 in pre-cover sprays followed by Fermate in the cover applications (Table 1).

These treatments were selected as those being most commonly used by the apple growers in the area at the time the experiment was started. Since it was already known that dichlone and phenyl mercury fungicides could not be used under high temperature conditions without causing serious injury, these materials were used only in the pre-cover sprays.[2] Fermate was used to replace these materials in the cover applications.

At the beginning of this experiment, there was little data available on the effects these fungicides might have upon yield and quality of

[1]Palmiter, D. H., and Hamilton, J. M. Influence of certain nitrogen and fungicide applications on yield and quality of apples. *New York State Agr. Exp. Sta. Bul. No. 766. 1954.*

[2]Palmiter, D. H. Some effects of fungicides on the quality and quantity of the New York apple crop. *New York State Hort. Soc. Proc.*, **94**: *239–243. 1949.*

TABLE 1.—FUNGICIDE TREATMENTS AND CONCENTRATIONS USED IN DUBOIS ORCHARD, NEW PALTZ, N. Y., 1949–1953.

PRE-COVER SPRAYS*		COVER SPRAYS	
Fungicide	Pounds or pints per 100 gallons	Fungicide	Pounds or pints per 100 gallons
Micronized (wettable sulfur)	8	Micronized	5
Micronized & lime†	8	Micronized & lime	5
Flotation (sulfur paste)	12	Flotation	8
Flotation	12	Fermate	1½
Crag 341 (1952–53)‡	2	Crag 341	1½
Fermate	1½	Fermate	1½
Phygon XL§	½	Fermate	1½
Tag Fungicide 331	½	Fermate	1½

*1949 Pre-cover spray dates: Apr. 13, 18, and 26; May 2, 9, and 16. Cover spray dates: May 23 and 31; June 14 and 28.
1950 Pre-cover spray dates: Apr. 28; May 9, 20, and 26. Cover spray dates: June 1, 12, 21, and 30; July 4.
1951 Pre-cover spray dates: Apr. 21 and 25; May 2, 9, 14, and 21. Cover spray dates: May 28; June 2, 8, and 25.
1952 Pre-cover spray dates: April 19, 22, and 28; May 2, 10, 17, and 22. Cover spray dates: May 29; June 3, 12, and 23; July 5.
1953 Pre-cover spray dates: Apr. 15 and 25; May 4, 9, and 13. Cover spray dates: May 18 and 25; June 3 and 18.
†Lime at 3–100 was used with Micronized.
‡Crag 341C with lime was applied at 2 pints per 100 gallons in the pre-cover and at 1 pint in the cover sprays in 1949. Crag 341 was used at 3 pints per 100 gallons in the pre-cover and at 2 pints in the cover sprays in 1950 and 1951. Lime 3–100 was used throughout.
§U. S. Rubber fungicide sticker was used at ½ pint per 100 with Phygon XL in 1951 and 1952.

apples over a period of years. The test materials were applied to mature McIntosh trees for five seasons, 1949–1954.

The present high cost of apple production makes it important for growers to maintain high production and quality. Fungicides that control diseases but reduce production and quality are not economical, whereas effective disease control plus improvement in yield and quality may justify extra expense for spray materials. Recent experiments in New York State indicated increased production of McIntosh apples that had been sprayed with ferbam fungicides in comparison with wettable sulfur.[3]

It seems evident from local experience and reports from other fruit sections that no fungicide now available is satisfactory for all varieties or all fruit areas, so the results reported should be considered pertinent only for McIntosh under Hudson Valley or similar conditions.

Materials and Methods

Spray materials

Micronized (wettable sulfur): Micronized contained 93 per cent wettable sulfur. Particle size was 3.6 microns with 47 per cent by weight

[3]Palmiter, D. H. Fungicides for apple scab and their effects on yield and quality of fruit. *New York State Hort. Soc. Proc.*, **96:** *271–274. 1951.*

under 4 microns. Prepared and provided by the Corona Chemical Division of the Pittsburgh Plate Glass Company, Moorestown, N. J.

Everett flotation sulfur paste: Flotation paste contained 50 per cent Koppers thylox-type flotation sulfur. Prepared by the Boston Consolidated Gas Company and provided by Koppers Co., Inc., Pittsburgh 19, Pa.

Fermate (ferbam): This wettable powder contained 76 per cent ferric dimethyldithiocarbamate as the active ingredient. It was produced and provided by the Grasselli Chemicals Division of E. I. du Pont de Nemours and Co., Inc., Wilmington, Del.

Crag Fruit Fungicide 341C (glyodin): This liquid contained 56 per cent of a mixture of glyoxalidines in isopropanol and was used in 1949.

Crag Fruit Fungicide 341: This glyodin fungicide contained 34 per cent 2–heptadecyl glyoxalidine as the active ingredient. Both Crag materials were produced and supplied by the Carbide and Carbon Chemicals Comany, New York, N. Y.

Phygon XL (dichlone): This wettable powder contained 50 per cent 2,3–dichloro 1,4–naphtho-quinone as the active ingredient. It was produced and supplied by the Naugatuck Chemical Division, U. S. Rubber Company, Naugatuck, Conn.

Tag Fungicide No. 331: This liquid contained 10 per cent phenyl mercury acetate as the active ingredient. It was provided by the California Spray Chemical Corporation, Elizabeth, N. J.

Lime: A high-grade hydrated calcium spray lime was used as indicated.

Description of orchard

A block of McIntosh trees on the Fred DuBois farm near New Paltz, N. Y., was used. (See cover illustration and Fig. 1.) This orchard was especially suitable for the experiment because it was uniform in topography, soil type, drainage, and age and spacing of trees.

The trees were spaced 32 × 36 feet and were about 20 years old in 1949. The orchard was in permanent sod which was mowed but undisturbed by cultivation during the experiment. The soil was a well-drained Cossayuna gravelly loam and there was no difficulty in getting through the orchard at any time. The orchard consisted of eight long rows of McIntosh trees that were used for records and two rows of young Cortland, Delicious, and Golden Delicious trees that provided cross pollination. Several hives of bees were placed in the orchard during the bloom period each year, starting in 1950. Pruning of this orchard was kept as uniform as possible, and the trees were kept open so all parts could be well covered with spray.

Fertilizer treatments

In August, 1949, leaf samples were taken from each count tree for nitrogen determinations. This record was then used in making soil nitrogen applications to individual trees in April, 1950, to even up the nitrogen level of the different trees. Trees with a leaf nitrogen content of less than 1.80 per cent were given 2 pounds of NuGreen, a urea product containing 45 per cent nitrogen, in 1950. Trees with leaf nitrogen between 1.80 and 1.89 per cent received 1 pound of NuGreen and those above 1.90 per cent received no soil application. Leaf samples taken in July, 1950, showed that the trees were quite uniform in nitrogen, as 93 per cent showed slightly better than 2 per cent nitrogen and only one sample was below 1.90 per cent. By 1951, the nitrogen level of the trees was still more uniform (Table 4).

Foliage applications of nitrogen were made to all the trees each year. In 1949, three applications of NuGreen were made at the rate of 5 pounds to 100 gallons of water in combination with the pest control sprays, starting at petal-fall and continuing with the next two applications. In 1950 and 1951, NuGreen at 5–100 was included in the petal-fall and 10-day applications. In 1952 and 1953, NuGreen at 3–100 was included in four consecutive applications, starting with the pink spray.

When magnesium deficiency accentuated by spray injury became apparent, high magnesium limestone was spread in the orchard at the rate of 2 tons per acre in March, 1951. This raised the soil pH from 4.4 in 1950 to 5.4 by October, 1951. As an extra precaution, two special spray applications of magnesium sulfate at 10–100 were made after bloom in 1951.

Plot arrangement

The fungicide treatments were arranged so that the sulfur-sprayed rows served as buffers between the organic fungicide treatments (Fig. 1). The sprays were applied the short way of the rows so as to include about eight McIntosh trees in each of the four replicates and a total of about 32 trees per treatment.

Trees were selected for records according to trunk circumference and freedom from visible injuries that might affect yield or fruit quality. Trees with trunk circumference measurements between 26 and 39 inches were selected. The number of trees of any size in a given treatment was adjusted so that the count trees averaged close to 32 inches for each treatment. Records were taken from 17 to 25 trees per treatment.

	Phygon/Fermate	*M*	*M*	M	*M*	G					
	Tag/Fermate	*M*	*M*	*M*	*M*	G	*M*				
	Flotation/Fermate	*M*	*M*	*M*	*M*	G	*M*				
Rep.	Crag 341	M	*M*	*M*	*M*	C	*M*	*M*			
D	Micronized + lime	*M*	*M*	*M*	M	G	*M*	*M*			
	Phygon/Fermate	*M*	*M*	*M*	*M*	C	*M*	*M*			
	Micronized	*M*	*M*	M	*M*	C	*M*	M	*M*		
	Fermate	M	*M*	*M*	M	G	*M*	*M*	*M*		
	Flotation	*M*	*M*	*M*	M	G	M	M	*M*	*M*	
	Phygon/Fermate			M	M	C	*M*	*M*	M	M	
	Micronized + lime	*M*	*M*	M.	*M*	G	*M*	*M*	M	*M*	
	Crag 341	*M*	*M*	M	*M*	C	*M*	*M*	*M*	M	
Rep.	Micronized	*M*	*M*	*M*	*M*	C	*M*	*M*	*M*	*M*	
C	Fermate	M	*M*	*M*	M	G	*M*	*M*	M	*M*	
	Flotation/Fermate	*M*	*M*	*M*	M	G	*M*	*M*	*M*	M	
	Tag/Fermate	M	*M*	*M*	*M*	G	*M*	*M*	*M*	*M*	
	Flotation	*M*	*M*	*M*	*M*	C	*M*	*M*	*M*	*M*	D
	Crag 341	*M*	*M*	*M*	*M*	C	*M*	*M*	*M*	*M*	G
	Flotation/Fermate	*M*	*M*	M	*M*	G	M	*M*	*M*	*M*	C
	Tag/Fermate	*M*	*M*	*M*	*M*	G	*M*	*M*	*M*	*M*	D
Rep.	Micronized	*M*	*M*	*M*	M	C	M	M	M	*M*	D
B	Phygon/Fermate	*M*	*M*	*M*	*M*	G	*M*	M	*M*	*M*	D
	Flotation	*M*	*M*	*M*	*M*	G	*M*	M	M	*M*	D
	Fermate	*M*	*M*	*M*	*M*	C	D	*M*	*M*	M	D
	Micronized + lime	*M*	*M*	*M*	M	G	*M*	M	M	*M*	D
	Phygon/Fermate	*M*	*M*	M	*M*	G	*M*	*M*	M	M	D
	Flotation/Fermate	*M*	*M*	*M*	*M*	G	*M*	*M*	*M*	*M*	D
	Tag/Fermate	M	*M*	*M*	*M*	G	*M*	*M*	M	M	C
Rep.	Micronized + lime	*M*	*M*	M		G	M	*M*	*M*	*M*	D
A	Fermate	*M*	*M*	*M*	M	G	M	*M*	*M*	*M*	D
	Flotation	*M*	M	*M*	M	C	M	*M*	*M*	M	C
	Crag 341	*M*	M	*M*	M	C	*M*	*M*	*M*	M	C
	Micronized	M	M	*M*	*M*	G	M		*M*	*M*	Gr
Row No.		1	2	3	4	5	6	7	8	9	10

N

FIG. 1.—DIAGRAM OF FRED DUBOIS MCINTOSH ORCHARD, NEW PALTZ, N. Y., 1949.

