Influence of Certain Nitrogen and Fungicide Applications on Yield and Quality of Apples

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New York State
Agricultural Experiment Station
Cornell University, Geneva, N. Y.

Bulletin No. 766

April, 1954

Contents

Frontispiece illustrates typical operation followed in the course of the experiments reported here. The orchard is representative of the commercial plantings used in the study.

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Influence of Certain Nitrogen and Fungicide Applications on Yield and Quality of Apples

D. H. PALMITER AND J. M. HAMILTON[1]

Abstract

RESULTS of long-term experimentation are presented on the effect of various soil and foliage applications of nitrogenous materials, particularly urea (Uramon or NuGreen), in combination with a wettable sulfur, on apple yields, fruit quality, orchard vigor, and apple scab control. Fermate (ferbam), was included as one of the foliage spray treatments.

The data over a nine-year period indicate that the inclusion of urea 5–100 in the first three pesticide sprays following bloom maintained apple trees at a satisfactory level of nitrogen nutrition. It is possible to influence the set, size, and color of fruit by altering the number of urea foliar applications and the time of the spray with respect to the stage of tree development.

Fruit drop increased as the nitrogen level rose with both foliage and soil applications of nitrogen. Fruit color decreased more with soil application than with foliage applications.

The addition of soluble complete fertilizer, of mixtures of minor elements, and of physical adjuvants to the urea spray mixture appears to be of questionable value for the average orchard.

Urea was found to be compatible with standard pesticides and may be used on standard varieties in western New York. Tests indicated that injury may occur at concentrations above 24 pounds to 100 gallons of spray.

Trees receiving foliage applications of urea showed a lower incidence of apple-scab infection than those with soil treatments of nitrogen but with the same sulfur spray program.

Trees sprayed with Fermate without additional nitrogen outyielded those sprayed with wettable sulfur with or without supplemental nitrogen.

Continuous use of sulfur and arsenate of lead without lime lowered the pH of the soil to an undesirable level.

Fermate-sprayed trees maintained their yield without raising the nitrogen level and, thus, were more resistant to scab infection.

Fruit from trees sprayed with Fermate dropped less at harvest, had better color, and was firmer and larger than that from trees sprayed with sulfur and treated with nitrogen to maintain yield.

[1]The writers wish to acknowledge the assistance of Dr. G. L. Mack of this Station in the analytical determinations.

Introduction

WORK done in 1942 suggested the possibility that the application of urea (Uramon or NuGreen) as a foliar spray might be a means of regulating the nitrogen supply of apple trees (8)[2] and thus influence susceptibility to apple scab (*Venturia inaequalis,* Cke. and Winter). Interest in foliar feeding of fruit trees was further stimulated by findings made on the mode of leaf penetration and translocation of Fermate (ferbam) in relation to its effectiveness against the cedar-apple rust fungi, and observations on the possible nutritional value of Fermate to fruit trees (9, 13).

Analyses of the foliage of potted greenhouse-grown Medina apple trees sprayed with Uramon indicated that the tree takes up an appreciable amount of nitrogen with this method of application (Table 1).

TABLE 1.—THE ENTRANCE OF UREA NITROGEN THROUGH THE EPIDERMIS OF APPLE LEAVES GROWN ON POTTED GREENHOUSE MEDINA TREES AT GENEVA, N. Y.

TREATMENT	HOURS IN MOIST CHAMBER	POSITION OF LEAF FROM END OF TERMINAL	TOTAL NITROGEN MG/CM²
Series 1, March 9, 1943			
Untreated	None	1, 4, 6	0.21
Uramon 5–100 + lime 3–100	None	1, 4, 6	0.24
Series 2, March 11, 1943			
Untreated	24	2, 3	0.14
Uramon 5–100 (lower side only)	24	2, 3	0.20
Uramon 5 + lime 1–100 (lower side only)	24	2, 3	0.19
Uramon 5 + lime 1–100 (top side only)	24	2, 3	0.17
Uramon 5 + lime 1–100 (lower side only)	None	2, 3	0.22
Uramon 8 + lime 1–100 (lower side only)	24	2, 3	0.23
Biuret 2.7–100 (lower side only)	24	2, 3	0.16
Series 3, April 14, 1943			
Untreated	None	5, 7	0.19
Uramon 5–100 + lime 3–100	None	5, 7	0.24
Uramon 5–100 + lime 3–100	24	5, 7	0.17
Series 4, April 16, 1943			
Untreated	None	6	0.15
Untreated	24	6	0.12
Uramon 5–100	None	6	0.19
Uramon 5–100	18*	6	0.17
Uramon 5–100 + lime 3–100	18*	6	0.16
Uramon 5–100	24	6	0.13

*Trees dried 6 hours after spraying before placing in moist chamber.

[2]Figures in parenthesis refer to Literature Cited, page 40.

Nitrogen is taken up by the leaf through both the upper and lower surfaces, particularly the latter. The greenhouse data indicated that an appreciable amount of nitrogen was taken up within a few hours but that the degree of uptake was significantly correlated with relative humidity, moisture, and rate of drying.

A review of the literature pertinent to the uptake of nutrients by leaves of fruit trees is given by Tukey (16), together with results of substantiating experimentation which included work with radio-active isotopes. Rodney (14), Cook and Boynton (4), and Boynton, Margolis, and Gross (2) give further support to this thesis.

The orchard tests were designed for comparative evaluation of the effects of both foliar and ground applications of nitrogenous compounds on fruit yield, fruit quality, orchard vigor, and scab control. Ferbam was also used as one of the foliar treatments. Wettable sulfur was used as the basic fungicide.

Data from the McIntosh orchard of W. A. McKiernan located at Rock City in the Hudson Valley are presented in detail since they were least affected by limitations and since an individual tree yield record was available for the two seasons previous to the beginning of the test. Additional data from this and other orchards will also be presented, in less detail, in an attempt to give further information on how foliage spraying with nitrogenous materials may help to maintain a satisfactory level of nitrogen, and to emphasize the importance of the possible influences of limiting cultural and environmental factors which might interfere and mask the full effect of foliar sprays. While NuGreen was tested as a dilute spray in these operations, it was also evaluated as a concentrate. Compatibility with certain of the standard fungicides as to scab control and spray injury was ascertained. It was hoped that a spray program could be developed that would maintain high production without increasing the problem of scab infection or reducing the long-term vigor of the orchard.

Orchard Experiments

McKiernan Orchard (McIntosh)

Experimental Procedure

Urea applications were made to soil and foliage alone and in combination with sulfur and arsenate of lead in a uniform block of 18-year-old McIntosh trees at Rock City, N. Y. The trees were spaced 40 × 40 feet and were kept in grass sod culture throughout the experiment. The soil type was a well-drained Hoosic gravelly loam.

Applications were made with a hydraulic sprayer, using a spray gun at 500 pounds pressure. From 1943 to 1948 all sprays were applied from the ground, but after 1948, when the plots were simplified, most of the applications were made from the top of the sprayer. The trees were sprayed to the point of drip avoiding excessive run-off.

Single tree plots replicated seven times were set up to compare single soil applications broadcast under the branches at the rates of 2.5, 5, and 7.5 pounds of NuGreen[3] per tree each spring with three post-bloom foliage applications comparing 3, 5, and 8 pounds of NuGreen to 100 gallons of water.

NuGreen applied to the foliage was included with the wettable sulfur and arsenate of lead. There was also one treatment of NuGreen 5–100 without the pesticides sprayed on the ground at the same time as the foliar applications. Approximately 18 to 20 gallons of spray per tree per application were used on both the ground and foliage. At this rate, NuGreen 5–100 would furnish about 2.5 pounds of NuGreen per tree per season.

Two sets of unfertilized trees were included in the experiment. One was sprayed with sulfur the same as the fertilized plots and the other was sprayed with Fermate[4] 1½–100 throughout the season each year. The arrangement of treatments and replications is shown in Fig. 1.

Micronized wettable sulfur was used as the standard fungicide throughout the experiment. However, from 1943 to 1948 each replicate received a different wettable sulfur fungicide in either paste or powder form. Where apple scab control data are given, they are based on control with Micronized used at 5–100 from 1943–48 and at 8–100 in the pre-cover applications from 1949–51. Spray lime was used in equal amounts with arsenate of lead during the last three years of the experiment.