M—McIntosh trees about 20 years old
C—Young Cortland trees
G—Young Golden Delicious trees
D—Young Delicious trees
Gr—Greening trees

This orchard is fairly level but has a gentle slope from west to east and from north to south. The greatest difference in elevation is 20 feet. The fungicide treatments were assigned to one east-west row in replicates A to D, making a total of 28 to 32 McIntosh trees for each treatment. Letters in italics indicate the trees in each row which were most uniform in size and were used for recording data. Diagonal line indicates first material was used in pre-cover sprays

Spray treatments

Eight fungicide treatments were included in the experiment. The fungicides and the concentrations used during the early applications and cover applications are shown in Table 1. The fungicide concentra-

tions were kept uniform throughout the experiment except for Crag 341C which was changed after the first year to an improved formulation to avoid foliage injury. In 1950 and 1951, the 3-pint recommendation of the manufacturer was followed, but in 1952 and 1953 it was reduced to 2 pints to 100 gallons in the early sprays and to 1½ pints in the cover sprays.

The U. S. Rubber fungicide sticker at ½ pint in 100 gallons of spray was used with Phygon in 1950, 1951, and 1952, but was omitted in 1953 since it was felt that the sticker may have increased the amount of fruit injury in 1952.

All sprays were applied with a Speed Sprayer and dilute concentrations were used. The treatments were applied in the order shown in replicate A (Fig. 1), starting with Micronized sulfur. Spray was applied to two sides of each tree. The materials were made up in 500-gallon amounts and when the trees were in full leaf all of this was applied to the experimental trees, so each tree received about 15 gallons of spray. All fungicide applications were timed for protective action and all materials were applied the same day.

Arsenate of lead at 3–100 was the standard insecticide used with the fungicides, starting with the petal-fall application. A few extra DDT applications were necessary for codling moth control in 1952 and 1953, but most of these came after the fungicide treatments were completed for the season. Mites and aphids were held in check with dormant applications of DN289 or Elgetol 318. Additional spray applications for control of apple maggot, codling moth, and mites were made later than the dates indicated for the fungicide applications, but such treatments were kept uniform for the entire orchard. There was little fruit loss from insect injury except for about 5 per cent codling moth injury in 1952.

All spray materials other than fungicides were applied uniformly throughout the orchard.

Method of taking records

Apple scab control, fruit size, color, and spray injury records were taken at harvest by examining all the fruit from four boxes picked at random from each of 16 count trees per treatment. The fruit in these boxes was leveled off and each apple examined, graded, and counted. The number of scabby or spray-injured fruit was recorded. The four color grades were 0–24 per cent of the fruit colored red, 25–49 per cent red, 50–74 per cent red, and 75–100 per cent red. Fruit in

the first group would be excluded from U. S. No. 1 grade and that in the two highest groups would meet the color requirements for U. S. Fancy grade. The total number of apples per box was used to indicate fruit size. The total yield for each count tree was recorded as boxes picked and boxes of drops.

Foliage scab infection was recorded in July or August by examining all of the leaves of 30 terminals per tree and counting the scab spots on each leaf. Notes on spray injury were made at the same time. Leaf-size measurements were made three seasons, but no consistent differences were found.

Leaf nitrogen and chlorophyll determinations were made through the cooperation of Elwood Fisher and Damon Boynton of the Pomology Department at the College of Agriculture, Ithaca. The nitrogen content of dried leaves was analyzed by a modified Kjeldahl method. The chlorophyll method was that of Compton and Boynton.[4]

Because of limited storage facilities, only one sulfur treatment (Micronized without lime) was included in the maturity and storage experiment. Records on all of the organic fungicide treatments were taken.

For maturity and storage studies 25 fruits of approximately 2¾ inches diameter were picked at shoulder height from the periphery of the tree at each harvest date. At each picking 16 trees were sampled from each treatment (four trees from each of four replicates).

At each harvest date firmness, ground color, and soluble solids determinations were made on 10 fruits from each tree. Firmness was measured with a Ballauf fruit pressure tester, using a $^{7}/_{16}$-inch point. Ground color was measured, using the Cornell color chart for McIntosh apples. Soluble solids were determined with a Zeiss refractometer. The latter determinations were discontinued after the third year because of the small differences obtained.

Two fruits from each tree at each harvest date were selected at random from the 25 fruits mentioned above for respiration measurements. These fruits were composited and used as 32-fruit samples for respiration determinations at 74° F. The first respiration measurements were made within 24 hours after harvest. Carbon dioxide-free air was passed over the fruits and the carbon dioxide evolved by the apples was absorbed in 0.3 normal sodium hydroxide. This absorption was carried out each day for a 2-hour period. After adding barium

[4]Compton, O. C., and Boynton, Damon. A rapid method for the determination of chlorophyll in apple leaves. *Proc. Amer. Soc. Hort. Sci.*, **46**: *45–50. 1945.*

chloride, the sodium hydroxide was titrated with standard strength hydrochloric acid.

The remaining fruits from each harvest were stored at 32° F until late February or March each year. After storage, each fruit was examined as to firmness, scald, and brown core. Scald counts were not made until after the fruits had been at room temperature for 3 days after removal from storage.

Probable errors of means were calculated on the maturity and storage data. The "T" test was used to determine statistical significance.

Methods of taking other records are given with the results in the text.

Results

Disease control

Apple scab caused by *Venturia inaequalis* was the main disease encountered in this orchard during the five years the experiment was in progress. The only other fungus disease to cause any fruit loss was Botrytis blossom-end rot. In 1951, a cool rain period at the end of McIntosh bloom resulted in sepal infection by *Botrytis cinerea.* The infection worked into the blossom end of the fruit causing a dry rot. Fruit counts were made to determine if there were differences in the amount of this infection in the various fungicide plots. Unsprayed and sulfur-sprayed trees showed an average of about 5 per cent infection. Trees sprayed with Phygon/Fermate,[5] Crag 341, and Tag/Fermate averaged 4, 3, and 2 per cent infection, respectively. The Fermate-sprayed trees showed less than 1 per cent infection.

Apple scab control was consistently good during the five-year period with all the fungicide treatments. Good timing of applications is mainly responsible for this result. Unsprayed trees in a nearby orchard were defoliated early each year due to scab infection. Perhaps some of the organic fungicides would have given adequate control if applied at less frequent intervals, but it was considered best to keep all the treatments on the same schedule and to use sufficient applications to insure good control from the wettable sulfur materials.

Under these conditions, the poorest sulfur treatment averaged only 3 per cent fruit scab during the five years (Table 2). The highest amount of scab infection was recorded in 1950 on trees sprayed with Micronized which averaged 7 per cent fruit scab. Foliage infection was

[5]The diagonal line used throughout the text and tables indicates that the first material was used as a pre-cover spray and the second material as a cover spray.

also held under control each year. The greatest amount of leaf scab was found on trees sprayed with Micronized without lime. This treatment averaged 12 scab spots per 30 terminals compared with 7 spots where lime was used with the same amount of sulfur. There was little

TABLE 2.—FIVE-YEAR SUMMARY OF APPLE SCAB CONTROL ON MCINTOSH, DUBOIS ORCHARD, NEW PALTZ, N. Y.

FUNGICIDE	PERCENTAGE OF FRUIT INFECTED*					
	1949	1950	1951	1952	1953	Average
Micronized	2	7	1	1	4	3
Micronized & lime	1	4	1	2	4	2
Flotation	2	3	t	2	4	2
Flotation/Fermate	1	5	t	1	2	2
Crag 341	1	5	t	1	3	2
Fermate	1	2	1	1	1	1
Phygon/Fermate	3	1	t	t	2	1
Tag/Fermate	t	1	t	t	1	t

*t = trace (less than 0.5%).

difference between the organic fungicides and they all showed better control of leaf scab than the sulfur treatments.

Spray injury

Average annual spray injury loss of U. S. No. 1 grade fruit ranged from 1 to 4 per cent for the eight treatments. Leaf injury was observed in some of the plots and spray injury in relation to fruit set was observed in 1953.

In 1949 and 1950, magnesium deficiency symptoms developed in the experimental plots and in the first year were confused with spray injury on plots sprayed with Crag 341C. Considerable leaf injury developed following the hot dry summer. It first appeared as small necrotic spots on the leaves and later as a marginal leaf burn which reached a point of slight defoliation by the end of August. Some of the other fungicide treatments also showed evidence of marginal leaf injury but not so consistently or so severely.

In 1950 and thereafter, Crag 341 was used in place of the Crag 341C formulation. No visible foliage injury was noticed in 1950 until late August. At that time, symptoms of magnesium deficiency began to appear. By harvest, some of the trees had lost a few leaves on certain branches and fruit drop was heavy on some trees. Trees that had been sprayed with Crag 341 or sulfur without lime showed a higher incidence of leaf scorch than was present in the other treatments. The

amount of injury was greatly reduced where lime was used with sulfur and somewhat reduced where Fermate was used in the cover applications (Table 3).

TABLE 3.—EFFECT OF FUNGICIDES ON MAGNESIUM DEFICIENCY SYMPTOMS ON MCINTOSH, DUBOIS ORCHARD, NEW PALTZ, N. Y., 1950.

FUNGICIDE	PERCENTAGE OF TREES SHOWING DEFICIENCY SYMPTOMS		
	Mild	Severe	Total
Micronized	53	16	69
Micronized & lime	24	0	24
Flotation	41	23	64
Flotation/Fermate	56	7	63
Crag 341	57	8	65
Fermate	36	5	41
Phygon/Fermate	42	0	42
Tag/Fermate	60	0	60

After the magnesium deficiency was corrected, Crag 341 caused no visible leaf injury on McIntosh trees, but some young Cortland interplants in the Crag 341 plots continued to show marginal burn and spotting in late August each year. In general, the McIntosh trees that were sprayed with Crag 341 appeared to be lighter green in color than those sprayed with Fermate and leaf samples showed less chlorophyll (Table 4).

TABLE 4.—EFFECT OF FUNGICIDES ON THE NITROGEN AND CHLOROPHYLL CONTENT OF MCINTOSH LEAVES, DUBOIS ORCHARD, NEW PALTZ, N. Y., 1951.

FUNGICIDE	N, PER CENT DRY WEIGHT			CHLOROPHYLL, mg/100 cm^2*
	High	Low	Average	
Micronized	2.07	1.95	1.99	2.04
Micronized & lime	2.09	1.99	2.04	2.14
Flotation	2.12	1.94	2.03	2.02
Flotation/Fermate	2.15	1.91	2.02	2.15
Crag 341	2.20	1.93	2.06	1.97
Fermate	2.11	1.90	2.00	2.15
Phygon/Fermate	2.09	1.98	2.02	2.15
Tag/Fermate	2.16	1.93	2.06	2.12

*Samples from 17 to 25 trees per treatment on June 27.