Using the average yield of the 1941 and 1942 crops as a basis, the yields for 1943 to 1951 are computed as increases in yield over this average (Table 2). Yield data are expressed in terms of standard eastern apple boxes holding 1⅛ bushels. Because of spring frost damage in

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[3]Two urea products were used. From 1943 through 1945 Uramon was used for both soil and foliage applications. From 1946 through 1951 NuGreen was used for both methods of application. The main difference was the type of conditioning agents employed. The NuGreen product was the best for spray purposes since it contained less insoluble material and was in free-flowing pellet form. Uramon contained 42 per cent nitrogen and NuGreen 45 per cent nitrogen.

[4]Fermate is a ferbam wettable powder that contains 76 per cent ferric dimethyldithio carbamate as the active ingredient. It is produced by the Grasselli Chemicals Department of E. I. duPont de Nemours and Co., Inc., Wilmington, Del.

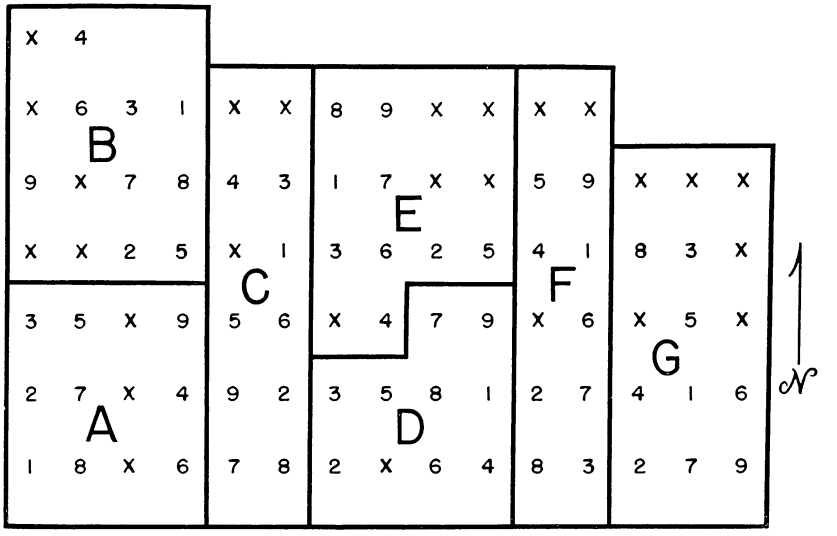

FIG. 1.—Diagram of the experimental plots in the W. A. McKiernan Orchard, Rock City, N. Y., showing the location of the treatments in the seven replicates, A to G. The numbers refer to the treatments listed in Table 2.

1945 and 1946, yield data are available for only seven of the nine years. Only the petal-fall application of NuGreen was given to the foliage-sprayed plots in 1945 and 1946 when the crop was destroyed by frost, whereas the plots that received the scheduled amounts of nitrogen to the soil had received their full treatments before the frost damage occurred.

Beginning with the season of 1949, the experiment was simplified and only the more promising soil and foliage treatments were continued. Sulfur alone, sulfur with 2.5 pounds of NuGreen applied to the soil, sulfur with NuGreen 5–100 as a foliage spray, and Fermate without nitrogen were the only treatments which remained the same throughout the experiment. The soil applications of NuGreen at the rates of 5 and 7.5 pounds per tree were lowered to 2.5 pounds per tree. The sulfur plots receiving NuGreen 5–100 sprayed on the soil were changed to Fermate plots receiving 2.5 pounds of NuGreen broadcast on the soil. The sulfur plots which had received NuGreen 3–100 and 8–100 as foliage sprays were given NuGreen 5–100 as a foliage spray. The entire orchard was limed in the spring of 1949. The data will be discussed as to the status of the project at the end of 6-year and 9-year periods.

TABLE 2.—COMPARATIVE EFFECT OF FUNGICIDES AND SOIL AND FOLIAGE APPLICATIONS OF NUGREEN ON THE YIELD OF MCINTOSH TREES, 1943–51.†