Evidence from other orchard experiments indicate the possibility of foliage injury when Crag 341 and arsenate of lead are used together in a full after-bloom schedule. How much of the injury is due to the insecticide has not been determined, but Crag 341 acts as a deposit builder for arsenate of lead when used at more than 1½ pints per 100 gallons. Therefore, arsenical injury might be expected from the combination if used too frequently or at too high concentration.

Trees in the plots that received Phygon in the early sprays showed yellow spur leaves in 1951 and 1953. The yellowing was confined to the first leaves on the fruiting spurs. These small yellow leaves dropped early. Typical chlorosis was evident on the early terminal leaves in Phygon plots some seasons, but it was not serious since the Phygon applications were stopped and Fermate substituted before high temperatures arrived.

Sulfur-sprayed trees showed no definite leaf injury symptoms, but by midseason they were lighter green in color than those sprayed with Fermate in the cover applications. Chlorophyll readings made on leaf samples collected June 27, 1951, showed a reduced amount of chlorophyll in the leaves from sulfur-sprayed trees, especially when lime was not used (Table 4). The nitrogen level of the trees was quite uniform. Perhaps part of the injury resulted from the arsenate of lead and was corrected when lime was used.

Fruit spray injury was not a problem except in 1952 when temperatures of 90° F or higher occurred on nine days in June and July. Under these conditions, considerable sulfur-sun scald developed on all of the sulfur plots. Some of the fruit was injured to the extent that it dropped early. Drops examined on September 5 under the trees sprayed with flotation sulfur showed over 50 per cent sun scald. At harvest, records were kept of the amount of fruit showing sufficient injury to keep it from U. S. No. 1 grade. To comply with this grade, fruit must be free from any injury that detracts from the appearance of the fruit, such as light smooth russeting which covers more than 25 per cent of the surface, solid russet which covers more than 10 per cent of the surface, rough russet spots more than one-quarter inch in diameter, and all spray injury which does not blend into the normal color of the fruit.

All of the sulfur fungicide treatments showed fruit injury, but Micronized without lime had the most with 18 per cent below grade. Phygon/Fermate plots showed a different type of injury. This developed near the bloom period. Some fruit outgrew the injury, but at harvest 12 per cent of the picked fruit had sufficient russet to throw it out of No. 1 grade. Crag, Tag/Fermate, and Fermate averaged 8, 7, and 5 per cent fruit injury at harvest, respectively.

Spray injury in relation to fruit set was clearly evident in 1953. The fungicide materials scheduled for early season use were applied during bloom. Large branches were tagged during bloom and the number of blossom clusters was counted. The average amount of bloom for all of the treatments was quite good, but the Micronized and Crag 341

plots showed more individual tree variation than the others. This was to be expected since the orchard had already produced three big crops in a row. The fruit set records included from 1,100 to 2,000 bloom clusters examined on 16 trees for each treatment. The fruit set counts were made July 1 after the June drop was complete.

Fermate-sprayed trees had the highest set with 60 apples per 100 blossom clusters. The sulfur and Crag 341 plots ranged from 45 to 50 per cent set, Phygon/Fermate plots, 42 per cent, and Tag/Fermate plots, 29 per cent (Table 5). The reduction in set was especially noticeable in the Tag/Fermate plots. The reduction in yield, however, was not as great as one might expect considering the low percentage of fruit set in these plots. Due to the dry summer, the thinning action of Tag apparently allowed these trees to produce larger apples than trees with heavier sets and this partly compensated for the low set as the large apples tended to increase yield.

TABLE 5.—EFFECT OF FUNGICIDES ON MCINTOSH BLOOM, SET, AND YIELD, DUBOIS ORCHARD, NEW PALTZ, N. Y., 1953.

FUNGICIDE*	ESTIMATED BLOOM ON COUNT TREES PER CENT	FRUIT SET PER 100 BLOSSOM CLUSTERS, NO.	AVERAGE YIELD OF PICKED FRUIT PER TREE, BOXES
Micronized	67	45	12
Micronized & lime	72	51	16
Flotation	72	46	10
Flotation/Fermate	76	45	18
Crag 341	65	48	15
Fermate	76	60	20
Phygon/Fermate	71	42	16
Tag/Fermate	79	29	15

*A fungicide application was made on May 9 when the trees were in bloom.

Tree growth

In 1953, the length of terminal growth was measured for each of the five years the experiment had been underway. Branches around the tree were selected to avoid those that had been pruned back during the past five years. The average length of the terminal growth was slightly greater where lime was used with Micronized than where it was omitted. The trees sprayed with Fermate, Phygon/Fermate, or Tag/Fermate showed greater terminal growth than those sprayed with sulfur or Crag 341 (Table 6). The number of fruit spurs present on these same terminals in 1953 was also greatest on the trees sprayed with Fermate, Phygon/Fermate, or Tag/Fermate. This was especially

true on the 1952 wood (Table 6). The number of apples set on the 1949, 1950, and 1951 wood, used for the above records, was counted. The highest average number of apples per terminal for the three years was 4.1 recorded for the Fermate-sprayed trees. The lowest number of apples per terminal was 1.7 recorded for the straight flotation treatment (Table 6).

TABLE 6.—THE LONG-TERM EFFECT OF FUNGICIDES ON THE TERMINAL GROWTH AND FRUIT SPUR DEVELOPMENT OF MCINTOSH TREES, DUBOIS ORCHARD, NEW PALTZ, N. Y.

FUNGICIDE	YEAR IN WHICH TERMINAL GROWTH WAS PRODUCED					TOTAL
	1949	1950	1951	1952	1953	
	Average Terminal Length, cm					
Micronized	21	22	24	18	10	95
Micronized & lime	21	24	27	20	10	101
Flotation	20	23	26	19	10	98
Flotation/Fermate	20	23	25	19	11	98
Crag 341	20	21	25	20	10	96
Fermate	23	26	27	20	11	107
Phygon/Fermate	22	24	25	19	10	100
Tag/Fermate	23	25	26	22	11	107
	Av. No. Fruit Spurs Present on Above Shoot Growth, 1953					
Micronized	3.2	3.8	5.4	2.9	—	15.3
Micronized & lime	3.1	4.2	5.6	2.7	—	15.6
Flotation	3.2	4.3	6.3	3.1	—	15.9
Flotation/Fermate	2.8	3.8	5.2	3.4	—	15.2
Crag 341	3.1	3.8	6.2	3.4	—	16.1
Fermate	3.9	4.7	6.5	3.4	—	18.5
Phygon/Fermate	3.9	4.7	5.8	3.5	—	17.9
Tag/Fermate	3.8	4.9	6.4	4.1	—	19.2
	Av. No. Apples Present on Above Fruit Spurs, 1953					
Micronized	0.9	0.6	0.4	—	—	1.9
Micronized & lime	1.1	0.9	0.6	—	—	2.6
Flotation	0.8	0.5	0.4	—	—	1.7
Flotation/Fermate	0.7	0.7	0.5	—	—	1.9
Crag 341	1.0	0.7	0.7	—	—	2.4
Fermate	1.8	1.3	1.0	—	—	4.1
Phygon/Fermate	1.1	0.9	0.3	—	—	2.3
Tag/Fermate	1.3	1.1	0.6	—	—	3.0

Trunk circumference measurements were made in 1949 and 1953 (Table 7). The increase in size averaged 13 or 14 per cent for all of the treatments, except Tag/Fermate which averaged 18 per cent. The increased growth of the trees in these plots probably reflects the poor set of fruit caused by the treatment in 1952 and 1953. With a light fruit set and mild fungicide applications in the summer period, the trees made more vegetative growth.

Yield

Differences in yield began to show the third year of the experiment, but the trends were much more clear-cut the last two seasons. The yield data were recorded for each tree individually and the picked fruit and drops were recorded separately. Under present economic conditions, McIntosh drops are worth little more than the cost of picking them up, so our main concern with yield is in the amount of picked fruit. However, since the total yield (dropped and picked) indicates the productive capacity of the trees under the conditions of the experiment, this information may be of interest (Table 7).

The average yield of picked fruit per tree for the different fungicide treatments and the trend after the first three years of adjustment are shown in Table 7. At the end of the first three years, the highest and lowest yields of picked fruit were both recorded for sulfur fungicides, but trees sprayed with Fermate had the highest total yield. Micronized plus lime and flotation had average yields of 19 and 13 boxes of picked fruit per tree, respectively. All of the sulfur treatments declined in yield during 1952 and 1953. The all-season Fermate treatment was the only one that showed a greater average yield of picked fruit during the last two years than for the first three years of the experiment, but the total yield was reduced from 25 to 21 boxes per tree due to poorer growing conditions. These trees averaged 19 boxes per tree which was 4 boxes above the average for all treatments. Trees sprayed with flotation followed by Fermate had the second best yield of picked fruit for the first three years (18 boxes) as well as for the last two (17 boxes).

The total yield of picked fruit for the five-year period averaged 90 boxes per tree in the Fermate plots and 88 boxes per tree in the flotation/Fermate plots. Trees sprayed with Micronized plus lime averaged 87 boxes and those sprayed with Crag 341, 81 boxes per tree (Table 9).

The yield of U. S. No. 1 fruit is of more importance than the total yield. The amount of No. 1 fruit was determined by subtracting the amount below grade due to lack of color, scab infection, and spray injury (Table 8). The greatest loss of No. 1 fruit was recorded for the Micronized treatment and amounted to 392 boxes per acre during the five-year period, or 17 per cent of the picked fruit. The least loss of grade was recorded for the Fermate treatment. This was 135 boxes, or 5 per cent of the picked fruit. The amount of loss was relatively low for all treatments where Fermate was used in the cover applications.

The yield per acre was based on the average yield per tree multi-

TABLE 7.—McINTOSH YIELD TRENDS AS AFFECTED BY FUNGICIDES USED FOR A FIVE-YEAR PERIOD, DuBOIS ORCHARD, NEW PALTZ, N. Y., 1949 TO 1953.

FUNGICIDE	AVERAGE TRUNK CIRCUMFERENCE, IN.			AVERAGE NUMBER BOXES OF FRUIT PER TREE							
	1949	1953		1949	1950	1951	1952	1953	1949–53	1949–51	1952–53
Micronized	33.2	38.2	Total	9	24	29	16	13	18	21	15
			Picked	**7**	**22**	**22**	**13**	**12**	**15**	**17**	**13**
Micronized and lime	32.7	36.9	Total	11	26	30	16	17	20	22	17
			Picked	**8**	**24**	**24**	**14**	**16**	**17**	**19**	**15**
Flotation	31.1	35.5	Total	8	22	26	12	13	16	19	13
			Picked	**5**	**20**	**18**	**11**	**12**	**13**	**14**	**11**
Flotation/Fermate	32.6	37.4	Total	9	27	31	19	19	21	22	19
			Picked	**8**	**25**	**22**	**16**	**18**	**18**	**18**	**17**
Crag 341	32.6	37.3	Total	9	23	28	18	18	19	20	18
			Picked	**6**	**21**	**21**	**15**	**16**	**16**	**16**	**15**
Fermate	32.9	37.6	Total	9	28	30	20	22	22	25	21
			Picked	**7**	**25**	**20**	**17**	**20**	**18**	**17**	**19**
Phygon/Fermate	33.0	37.3	Total	9	23	30	13	17	18	22	15
			Picked	**6**	**20**	**21**	**11**	**16**	**15**	**16**	**13**
Tag/Fermate	32.1	38.0	Total	6	20	28	13	16	17	20	15
			Picked	**5**	**19**	**24**	**11**	**15**	**15**	**16**	**13**
Picked fruit L.S.D.	.05% level			NS	4.61	NS	3.64	3.05	3.56	—	—
	.01% level			NS	NS	NS	4.96	4.15	4.84	—	—

TABLE 8.—FUNGICIDES IN RELATION TO REDUCTION OF U. S. NO. 1 FRUIT DUE TO POOR COLOR, APPLE SCAB, AND SPRAY INJURY, DUBOIS ORCHARD, NEW PALTZ, N. Y., 1949–1953.

FUNGICIDE	AVERAGE ANNUAL LOSS OF NO. 1 GRADE DUE TO			TOTAL, PER CENT
	Poor color, per cent	Apple scab, per cent	Spray injury, per cent*	
Micronized	10	3	4	17
Micronized and lime	8	2	2	12
Flotation	7	2	3	12
Flotation/Fermate	4	2	1	7
Crag 341	10	2	2	14
Fermate	3	1	1	5
Phygon/Fermate	3	1	2	6
Tag/Fermate	4	1	1	6

*Most of the spray injury occurred in 1952.

plied by 30. The yield of 540 boxes of apples per year over a five-year period for the best treatment is much higher than that attained in most commercial orchards of this area. The yield of 512 boxes per acre of U. S. No. 1 apples in the Fermate plots was even more outstanding. This amounted to an increase of 169 boxes of No. 1 apples over the 343 boxes produced by the poorest treatment (Table 9).

TABLE 9.—SUMMARY OF EFFECTS OF FUNGICIDES ON MCINTOSH YIELDS OVER A PERIOD OF FIVE YEARS, DUBOIS ORCHARD, NEW PALTZ, N. Y., 1949 TO 1953.

FUNGICIDE	TOTAL BOXES PICKED				BOXES OF U. S. NO. 1 APPLES		
	Per tree		Per acre		Per acre		Av. annual increase over flotation sulfur
	5 years	Av.	5 years	Av.	5 years	Av.	
Fermate	90	18	2,700	540	2,563	512	169
Flotation/Fermate	88	18	2,640	528	2,455	490	147
Micronized and lime	87	17	2,610	522	2,297	459	116
Crag 341	81	16	2,430	487	2,090	418	75
Tag/Fermate	74	15	2,220	445	2,087	417	74
Phygon/Fermate	73	15	2,190	438	2,069	414	71
Micronized	77	15	2,310	462	1,918	384	41
Flotation	65	13	1,950	392	1,716	343	0

The percentage of fruit drop varied considerably from year to year, depending, in part, on seasonal weather conditions, use of drop-prevention sprays, and harvest date of the various plots. In 1949, 1950, and 1953, the drop was considered light as it amounted to less than two boxes per tree, including those knocked off during harvest. The drop in 1951 was very heavy. "Color-Set" (2,4,5–trichlorophenoxy-propionic acid) was applied at the rate of ¼ pint to 100 gallons for

drop control on September 15. The drop from plots picked September 17 to 20 was moderate, but those picked after September 24 dropped up to 30 per cent, except for the Tag/Fermate plots where drop was only 18 per cent. Over the five-year period, Phygon/Fermate-sprayed trees showed the greatest fruit drop and Tag/Fermate-sprayed trees the least, considering the date of harvest (Table 10).

Fruit drop is related to maturity, and the effect of each fungicide on the rate of maturity should be taken into consideration in evaluating fruit drop since it was not possible to pick all of the plots at the proper time. Trees sprayed with flotation sulfur all season and those sprayed with flotation/Fermate had about the same percentage of fruit drop, yet the latter plots were picked about a week later each year, except in 1949. Thus, the use of Fermate in place of sulfur in the cover applications made it possible to delay harvest one week without any increase in fruit drop.

Quality

Fruit quality is hard to define, but it depends, in part, on such things as size, color, firmness, taste, and amount of spray, insect, and disease injury.

Size

The effects of fungicides on fruit size were recorded each year and the results summarized for the five-year period. Fruit size was consistently better in the plots sprayed with Fermate all season or in the cover applications (Table 11). Trees that received straight sulfur treatments had the smallest average fruit size. The addition of lime to Micronized resulted in improved fruit size every year compared with the fruit size of trees sprayed with Micronized without lime. The fruit size of the trees sprayed with Crag 341 varied from fair size in 1949, 1951, and 1952 to the smallest size in 1950 and 1953.

Color

Fruit color, firmness, and taste are all related to maturity at the time of harvest as well as weather conditions in the different years. What is reported here with regard to fruit color should be considered in relation to the data presented on the effect of the fungicides on fruit maturity and the harvest dates of the various plots each season (Table 10).

The picking date in 1949 was the same for all plots. Under these conditions, fruit from trees sprayed with sulfur and Crag 341 was more

TABLE 10.—EFFECT OF FUNGICIDES ON MCINTOSH FRUIT DROP IN DUBOIS ORCHARD, NEW PALTZ, N. Y.

FUNGICIDE	HARVEST DATE AND PERCENTAGE FRUIT DROP										Average drop
	1949		1950		1951		1952		1953		
	Date	Drop	Date	Drop	Date	Drop	Date	Drop	Date	Drop	
Micronized	Sept. 15	2	Sept. 23	9	Sept. 17	22	Sept. 12	17	Sept. 14	10	12
Micronized & lime	Sept. 15	3	Sept. 23	8	Sept. 17	20	Sept. 12	16	Sept. 14	9	11
Flotation	Sept. 15	3	Sept. 23	8	Sept. 17	29	Sept. 12	16	Sept. 14	10	13
Flotation/Fermate	Sept. 15	2	Sept. 29	9	Sept. 24	28	Sept. 20	15	Sept. 21	9	12
Crag 341	Sept. 15	3	Sept. 18	6	Sept. 17	21	Sept. 12	11	Sept. 14	10	10
Fermate	Sept. 15	2	Sept. 29	10	Sept. 26	32	Sept. 20	15	Sept. 21	10	14
Phygon/Fermate	Sept. 15	3	Sept. 29	12	Sept. 24	33	Sept. 20	18	Sept. 14	9	15
Tag/Fermate	Sept. 15	1	Sept. 29	7	Sept. 26	18	Sept. 20	14	Sept. 21	9	10

TABLE 11.—EFFECTS OF FUNGICIDES ON FRUIT SIZE AND COLOR OF McINTOSH, DUBOIS ORCHARD, NEW PALTZ, N. Y., 1949–53.

FUNGICIDE *	FRUIT SIZE AND COLOR					
	1949	1950	1951	1952	1953	Average
Number of Apples per Box						
Micronized	126	135	139	127	177	141
Micronized and lime	120	130	136	119	176	136
Flotation	121	137	138	128	178	140
Flotation/Fermate	113	122	130	114	153	126
Crag 341	116	139	128	120	186	138
Fermate	118	125	126	114	163	129
Phygon/Fermate	112	123	133	115	171	130
Tag/Fermate	118	115	120	110	159	125
Percentage of Apples with Fancy Color						
Micronized	79	45	45	82	27	55
Micronized and lime	79	51	54	81	37	60
Flotation	77	53	56	82	37	61
Flotation/Fermate	79	74	67	84	56	72
Crag 341	81	42	56	86	35	60
Fermate	83	79	65	88	63	76
Phygon/Fermate	76	75	71	90	38	70
Tag/Fermate	63	82	56	83	66	70

*All treatments were picked at the same time in 1949, but in the following years all plots with Fermate in the cover applications were picked about a week later than the other plots in an effort to have them picked at the same stage of maturity. In 1953, the Phygon/Fermate plots were picked with the first group.

mature and that sprayed with Tag/Fermate less ripe than the Fermate- and Phygon/Fermate-sprayed fruit. The Tag/Fermate plots in particular showed less fruit color due to early picking. In the other four years, the plots were picked (as closely as convenient) according to the maturity of samples collected a week before the start of harvest. Other samples were collected at harvest for comparison.

Fruit color was best in plots that received Fermate in the cover applications. The addition of lime to Micronized improved fruit color in three of the five years. When picked in relation to fruit maturity, the Tag/Fermate plots produced good fruit color without loss of firmness (Table 11). The percentage of fruit too green for U. S. No. 1 grade varied from year to year but was highest for most treatments in 1951. Micronized and Crag 341 both averaged 10 per cent loss due to poor color during the 1949–53 period (Table 12). If these trees had been picked a week later, they no doubt would have had better fruit color, but the loss from drop would have been greater.

The number of boxes of U. S. No. 1 grade reflects the effect of fungicides on color, scab control, and fruit finish. Fortunately, under the conditions of this experiment, scab was well controlled by all treat-

TABLE 12.—AVERAGE LOSS OF U. S. NO. 1 GRADE FRUIT OVER A FIVE-YEAR PERIOD IN PLOTS SPRAYED WITH DIFFERENT FUNGICIDES IN THE DUBOIS ORCHARD, NEW PALTZ, N. Y.

FUNGICIDE*	PERCENTAGE OF FRUIT TOO GREEN FOR U. S. NO. 1 GRADE					
	1949	1950	1951	1952	1953	AV.
Micronized	4	11	17	3	14	10
Micronized and lime	4	9	13	3	9	8
Flotation	3	9	14	3	7	7
Flotation/Fermate	3	2	10	3	2	4
Crag 341	1	21	11	2	13	10
Fermate	1	4	4	2	2	3
Phygon/Fermate	5	2	8	2	10	5
Tag/Fermate	7	1	10	3	1	4

*All treatments were picked at the same time in 1949, but in the following years, all plots that received Fermate in the cover sprays were picked a week later than the other plots in an effort to have them picked at the same stage of maturity. In 1953, the Phygon/Fermate plots were picked with the first group.

ments. Fruit injury was a major factor in grade of the fruit only in 1952. Considerable fruit injury developed on the sulfur and Phygon/Fermate plots following the high temperatures that occurred in June of that year. The total loss of grade due to poor color, fruit scab, and spray injury was highest for the straight sulfur treatments and Crag 341 (Table 8). Where flotation was followed by Fermate in the cover applications, substantial improvement in color and finish was evident.

Maturity

1949–50 Data

Only one harvest was made in 1949, but it is apparent that fruit sprayed with Crag 341C was softer than that of the other treatments (Table 13). There was some leaf injury from Crag 341C during this season and it is possible that this accounted for the advance in softening rate. There were no other significant differences in fruit firmness at harvest among the different treatments, although Micronized sulfur-sprayed fruit was slightly softer than that sprayed with Fermate, Phygon/Fermate, or Tag/Fermate. The Micronized-sprayed fruit had a much more highly developed ground color at harvest than the other fruits. The Tag/Fermate-sprayed fruits had the greenest ground color. There were no consistent differences in soluble solids, although fruit sprayed with Crag 341C had more than that sprayed with Phygon.