PLOT No.	TREATMENT‡		AV. YIELD 1941 AND 1942, BOXES	INCREASE OVER 1941 AND 1942 YIELD IN BOXES PER TREE									
	Fungicide	NuGreen, pounds		1943	1944	1947	1948	Total 1943–48	1949	1950	1951	Total 1949–51	Total 1943–51
1	Sulfur 1943–51	None	8	0	0	1	2	3	8	9	16	33	36
2	Sulfur 1943–51	2.5/soil	8	5*	7*	1	1	14*	11*	13	21	45	59**
3	Sulfur 1943–48	5/soil	7	5*	12*	3	3	23*	—	—	—	—	—
	Sulfur 1949–51	2.5/soil	—	—	—	—	—	—	10	12	15	37	60*
4	Sulfur 1943–48	7.5/soil	9	6*	10*	0	2	18*	—	—	—	—	—
	Sulfur 1949–51	2.5/soil	—	—	—	—	—	—	10	10	20	40	58**
5	Sulfur 1943–48	5–100/soil	8	1	3	1	2	7	—	—	—	—	—
	Fermate 1949–51	2.5/soil	—	—	—	—	—	—	10	14	17	41	48*
6	Sulfur 1943–48	3–100/foliage	9	4*	4*	0	2	10	—	—	—	—	—
	Sulfur 1949–51	5–100/foliage	—	—	—	—	—	—	11*	9	24	44	54**
7	Sulfur 1943–51	5–100/foliage	9	4*	4*	3	3	14*	9	13	19	41	55**
8	Sulfur 1943–48	8–100/foliage	9	3	4	2	0	9	—	—	—	—	—
	Sulfur 1949–51	5–100/foliage	—	—	—	—	—	—	8	8	11	27	36
9	Fermate 1943–51	None	9	2	5*	11*	9*	27*	10	15	17	42	69**

†Boxes are the standard eastern box, 1⅛ bushels. The treatments on plot Nos. 3, 4, 5, 6, and 8 were changed at the end of 1948 to those given on the second line. Frost damage destroyed the crop in 1945 and 1946. Only the petal-fall application of NuGreen to the foliage was made in these years.

‡Micronized sulfur was used at the rate of 5–100 from 1943–48 and at 8–100 with hydrated spray lime 3–100 from 1949–51, and Fermate at 1½–100 throughout. Uramon was used in 1943–45 and NuGreen in 1946–51. Urea was included in the first three sprays after petal fall and the liquid applications to the soil were made at the same time and at equivalent rates. The dry applications to the soil were made once each year at the beginning of the growing season.

*Significant differences at the 5 per cent level compared with the trees receiving sulfur alone.

**Significant differences at the 1 per cent level compared with the trees receiving sulfur alone.

Results

Yield

Sulfur-sprayed trees that received no nitrogen showed no increase in yield in 1943 and 1944 over the 1941–42 average. Increases of 1 and 2 boxes per tree were recorded in 1947 and 1948, respectively (Table 2). The increases for 1949, 1950, and 1951 were 8, 9, and 16 boxes per tree, respectively, with a total increase of 33 boxes. The total increase for the 1943–51 period was 36 boxes.

The soil and foliage applications of NuGreen, for the most part, significantly increased the yield in 1943 and 1944, but in 1947 and 1948, the increase was little more than for the unfertilized sulfur plots. In general, soil applications of NuGreen at rates of 2.5, 5, and 7.5 pounds per tree increased the yield more than foliage applications at 3–, 5–, and 8–100 in 1944. It appeared that trees sprayed with NuGreen were kept in better nitrogen balance than those receiving soil treatments. NuGreen 5–100 was the most satisfactory of the foliage treatments. The soil application of 2.5 pounds of NuGreen per tree gave results most comparable to the foliage application of NuGreen 5–100. NuGreen 3–100 as a foliage spray looked good the first two years but failed to keep up production as well as NuGreen 5–100. The change in amount of NuGreen from 3–100 to 5–100 in 1949 greatly improved the yield of these trees. NuGreen 8–100 caused foliage injury several seasons and did not increase yields as much as NuGreen 5–100. These trees appeared to be out of nitrogen balance and failed to recover fully when the rate of NuGreen was reduced to 5–100 in 1949–51.