Respiration results show that the Tag/Fermate-sprayed fruits were the slowest in coming to the climacteric peak (Fig. 2). Fruit sprayed with Crag 341C reached the climacteric first, indicating the most

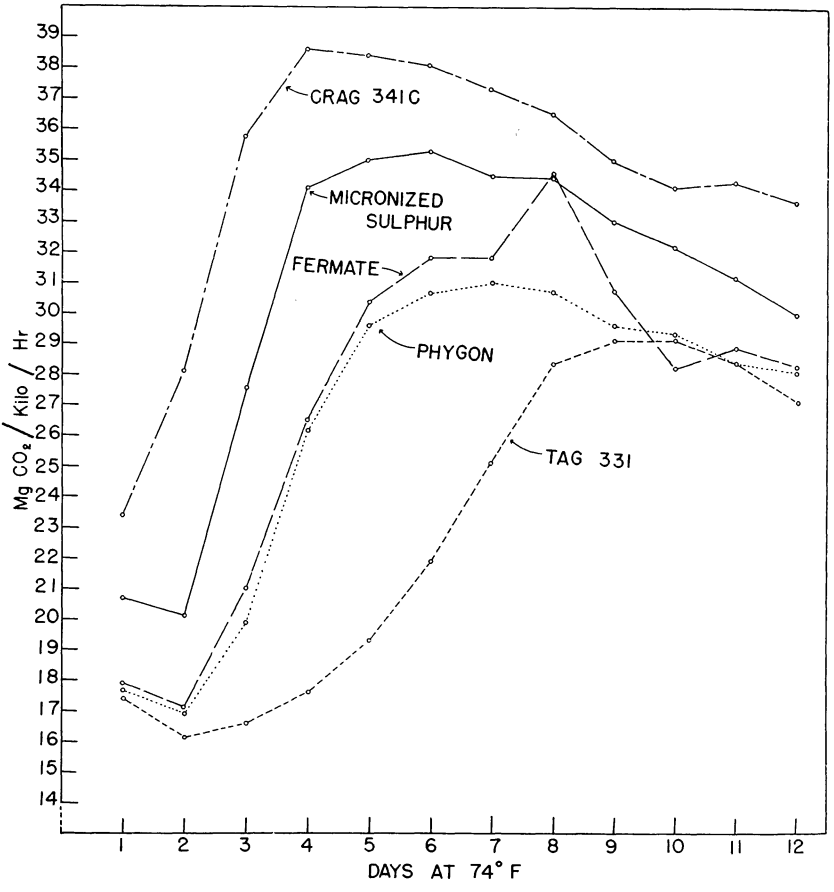

FIG. 2.—Respiration of McIntosh apples as affected by fungicide treatment after harvest on September 7, 1949. Fermate replaced the Phygon and Tag fungicides in the cover applications.

advanced maturity. Micronized-sprayed fruit reached the peak slightly later. Fruit from the Fermate and Phygon/Fermate plots were intermediate between the extremes.

After storage, fruits sprayed with Tag/Fermate and Phygon/Fermate were the most firm, with the Crag 341C-sprayed fruit being the softest (Table 13). There was less scald on the Crag 341C-sprayed fruits, which was probably a reflection of advanced maturity at harvest time.

TABLE 13.—EFFECT OF FUNGICIDES ON MATURITY AT HARVEST AND CONDITION AFTER STORAGE OF McINTOSH APPLES, AVERAGES OF 16 TREES, 1949–50.

TREATMENT	AT HARVEST, SEPT. 7, 1949			AFTER STORAGE, FEB. 18, 1950		
	Firmness, pounds	Ground color*	Soluble solids, per cent	Firmness, pounds	Brown core, per cent	Scald, per cent
Micronized	16.3±.21†	3.1±.06	12.9±.07	9.4±.14	0.0	87±4.2
Fermate	16.7±.14	3.6±.10	12.9±.19	9.5±.10	0.0	95±2.3
Crag 341C	15.1±.25	3.6±.07	13.2±.11	8.8±.11	0.0	54±5.7
Tag/Fermate	16.7±.24	3.9±.07	13.0±.16	10.2±.10	0.0	95±3.9
Phygon/Fermate	16.6±.16	3.6±.12	12.7±.15	10.2±.20	0.0	96±1.8

*The higher the value, the greener the ground color.
†Standard error of mean values.

1950–51 Data

Considerable magnesium deficiency was evident in this orchard during 1950 and this may have confounded the data. It should be noted that the new formulation of Crag was used beginning in 1950.

At harvest time, Fermate-sprayed fruits were slightly firmer than the other fruits (Table 14). There were no other differences in firmness. The Crag 341-sprayed fruit had the most highly developed ground color, but there were no other differences in ground color. The soluble solids content in Crag 341-sprayed fruit was slightly higher than in the other treatments.

TABLE 14.—EFFECT OF FUNGICIDES ON MATURITY AT HARVEST AND CONDITION AFTER STORAGE OF McINTOSH APPLES, AVERAGES OF 16 TREES, 1950–51.

TREATMENT	AT HARVEST, SEPT. 18, 1950			AFTER STORAGE, MAR. 27, 1951		
	Firmness, pounds	Ground color*	Soluble solids, per cent	Firmness, pounds	Brown core, per cent	Scald, per cent
Micronized	14.5±.15	3.8±.10	10.8±.09	9.5±.06	33±6.4	64±3.7
Fermate	15.0±.11	3.7±.06	11.0±.15	9.5±.07	43±5.1	91±2.5
Crag 341	14.6±.17	3.1±.04	11.2±.07	9.6±.07	51±6.4	82±4.2
Tag/Fermate	14.5±.15	3.8±.06	10.8±.08	9.5±.06	33±5.4	64±7.7
Phygon/Fermate	14.4±.13	3.9±.09	10.9±.07	9.3±.09	51±4.2	69±6.4

*The higher the value, the greener the ground color.

Respiration differences were not large, but fruit sprayed with Crag and Tag/Fermate were somewhat later in coming to the climacteric rise than the others (Fig. 3). These two lots also softened more slowly than the other lots during the holding period at 74° F.

All lots were about equally firm after storage. There were some small differences in the amount of brown core, but none that were significant. There was slightly more scald on the Fermate lot after storage.

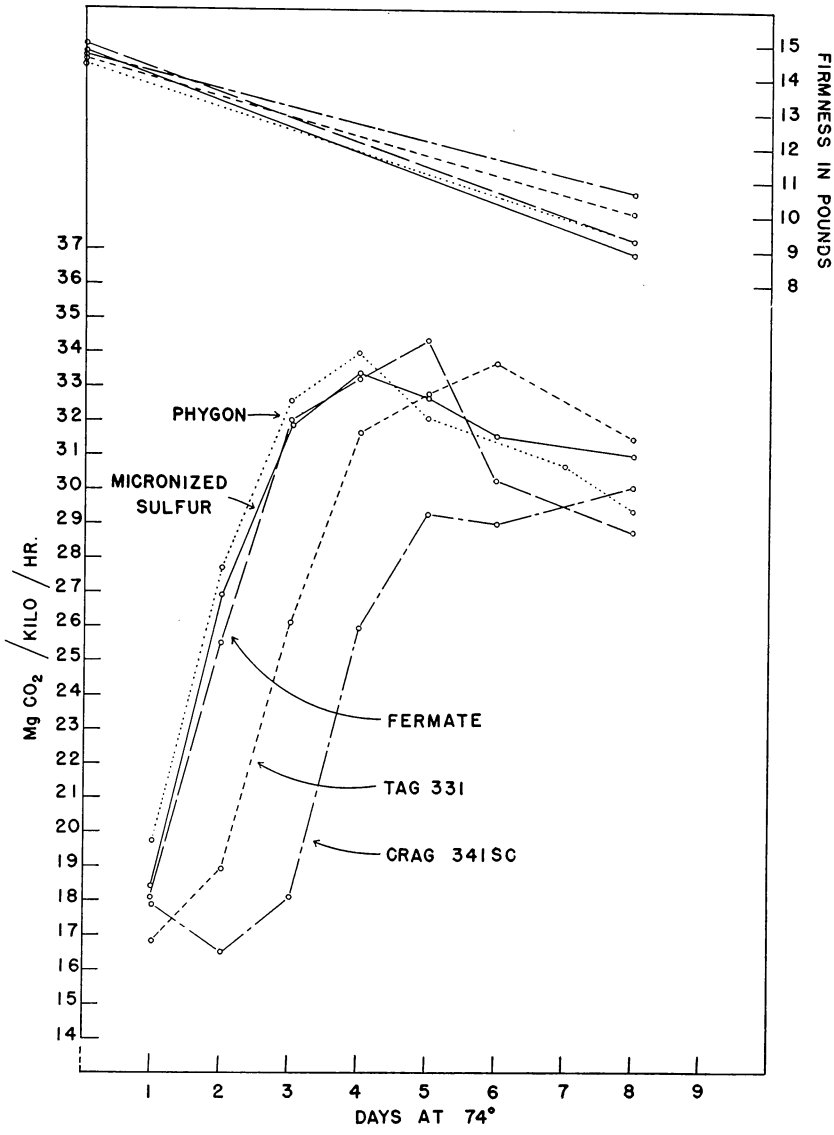

FIG. 3.—Respiration of McIntosh apples as affected by fungicide treatment after harvest on September 18, 1950. Fermate replaced the Phygon and Tag fungicides in the cover applications.

1951–52 Data

At the first harvest date, the Tag/Fermate-sprayed fruits were the firmest (Table 15). The other differences were not significant. The Micronized and Crag 341 treatments had fruit with the most highly developed yellow ground color. There were no differences in soluble solids.

It should be noted that with the second picking, harvesting was done on two different dates three days apart. At this harvest, fruit from the Crag 341 and Micronized plots were softer than that of other treatments even though the apples were picked sooner. The Tag/Fermate-sprayed fruits were firmer than those of the other treatments at this harvest. Crag 341- and Micronized-treated fruits were considerably more yellow in ground color than the others. Tag/Fermate-sprayed fruits were the most green in ground color.

TABLE 15.—EFFECT OF FUNGICIDES ON MATURITY AT HARVEST AND CONDITION AFTER STORAGE OF McINTOSH APPLES, AVERAGES OF 16 TREES, 1951–52.

TREATMENT	AT HARVEST			AFTER STORAGE, MAR. 19, 1952		
	Firmness, pounds	Ground color*	Soluble solids, per cent	Firmness, pounds	Brown core, per cent	Scald, per cent
First Picking, Sept. 11, 1951						
Micronized	15.9±.19	3.4±.06	10.8±.07	11.0±.05	0.0	63±7.8
Fermate	16.2±.15	3.8±.07	10.7±.14	10.9±.13	0.0	74±5.8
Crag 341	16.0±.17	3.3±.07	11.0±.16	10.9±.13	0.0	56±5.6
Tag/Fermate	16.7±.17	3.9±.07	10.9±.09	10.9±.10	0.0	36±7.5
Phygon/Fermate	16.1±.18	3.9±.04	10.7±.08	10.9±.10	0.0	57±4.8
Second Picking, Sept. 21, 1951*						
Micronized	14.1±.23	2.6±.09	———	10.5±.11	0.0	30±5.7
Fermate	14.5±.22	3.0±.08	———	10.6±.10	0.0	48±6.1
Crag 341	13.6±.27	2.4±.13	———	10.2±.13	0.0	23±4.9
Tag/Fermate	15.3±.17	3.5±.05	———	11.2±.08	0.0	14±3.9
Phygon/Fermate	14.5±.16	3.0±.05	———	10.6±.09	0.0	28±3.9

*The higher the value, the greener the ground color.
†Micronized and Crag 341 plots picked Sept. 18, 1951.

Respiration data do not show any marked differences (Fig. 4). There was a slightly higher climacteric peak with Crag 341-sprayed fruits. During the holding period at 74° F, fruit sprayed with Crag 341 softened most rapidly.

After storage, there were no firmness differences in the apples picked first. In the second picking, Tag/Fermate-sprayed fruits were firmer than the other lots. The Crag 341-sprayed fruits were the softest. There

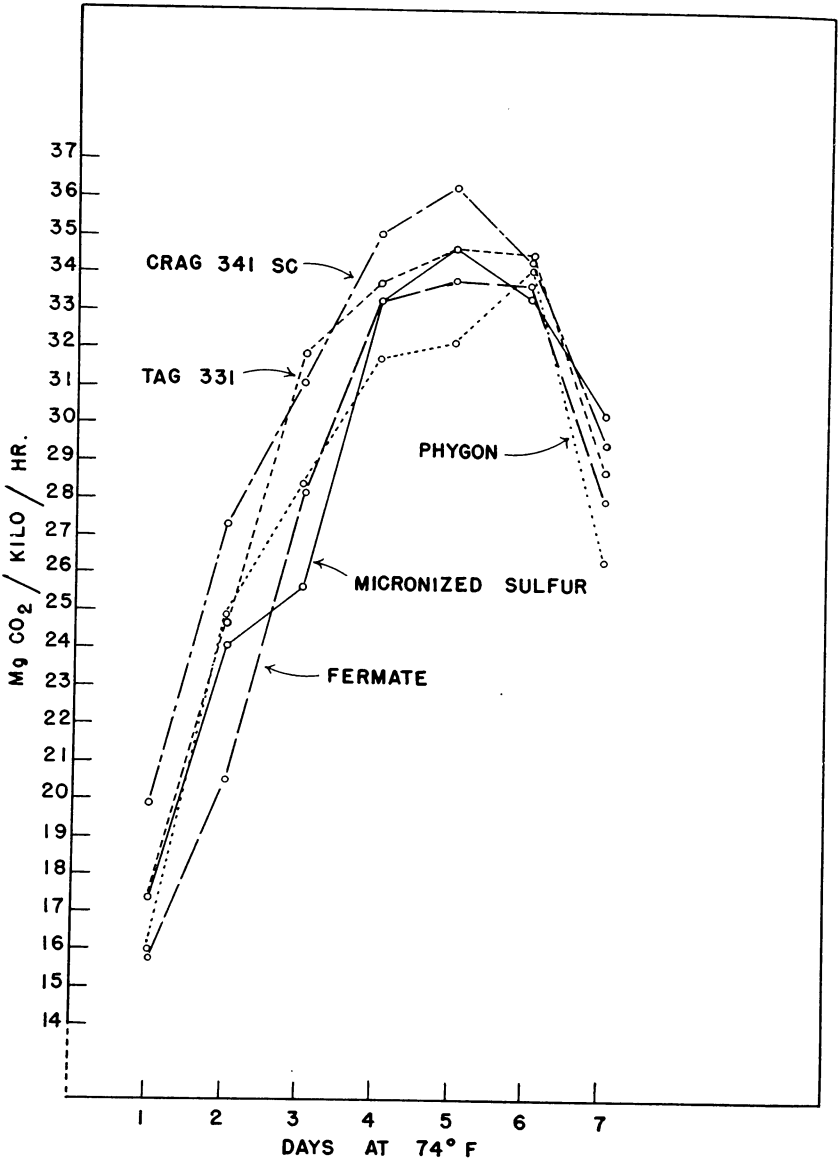

FIG. 4.—Respiration of McIntosh apples as affected by fungicide treatment after harvest September 11, 1951. Fermate replaced the Phygon and Tag fungicides in the cover applications.

was the most scald on the Fermate-sprayed apples and the least on the Tag/Fermate-sprayed fruits.

1952-53 Data

Three pickings were made from three treatments, but only two pickings were made of the Crag and sulfur plots.

During this season, the storage temperature was 34° F instead of 32° F as in all other years.

At the first picking, fruits sprayed with Tag/Fermate and Phygon/Fermate were firmer than those sprayed with Crag 341 or Micronized (Table 16). The latter fruits were the softest. The Tag/Fermate-

TABLE 16.—EFFECT OF FUNGICIDES ON MATURITY AT HARVEST AND CONDITION AFTER STORAGE OF MCINTOSH APPLES, AVERAGES OF 16 TREES, 1952–53.

TREATMENT	AT HARVEST		AFTER STORAGE, MAR. 26, 1953		
	Firmness, pounds	Ground color*	Firmness, pounds	Brown core, per cent	Scald, per cent
	First Picking, Sept. 5, 1952				
Micronized	15.1 ± .15	3.6 ± .13	10.2 ± .06	27 ± 6.4	79 ± 6.5
Fermate	15.6 ± .10	3.9 ± .06	10.3 ± .06	22 ± 5.7	99 ± 0.7
Crag 341	15.5 ± .11	3.3 ± .12	10.1 ± .10	14 ± 3.8	92 ± 3.1
Tag/Fermate	15.9 ± .08	4.0 ± .00	10.7 ± .06	31 ± 6.0	65 ± 5.9
Phygon/Fermate	15.9 ± .08	3.8 ± .10	10.6 ± .06	13 ± 3.2	96 ± 1.7
	Second Picking, Sept. 11, 1952				
Micronized	15.2 ± .15	2.9 ± .08	10.0 ± .14	27 ± 7.8	74 ± 6.5
Fermate	15.9 ± .12	3.1 ± .07	10.0 ± .05	28 ± 5.3	75 ± 6.5
Crag 341	15.4 ± .12	2.6 ± .12	9.8 ± .09	14 ± 3.6	42 ± 5.1
Tag/Fermate	16.2 ± .08	3.1 ± .09	10.9 ± .03	12 ± 3.2	48 ± 8.5
Phygon/Fermate	16.1 ± .09	3.3 ± .06	10.4 ± .08	20 ± 4.8	76 ± 6.2
	Third Picking, Sept. 18, 1952				
Micronized	———	———	———	———	———
Fermate	14.7 ± .31	2.8 ± .14	9.8 ± .08	3 ± 1.5	76 ± 4.4
Crag 341	———	———	———	———	———
Tag/Fermate	15.3 ± .29	3.1 ± .09	10.5 ± .08	1 ± 0.9	31 ± 5.5
Phygon/Fermate	14.9 ± .27	2.8 ± .10	10.1 ± .06	5 ± 2.4	54 ± 6.8

*The higher the value, the greener the ground color.

sprayed fruits had the greenest ground color. Crag 341- and Micronized-sprayed lots had the most yellow ground color.

At the second harvest date, fruits sprayed with Tag/Fermate and Phygon/Fermate were again the firmest with Crag 341- and Micronized-sprayed fruits being the softest. Fruits sprayed with Phygon/Fermate, Tag/Fermate, and Fermate were the greenest in ground color followed by those sprayed with Micronized and Crag 341.

Firmness differences were not significant at the third picking, but Tag/Fermate-sprayed fruits were slightly firmer than the others. Tag/Fermate-sprayed fruits had the greenest ground color of all lots at this picking.

The Tag/Fermate-sprayed fruits reached the climacteric peak later than other lots (Fig. 5). The other differences were not large, but fruits sprayed with Crag 341 and Micronized reached the climacteric the earliest. The Tag/Fermate-sprayed fruits softened most slowly during the holding period at 74° F.

After storage, the Tag/Fermate-sprayed fruits were somewhat firmer than the other lots, although the differences were not always significant. The Phygon/Fermate-sprayed fruits were next in firmness with the fruit sprayed with Crag 341 and Micronized being least firm.

The Tag/Fermate-sprayed fruits had slightly less scald than the other lots, except for Crag 341 at the second picking. Brown core differences were not consistent or significant.

1953–54 Data

At the first picking, fruits sprayed with Tag/Fermate and Fermate were firmer than those sprayed with Micronized, Crag 341, and Phygon/Fermate. The Tag/Fermate- and Fermate-sprayed fruits were slightly more green in ground color than the others.

At the second picking, fruit from the Tag/Fermate plots was firmer than that from the Micronized and Phygon/Fermate plots. The Fermate- and Crag 341-sprayed fruits were intermediate between these two extremes in firmness. The Tag/Fermate-sprayed fruits were slightly greener in ground color than the others.

At the third picking, fruit from the Tag/Fermate plots was firmer than that from the Fermate plots.

The Crag 341 data on respiration are missing as this sample was lost due to an accident. The Tag/Fermate-sprayed fruits were definitely the latest in reaching the climacteric (Fig. 6). The Phygon/Fermate-sprayed fruits were the first to reach the respiratory peak followed by the fruit from the Fermate and Micronized plots. The fruit from the Fermate plots would have been expected to follow that from the Micronized plots in its respiratory rise on the basis of other data. Why this discrepancy occurred is not known.

After storage, the Tag/Fermate-treated fruit was the firmest (Table 17). Other comparisons showed no real differences in firmness. None of these fruits showed any brown core. Scald was very severe even on the