The trees that received NuGreen 5–100 sprayed on the ground prior to 1949 showed a smaller increase in yield than those that received an equivalent amount of NuGreen applied as a foliage spray, no doubt due to the lateness of the applications to the soil and the loss of much of the nitrogen to the sod cover. The change of treatment from sulfur to Fermate with 2.5 pounds of NuGreen broadcast on the soil greatly increased yield (Table 2). During the crop years 1943, 1944, 1947, and 1948, trees under the sulfur program showed increases of 1, 3, 1, and 2 boxes per tree, respectively, compared with increases of 2, 5, 11, and 9 boxes per tree, respectively, for the trees sprayed with Fermate during the same four years. During the years 1949–51, these trees showed increases equal to those of the continuous Fermate program. This comparison is not strictly accurate since the method of adding nitrogen to the soil during the early period was by means of sprays and in the final years it was broadcast dry. However, the amount added was approximately the same in both cases. The point is that the trees came

TABLE 3.—YEARLY PRODUCTION OF INDIVIDUAL McINTOSH TREES SHOWING THE COMPARATIVE EFFECT OF SULFUR AND FERMATE FUNGICIDES APPLIED OVER A PERIOD OF NINE YEARS WITHOUT ADDITIONAL NITROGEN, 1943–51.†

FUNGICIDE‡	BOXES OF FRUIT PER TREE OF INDIVIDUAL TREE REPLICATES							
	A	B	C	D	E	F	G	Average
				Av., 1941–42				
Sulfur	5	8	11	7	11	8	10	9
Sulfur§	4	9	12	8	10	8	11	9
				1943				
Sulfur	6	6	9	10	7	12	10	8
Fermate	4	11	11	8	13	12	14	10
				1944				
Sulfur	4	8	15	7	7	9	6	8
Fermate	6	16	21	10	16	15	14	14*
				1946				
Sulfur	1	5	3	4	4	3	4	3
Fermate	5	5	6	7	7	7	2	6
				1947				
Sulfur	8	9	8	7	12	12	9	9
Fermate	14	19	22	21	23	23	17	20*
				1948				
Sulfur	3	10	9	12	11	11	15	10
Fermate	14	23	23	18	20	20	10	18*
				1949				
Sulfur and lime	8	16	24	14	15	15	17	16
Fermate	13	17	22	18	29	22	10	19
				1950				
Sulfur and lime	9	11	19	21	14	22	23	17
Fermate	14	27	33	21	24	26	18	23
				1951				
Sulfur and lime	18	24	32	29	26	26	15	24
Fermate	8	27	27	27	34	32	28	26
				Av., 1943–51				
Sulfur	7	11	15	13	12	14	12	12
Fermate	10	18	21	16	21	20	14	17**

*Significant differences at the 5 per cent level compared with the trees receiving sulfur alone.
**Significant differences at the 1 per cent level compared with the trees receiving sulfur alone.
†Frost damage destroyed the crop in 1945 and reduced it in 1946.
‡Micronized sulfur was used at the rate of 5–100 from 1943–48 and at 8-100 with hydrated spray lime 3–100 from 1949–51. Fermate 1½–100 was used throughout.
§These trees were sprayed with Fermate in 1943–51.

into full production as soon as Fermate was substituted for sulfur. The Fermate trees without nitrogen maintained yield almost as well during the 1949–51 period as those that had nitrogen.

Trees sprayed with Fermate but given no additional nitrogen tended to give a more or less steady increase in yield unlike the sulfur-nitrogen-treated plots. The total increase in yield for the 6- or 9-year period was greater than that for any of the sulfur-NuGreen combinations. In 1947 and 1948, the Fermate-sprayed trees averaged from 7 to 10 boxes per tree more than the corresponding sulfur-sprayed trees. Better scab control with Fermate during 1946, 1947, and 1948 may be partly responsible for the difference in yield, but reduction in spray injury and a beneficial effect on fruit bud formation are thought to be the main factors.

Apple scab was controlled to a greater extent during 1949–51 by more frequent fungicide applications, by spraying from the top of the sprayer, and by increasing the amount of Micronized sulfur used in the pre-cover applications from 5 to 8 pounds per 100 gallons of spray. Even under these conditions, Fermate-sprayed trees without nitrogen outyielded the sulfur-sprayed trees without nitrogen and almost equaled the best sulfur-nitrogen combination.

The total increase in boxes per tree for the period 1943 through 1951 was 69 with the Fermate fungicide treatment and 36 with the sulfur treatment without nitrogen. Sulfur-sprayed trees that received the soil application of 2.5 pounds of NuGreen and NuGreen 5–100 sprayed on the foliage showed increases of 59 and 55 boxes per tree, respectively. The plots receiving the modified treatments showed increases for the entire period ranging from 36 to 60 boxes per tree.

The individual tree yield records for the unfertilized trees sprayed with sulfur and Fermate are shown in Table 3. There was a steady increase in the yield of the trees sprayed with Fermate from 1943–48, whereas the yield of the sulfur-sprayed trees remained more or less constant. The yield of the trees sprayed with sulfur markedly increased with the addition of lime in 1949–51, which significantly narrowed the difference between the plots receiving sulfur and those receiving Fermate. As already stated, however, other factors, such as better scab control, reduction in spray injury, and more favorable growing conditions, are to be considered.

Fruit drop

The value of the various treatments should not be judged on total yield alone since there was a considerable difference in the amount of pre-harvest drop among the treatments. The trees that received no nitrogen showed the least drop. For the 4 years recorded, the average drop in the sulfur plots was 10 per cent and that in the Fermate plots 9 per

cent (Table 4). The percentage of fruit drop increased as the rate of NuGreen increased for both soil and foliage applications. However, the soil applications usually resulted in more drop than the foliage applications. The fruit drop for 1943, 1944, 1947, and 1948 averaged 25, 25, and 37 per cent for the 2.5-, 5-, and 7.5-pound rates of NuGreen, respectively, when applied to the soil. The corresponding drop was 17, 18, and 29 per cent, respectively, for the 3–, 5–, and 8–100 foliage applications of NuGreen.

TABLE 4.—PRE-HARVEST DROP OF MCINTOSH APPLES IN RELATION TO FUNGICIDES AND TO SOIL AND FOLIAGE APPLICATIONS OF NUGREEN, 1943–48.

PLOT NO.	FUNGICIDE	NUGREEN, POUNDS	FRUIT DROP, PER CENT				
			1943	1944	1947	1948	Average
1	Sulfur	None	6	8	6	18	10
2	Sulfur	2.5/soil	21	23	20	37	25
3	Sulfur	5/soil	18	22	23	38	25
4	Sulfur	7.5/soil	40	37	31	41	37
5	Sulfur	5–100/soil	5	14	22	30	18
6	Sulfur	3–100/foliage	19	16	10	24	17
7	Sulfur	5–100/foliage	17	17	11	27	18
8	Sulfur	8–100/foliage	25	47	9	33	29
9	Fermate	None	12	6	5	14	9

Fruit set and size

Blossom and fruit set records were kept on tagged branches in 1948 to determine whether the treatments had any effect on fruit set. Most of the trees had a good bloom. Bees were placed in the orchard and the weather was favorable for bee activity. However, the set on the trees sprayed with sulfur was not what it should have been. Although the season began early and was wet, it later became hot and dry. To protect fruit and foliage from scab, fungicides were applied when 60 per cent of the blossoms were open. Sulfur-sprayed trees without NuGreen averaged 29 per cent set compared with 45 per cent for Fermate-sprayed trees without NuGreen (Table 5). This may indicate sulfur injury to the pollen or that the pollen was weaker on the sulfur-sprayed trees. Bees have been observed to leave sulfur-sprayed trees in favor of unsprayed ones or trees sprayed with other materials. The fact that NuGreen applications tended to increase the set of sulfur-sprayed trees favors the weak pollen view, but all factors were probably involved. Many of the apples on the sulfur-sprayed trees were small and had few seeds. In spite of the good set, the Fermate-sprayed trees

TABLE 5.—INFLUENCE OF FUNGICIDE AND NUGREEN APPLICATIONS ON SET OF MCINTOSH APPLES IN 1948.*

PLOT NO.	FUNGICIDE	NUGREEN, POUNDS	FULL BLOOM,† PER CENT	CLUSTERS COUNTED	TOTAL FRUIT	SET, PER CENT
1	Sulfur	None	93	464	134	29
2	Sulfur	2.5/soil	76	364	90	25
3	Sulfur	5/soil	100	414	113	27
4	Sulfur	7.5/soil	93	442	160	36
5	Sulfur	5–100/soil	82	499	188	38
6	Sulfur	3–100/foliage	85	390	145	37
7	Sulfur	5–100/foliage	90	431	162	38
8	Sulfur	8–100/foliage	96	446	147	33
9	Fermate	None	98	384	173	45

*Fungicide applications were made when the trees were 60 per cent in bloom.
†The amount of bloom was estimated as closely as possible by visual observation without counts. The data are averages of seven trees from each treatment.

producd the largest fruit (Table 6). The Fermate treatment was consistent in producing good-sized fruit and this accounts in part for the increased yields.