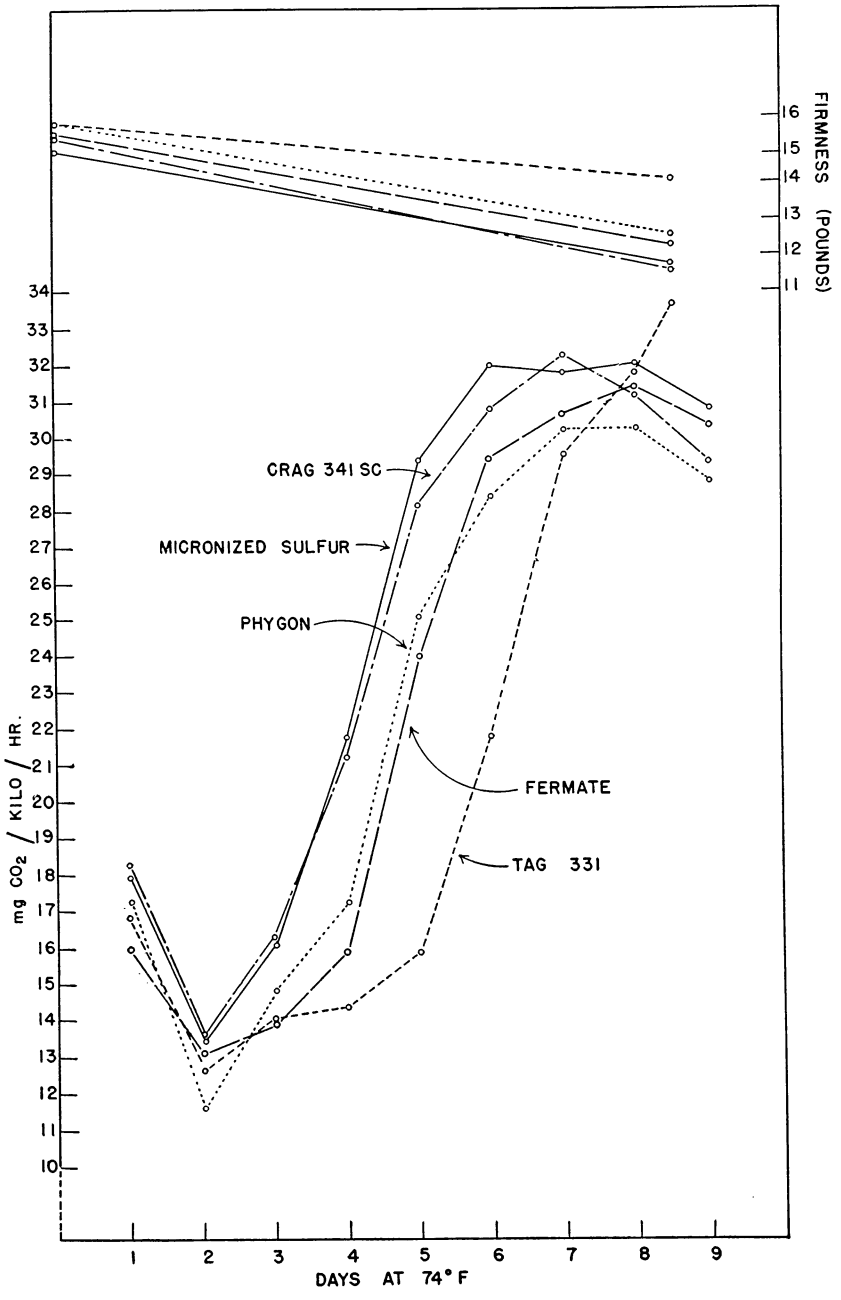

FIG. 5.—Respiration of McIntosh apples as affected by fungicide treatment after harvest September 5, 1952. Fermate replaced the Phygon and Tag fungicides in the cover applications.

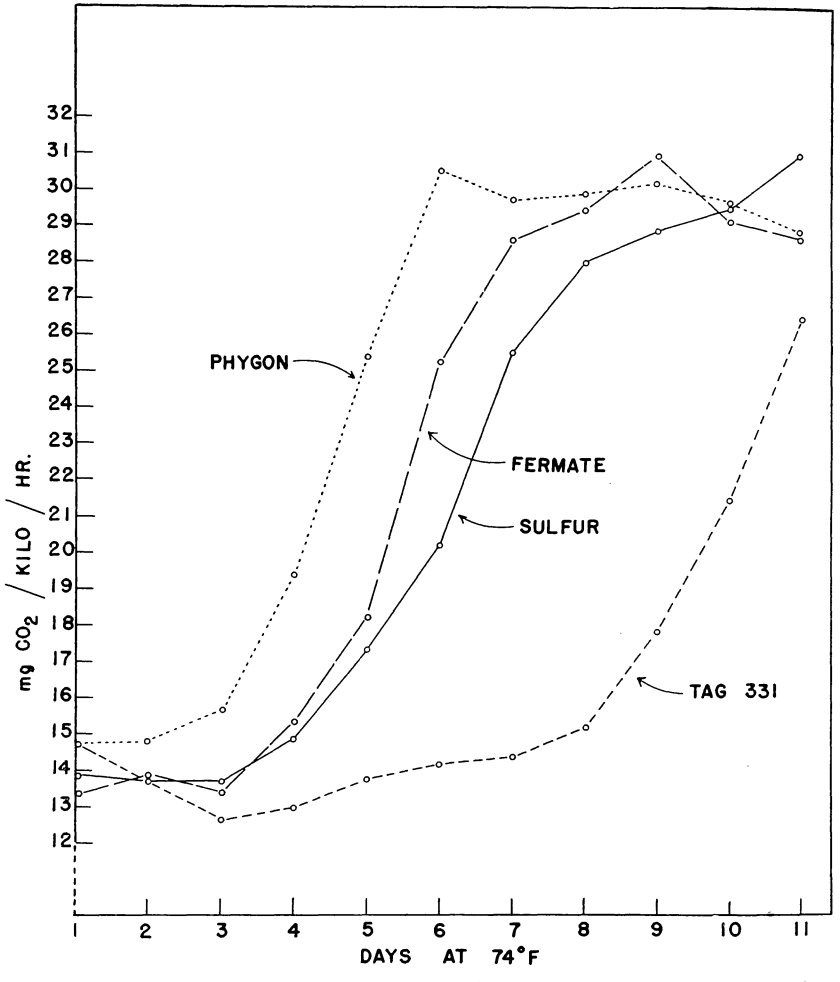

FIG. 6.—Respiration of McIntosh apples as affected by fungicide treatment after harvest September 4, 1953. Fermate replaced Phygon and Tag in the cover applications.

latest picked fruit. Differences in scald as affected by treatment were not consistent from picking to picking. An injury showed up on the red sides of these fruits. It is listed as "black scald" (Table 17). Differences due to treatments were not significant.

An attempt was made to summarize the data and rate the treatments as to their effect in delaying or hastening maturation on the tree. In

TABLE 17.—EFFECT OF FUNGICIDES ON MATURITY AT HARVEST AND CONDITION AFTER STORAGE OF MCINTOSH APPLES, AVERAGES OF 16 TREES, 1953–54.

TREATMENT	AT HARVEST		AFTER STORAGE, MAR. 22, 1954			
	Firmness, pounds	Ground color*	Firmness, pounds	Scald, per cent	Black scald, per cent	Brown core, per cent
			First Picking, Sept. 4, 1953			
Micronized.....	18.3 ± .25	3.9 ± .05	12.3 ± .12	85 ± 4.0	30 ± 4.0	0.0
Fermate.....	19.2 ± .15	4.0 ± .00	12.3 ± .10	95 ± 2.0	44 ± 4.0	0.0
Crag 341.....	18.6 ± .12	3.8 ± .06	12.5 ± .10	96 ± 1.0	34 ± 2.0	0.0
Tag/Fermate...	19.4 ± .19	4.0 ± .00	12.9 ± .12	79 ± 7.0	37 ± 5.0	0.0
Phygon/Fermate	18.5 ± .16	3.9 ± .04	12.4 ± .08	92 ± 4.0	50 ± 5.0	0.0
			Second Picking, Sept. 14, 1953			
Micronized.....	15.8 ± .19	3.4 ± .09	11.5 ± .16	74 ± 5.0	31 ± 3.5	0.0
Fermate.....	16.2 ± .08	3.4 ± .08	11.8 ± .12	93 ± 2.0	49 ± 3.5	0.0
Crag 341.....	16.1 ± .22	3.5 ± .10	11.8 ± .12	70 ± 7.0	37 ± 4.8	0.0
Tag/Fermate...	16.6 ± .22	3.7 ± .11	12.4 ± .09	75 ± 2.0	22 ± 3.0	0.0
Phygon/Fermate	15.8 ± .18	3.5 ± .09	11.5 ± .13	92 ± 2.0	35 ± 4.0	0.0
			Third Picking, Sept. 21, 1953			
Fermate.....	15.2 ± .04	2.5 ± .12	11.0 ± .09	69 ± 4.0	26 ± 5.0	0.0
Tag/Fermate...	16.0 ± .04	2.7 ± .11	11.6 ± .10	70 ± 7.0	19 ± 4.0	0.0

*The higher the value, the greener the ground color.

doing this, firmness and ground color data were used over the five-year period. Only significant differences between treatments were included. The data from each treatment were compared with every other treatment to see if one treatment was less mature at harvest time than the others. As a result of this rating scheme, the following values were obtained, with the highest values indicating the least mature fruit: Tag/Fermate, 36; Fermate, 24; Phygon/Fermate, 9; Micronized, 4; and Crag 341, 2.

It is clear from these data that Tag delayed maturity the most. Fermate delayed maturity considerably in comparison with Phygon/Fermate, Micronized, and Crag 341. Phygon/Fermate delayed maturity slightly in comparison with Micronized and Crag 341. Fruit sprayed with Crag 341 was about the same in reaching a given maturity as fruit sprayed with Micronized.

In the years in which there were marked respiratory differences, it was clear that the Tag/Fermate-treated fruits were the latest in reaching the climacteric peak. This would again be an indication of delayed ripening. Respiration data were not entirely consistent from year to year, but there was a definite suggestion of accelerated fruit ripening in several years with the Crag 341 and Micronized treatments.

An attempt was made to express the acceleration in maturity due to certain sprays in terms of actual days. This, at best, can only be an approximation. In the three years in which two pickings were made, the actual rate of softening could be plotted. It could be seen on such a graph that Micronized-sprayed fruit, for example, passed the value for the Tag/Fermate-sprayed fruit several days earlier. In the two years in which only one picking was made, it was estimated that the softening rate was 1 pound each 7 days to arrive at the values given in Table 18.

TABLE 18.—THE COMPARATIVE EFFECT OF FUNGICIDES ON DATE OF MATURITY OF McINTOSH FRUITS EXPRESSED ON BASIS OF FRUIT FIRMNESS.

TREATMENT	NO. DAYS FRUIT MATURED IN ADVANCE OF TAG/FERMATE PLOTS					
	1949*	1950*	1951	1952	1953	Av.
Crag 341	8	0	8	7	6	6
Micronized	4	0	8	13	7	6
Phygon/Fermate	1	0	5	4	7	3
Fermate	0	−3	5	3	2	1

*Estimated values.

There are variations in the results from year to year as shown in Table 18, but it is clear that the same trend is apparent as mentioned in the rating scale. Fruit from the Crag 341 and Micronized plots matured about one week ahead of that from the Tag/Fermate plots, for example. It is noteworthy that no particular differences in time of maturation were noted in 1950.

Scald differences were not consistent from year to year, but there was a suggestion of more scald with Fermate-sprayed apples in some years. Significant differences in scald between the treatments for the first two pickings were used in preparing a rating scale for the five-year period. The following values were obtained, with the highest indicating the most scald: Fermate, 23; Phygon/Fermate, 10; Crag 341, 6; Micronized, 5; and Tag/Fermate, 1. On the basis of fruit maturity, one would have expected the most scald with Tag/Fermate, but this was certainly not the case.

Cost

The cost of the different fungicide treatments varied from a minimum of $17.25 per acre per year, or 4½ cents per box for the flotation sulfur program, to a maximum of $53.50 per acre per year, or 11 cents per box for the Tag/Fermate program. The cost of Fermate all season

was $39.75 per acre per year, or 7½ cents per box (Table 19). When the cost was divided by the number of boxes of U. S. No. 1 fruit, the differences were less striking since some of the more expensive materials increased the proportion of No. 1 fruit. Thus, the all-season Fermate program, which cost 2½ cents a box more than Micronized on the total picked yield data, increased the cost only 1 cent per box when figured on the yield of U. S. No. 1 fruit. Put another way, an increase of 128 boxes of U. S. No. 1 fruit was produced at an additional cost of about 1 cent per box (Table 19).

TABLE 19.—THE AVERAGE COST OF FUNGICIDES OVER A FIVE-YEAR PERIOD, DUBOIS ORCHARD, NEW PALTZ, N. Y., 1949–53.