Frost during early bloom in 1946 reduced the crop on all plots. Plots with soil applications of NuGreen came into full bloom earlier than the unfertilized plots and those receiving NuGreen spray treatments. Thus, the trees in the latter plots suffered less frost damage than the soil-treated trees. The fruit that occurred on the latter developed from late or secondary blossoms, had few seeds, and remained small all season. This accounts for the large number of apples per box on these plots (Table 7). Except for the plot which received 5 pounds of NuGreen per tree on the soil, the soil treatments had lower yields and smaller apples than the sprayed plots.

TABLE 6.—INFLUENCE OF FUNGICIDE AND NUGREEN APPLICATIONS ON SIZE OF MCINTOSH FRUIT, 1943–48.

PLOT NO.	FUNGICIDE	NUGREEN, POUNDS	FRUIT SIZE, AS DETERMINED BY NUMBER OF APPLES PER BOX*				
			1943	1944	1947	1948	Average
1	Sulfur	None	165	142	164	172	161
2	Sulfur	2.5/soil	162	150	177	171	165
3	Sulfur	5/soil	160	144	147	183	159
4	Sulfur	7.5 /soil	156	143	154	163	154
5	Sulfur	5–100/soil	159	147	183	170	165
6	Sulfur	3–100/foliage	162	145	163	158	157
7	Sulfur	5–100/foliage	173	145	156	179	163
8	Sulfur	8–100/foliage	159	151	144	163	154
9	Fermate	None	156	143	149	158	151

*Eastern apple boxes holding approximately 40 pounds of McIntosh fruit were used to determine fruit size.

TABLE 7.—EFFECT OF NUGREEN, AND FUNGICIDES ON YIELD OF MCINTOSH WHEN FROST OCCURRED DURING BLOOM IN 1946.

PLOT NO.	FUNGICIDE	NUGREEN, POUNDS	BOXES, PER TREE	APPLES, PER BOX
1	Sulfur	None	3.3	198
2	Sulfur	2.5/soil	2.6	180
3	Sulfur	5/soil	2.6	140
4	Sulfur	7.5/soil	2.5	194
5	Sulfur	5–100/soil	4.4	162
6	Sulfur	3–100/foliage	3.2	177
7	Sulfur	5–100/foliage	5.2	165
8	Sulfur	8–100/foliage	3.3	157
9	Fermate	None	5.0	149

Under these conditions the Fermate-sprayed plots showed a fair yield with an average of 5 boxes per tree and an average of 149 apples per box compared with a yield of 3.3 boxes for the unfertilized, sulfur-sprayed trees with 198 apples per box.

Apple scab control

Apple scab was the only important fungus disease problem in this orchard. Conditions in this location are ideal for scab development. The orchard is on fairly level land with woods on the north side and hills on the south. This resulted in very calm air at night and the relative humidity reached 100 per cent about every night during the primary scab infection periods. This condition extended the length of the infection periods from 8 to 12 hours longer than would have been the case had the orchard been provided with better air drainage. Scab infections could have been reduced by more frequent applications, but one objective of the experiment was to determine the effect of the nitrogen treatments on scab development and this could be seen better with high rather than low incidence of scab.

The percentage of fruit infection increased as the rate of nitrogen applied to the soil was increased. The data indicate that it is possible to have a lower incidence of scab with the foliar sprays of nitrogen than with the broadcast ground applications (Table 8). Broadcast soil treatments of 2.5, 5, and 7.5 pounds of NuGreen per tree averaged 23, 30, and 34 per cent fruit scab, respectively, over a 4-year period, compared with 18 per cent where no nitrogen was used. Foliage treatments of NuGreen at 3–, 5–, and 8–100 and a soil application at 5–100 averaged 19, 17, 15, and 18 per cent fruit scab, respectively, for the same years. Fermate resulted in better fruit scab control than sulfur on trees without nitrogen in four out of seven years and was equal to sulfur in two

TABLE 8.—AMOUNT OF FRUIT SCAB IN RELATION TO SOIL AND FOLIAGE APPLICATION OF NUGREEN ON MCINTOSH APPLES, 1943–51.