FUNGICIDE	AV. YIELD PER ACRE		ANNUAL COST PER ACRE†	COST PER BOX	
	Total No. boxes*	U.S. No. 1 boxes		Total picked apples	U.S. No. 1 apples
Micronized	462	383	$26.00	$.055	$.068
Micronized & lime	522	459	28.50	.055	.064
Flotation	392	343	17.25	.045	.051
Flotation/Fermate	528	490	30.25	.055	.062
Crag 341	487	418	35.75	.075	.088
Fermate	540	512	38.75	.075	.079
Phygon/Fermate	438	414	35.75	.080	.085
Tag/Fermate	445	417	53.50	.110	.119

*Total boxes of picked fruit.
†Costs based on 1953 prices.

Discussion and Conclusions

All of the materials used in this experiment to determine the effect of fungicides on yield and quality of fruit provided adequate control of apple scab during the five-year period of 1949–53. This control was accomplished with an average of 11 fungicide applications per year, 5 of which were made before petalfall. Conditions were favorable for scab development each year and unsprayed trees in an adjoining orchard were defoliated by scab every year of the experiment. Good timing of the applications in a protective schedule was responsible for the good scab control. With poorer timing of the applications, Phygon and Tag might be expected to show to advantage in that they may control scab when applied after infection periods have occurred. Since this experiment began, the use of these two eradicant-type fungicides at full strength in a protective schedule is no longer being suggested. They may be used to advantage for a few emergency applications on a half-and-half basis with protective fungicides such as ferbam or glyo-

din, or at full strength, depending upon the duration of the wetting period. In the present experiment, however, they were continued as originally planned since there was interest in determining what results might follow such use.

Fermate appeared to be the safest of the fungicides tested for all-season use on McIntosh when arsenate of lead was used as the main insecticide. This was indicated by the appearance of the trees, the chlorophyll content of the leaves, the length of terminal growth, the formation of fruit spurs, and the set of fruit. The net result was that, after the first three years of adjustment, the yield of picked fruit from trees sprayed with Fermate increased in 1952 and 1953 while that of the other treatments decreased. The improvement in fruit size and color on the Fermate-sprayed plots, due, in part, to the later picking date, further increased the amount of U. S. No. 1 fruit over that produced with the other treatments. Full-season sulfur and Crag 341 treatments on McIntosh lowered the chlorophyll content of the leaves and indirectly reduced fruit size and yield. Such a condition might not be apparent in an orchard sprayed with only one material, but in these comparative tests the darker green color of the leaves in the plots sprayed with Fermate was quite evident. Darker foliage may be partly a result of the black Fermate spray residue, but the chlorophyll content was also greater.

Trees sprayed with flotation sulfur in the pre-cover period and Fermate in the cover applications ranked next to the all-season Fermate program in yield of U. S. No. 1 fruit, whereas the all-season flotation sulfur treatment had the lowest yield of U. S. No. 1 fruit. This would indicate that most of the sulfur-arsenate of lead injury occurred in the summer period.

The addition of lime to Micronized sulfur improved scab control, fruit size, and fruit color. Some of these differences were small, but since they have occurred over a 5-year period they must be significant as indicated by the increased amount of U. S. No. 1 fruit. It appears that part of the problem with the wettable sulfur fungicides is their incompatibility with arsenate of lead, especially when lime is not used.

Phygon used alone in the early sprays caused some foliage injury in the form of chlorosis or yellowing of the spur and basal terminal leaves. The use of Fermate on these plots during the cover applications prevented greater loss of leaf efficiency. The use of ¼ pound of Phygon with ¾ pound of Fermate in 100 gallons of spray has given good dis-

ease control with less injury than resulted from the Phygon as used in this experiment.[6]

The foliage of the trees sprayed with Tag during the early season looked thin in 1952 and 1953 and may have been associated with the frequent rain periods. The use of Fermate in the cover applications allowed the trees to recover sufficiently to produce a good bloom the following years. Here again, a mixture of Tag and Fermate, half and half, in the early applications would probably have caused less injury and given as good disease control as the full strength mercury.[7]

Fruit injury was serious only in 1952 and resulted from high temperatures in early June. Typical sulfur-sun scald developed on the fruit in all plots that had received sulfur, but it was much more severe where the sulfur program was continued through the cover applications.

Fruit sprayed with Phygon in the pre-cover applications showed a different type of fruit injury. This russet injury also started as a result of the high temperatures, but some of the fruit outgrew it by harvest.

Fermate, Crag 341, and Tag/Fermate treatments produced the best fruit finish. There was some enlargement of the lenticels at the blossom end of the Fermate-sprayed fruit, but it was not serious enough to reduce grade. These enlarged lenticels may be correlated with the occurrence of scald on the stored fruit from the Fermate plots.

Visible spray residue was not a problem as far as the fungicides were concerned in this experiment. Since scab was kept under control, late applications were unnecessary. The latest fungicide applications were made in June in three years and the first week of July in the other two.

Fungicide applications made during the bloom period in 1953 resulted in a serious reduction of fruit set with Tag and a slight reduction with Micronized, flotation, Phygon, and Crag 341. Trees sprayed with Fermate had the highest percentage set. Although fruit set records were not taken in 1952, the yield records indicate similar reductions in set that year. Since fungicide applications were required during bloom in four of the five years, the use of a mild fungicide during that period would be an important factor in maintaining high yields.

Relatively little research has been done on the effect of spray materials on fruit maturity and keeping quality. It has been observed fre-

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[6]Palmiter, D. H., and Emerson, F. H. Results of 1952 tests with fungicide mixtures for the control of apple scab and quince rust. *Plant Dis. Rptr.*, 37: *11–13. Jan. 15, 1953.*

[7]*Loc. cit.*

quently that pesticides which have a tendency to cause injury hasten maturity in certain years. Gerhardt and O'Neill[8] showed that the ripening characteristics and storage behavior of apples were not affected by either DDT or parathion. Garman, Keirstead, and Mathis[9] claimed that Crag 341 tended to increase the sugars in apples. They stated that a Phygon-lead arsenate program reduced the acid content of apples. Their findings led them to believe that lead arsenate sprays consistently affected flavor unfavorably in Baldwin and Gravenstein but not so much in McIntosh fruits.

In this experiment, the effect of fungicide treatments was quite evident each year, with the exception of 1950. Maturity was indicated by ground color of the fruit, firmness, pre-harvest drop, and respiration rate. Fruit from the various treatments ripened in the following order: Crag 341, Micronized, Phygon/Fermate, Fermate, and Tag/Fermate. The time interval between the earliest and latest maturing treatments varied from year to year but averaged about six days.

Perhaps the organic mercury in the Tag and the nitrogen or iron in the Fermate have a direct effect on the physiology of the plant. In certain years, such as 1949, there was actual visible leaf injury from Crag 341C and a marked stimulation in ripening on the tree.

Firmness data after storage did not show any differences that were not apparent at harvest time. In general, the apples that went into storage in the most firm condition were the most firm after storage. There was no indication that one lot of fruit ripened more slowly than another in storage. It should be noted, however, that apples stored together, as these were, tend to approach the same values in storage.

There were no consistent or significant trends in soluble solids at harvest time as affected by fungicides.

There were no differences in brown core attributable to the fungicide treatments.

Scald differences were not consistent from year to year, but there was a suggestion of more scald with Fermate-sprayed apples in some years.

It was found that under the conditions of this experiment the use of Fermate all season or in the cover applications increased the production of U. S. No. 1 fruit sufficiently to justify the added cost. The best

[8]Gerhardt, Fisk, and O'Neill, W. J. Storage and ripening of apples and pears as influenced by DDT and parathion sprays. *Proc. Wash. State Hort. Assoc.,* 45: *51–55. 1949.*

[9]Garman, Philip, Keirstead, L. G., and Mathis, W. T. Quality of apples as affected by sprays. *Connecticut Agr. Exp. Sta. Bul. No. 576. 1953.*

fungicide treatment tested (based on cost and yield) was flotation sulfur paste in the pre-cover applications followed by Fermate in the cover applications. This combination resulted in next to the highest yield of U. S. No. 1 fruit at a cost of about 6 cents per box.

Summary

1. Eight fungicide treatments were applied to McIntosh apple trees over a period of five years (1949–1953) to determine the effects on yield and quality.

2. The treatments included (1) Micronized wettable sulfur, (2) Micronized plus lime, (3) Everett flotation sulfur paste, (4) Everett flotation in the pre-cover sprays followed by Fermate in the cover applications, (5) Crag Fruit Fungicide 341, (6) Fermate, (7) Phygon XL in the pre-cover applications followed by Fermate in the cover sprays, and (8) Tag Fungicide 331 in the pre-cover sprays followed by Fermate in the cover applications. Arsenate of lead was the main insecticide used in combination with the fungicides.

3. All of the treatments provided adequate control of apple scab during the five-year period. The unsprayed trees were 100 per cent infected each year.

4. Fermate proved to be the safest of the test fungicides for all-season use on McIntosh in this experiment. This was indicated by the appearance of the trees, the chlorophyll content of the leaves, tree growth, and set of fruit.

5. After the first three years of adjustment, the yield of picked fruit from the trees sprayed with Fermate increased in 1952 and 1953 while that of the other treatments decreased. The Fermate produced the greatest amount of U. S. No. 1 fruit (512 boxes per acre) as a result of consistent yields of fruit with good size and color.

6. Trees sprayed with flotation sulfur in the pre-cover period and Fermate in the cover applications ranked next to the all-season Fermate program in yield of U. S. No. 1 fruit (490 boxes per acre), whereas the all-season flotation sulfur treatments had the lowest yield of U. S. No. 1 fruit (343 boxes per acre).

7. The use of sulfur during the summer period resulted in reduced chlorophyll content of leaves, poor fruit size and color, considerable sulfur-sun scald fruit injury in 1952, and reduced fruit set in 1953.

8. The addition of lime to Micronized sulfur improved scab control and fruit size and color. It appears that part of the problem with wet-

table sulfur fungicides is their incompatibility with arsenate of lead, especially if lime is not used.

9. Crag Fruit Fungicide 341 did not show to advantage in this experiment due to the use of arsenate of lead as the insecticide. Even though lime was used, it was evident from foliage injury, reduced chlorophyll content of leaves, and reduced yield of U. S. No. 1 fruit that this combination of spray materials was not satisfactory for top production of quality fruit.

10. Phygon XL and Tag Fungicide 331 provided the best scab control. However, since all treatments resulted in satisfactory scab control in this experiment, this advantage was of minor importance. There were indications of foliage injury and reduced fruit set following the use of these fungicides in the pre-cover sprays.

11. The fungicide treatments affected the maturity date of McIntosh apples. Fruit from the various treatments ripened in the following order: Crag 341, Micronized, Phygon/Fermate, Fermate, and Tag/Fermate. The time interval varied from 0 to 13 days depending upon the season.

12. The cost per acre for the various fungicide treatments varied from $17.25 to $53.50. The cost per box of U. S. No. 1 fruit varied from 5 to 12 cents. While the cost per acre for the organic fungicides was greater than for the sulfur materials, the use of Fermate alone or in combination with sulfur increased the production of U. S. No. 1 fruit sufficiently to justify the added cost.