PLOT NO.	FUNGICIDE	NUGREEN, POUNDS	FRUIT WITH SCAB, PER CENT								
			1943	1944	1947	1948	4-yr. av.	1949	1950	1951	7-yr. av.
1	Sulfur	None	10	3	38	22	**18**	3	21	1	**14**
2	Sulfur	2.5/soil	14	8	48	22	**23**	7	20	3	**17**
3	Sulfur	5/soil	18	11	51	38	**30**	—	—	—	—
4	Sulfur	7.5/soil	19	16	49	53	**34**	—	—	—	—
5	Sulfur	5–100/soil	14	5	36	16	**18**	—	—	—	—
6	Sulfur	3–100/foliage	8	3	39	26	**19**	—	—	—	—
7	Sulfur	5–100/foliage	7	3	38	21	**17**	6	20	3	**14**
8	Sulfur	8–100/foliage	5	5	35	13	**15**	—	—	—	—
9	Fermate	None	14	3	8	7	**8**	5	13	1	**7**

other years. Fermate-sprayed trees averaged 7 per cent fruit scab for the 7 years compared with 14 per cent fruit scab on the sulfur-sprayed trees.

No records of foliage scab were made in 1943 or 1944. Foliage scab was severe in all of the treatments in 1947 and 1948, but the trees sprayed with Fermate averaged about one-third the number of lesions recorded on the sulfur-sprayed trees. In 1949, 1950, and 1951 foliage scab was held to much lower amounts. The Fermate treatment resulted in a few more lesions per terminal than the sulfur treatment in 1950 but averaged better than sulfur in 1949 and 1951 (Table 9). Fermate has frequently been observed to give better control of scab on the fruit than on the foliage.

TABLE 9.—AVERAGE NUMBER OF FOLIAGE SCAB LESIONS PER TERMINAL, 1947–51.*

PLOT NO.	FUNGICIDE	NUGREEN, POUNDS	TOTAL NUMBER SCAB LESIONS PER 30 TERMINALS					
			1947	1948	1949	1950	1951	Av.
1	Sulfur	None	330	92	2	26	3	**91**
2	Sulfur	2.5/soil	598	188	15	28	4	**167**
7	Sulfur	5–100/foliage	377	114	9	31	4	**107**
9	Fermate	None	147	51	4	38	2	**48**

*Leaf scab counts were made during August. Vigorous terminals were selected around the perimeter of each count tree and all the leaves on 30 terminals were examined.

In 1948 the various treatments were evaluated for their effect on total yield and on the yield of scab-free, picked fruit. The sulfur-sprayed trees that received broadcast soil applications of 2.5, 5, and 7.5 pounds of NuGreen showed marked increases in total yield over those that received no nitrogen. However, as the yield of fruit increased, the percentage of fruit lost from drop and scab infection also increased so that the amount of scab-free, picked fruit was reduced as the rate of nitrogen increased (Table 10). The 2.5-, 5-, and 7.5-pound rates of NuGreen applied to the soil resulted in total yield increases of 30, 41, and 50 per cent but showed decreases of 0, 4, and 33 per cent in the yield of scab-free, picked fruit, respectively.

Trees that received NuGreen 5–100 sprayed on the ground at the same time the foliage applications were made showed a 10 per cent increase in total yield over that of the sulfur check. However, due to the increased amount of fruit drop, there was a 3 per cent decrease in the yield of scab-free, picked fruit.

TABLE 10.—A FOUR-YEAR SUMMARY OF THE EFFECTS OF SOIL AND FOLIAGE APPLICATIONS OF NUGREEN AS THEY AFFECT THE YIELD OF SCAB-FREE PICKED MCINTOSH APPLES, 1943–48.

PLOT NO.	FUNGICIDE*	NUGREEN, POUNDS	TOTAL YIELD 1943–48, BOXES PER 7 TREES†	YIELD INCREASE OVER SULFUR-SPRAYED CHECK, PER CENT	FRUIT DROP, PER CENT	SCAB ON PICKED FRUIT, PER CENT	SCAB-FREE PICKED FRUIT	
							Boxes	Deviation from sulfur plot No. 1 per cent
1	Sulfur	None (check)	247	—	10	15	185	—
2	Sulfur	2.5/soil‡	321	30	25	17	186	0
3	Sulfur	5/soil	348	41	25	24	178	–4
4	Sulfur	7.5/soil	371	50	37	30	123	–33
5	Sulfur	5–100/soil	271	10	18	16	179	–3
6	Sulfur	3–100/foliage§	327	32	17	17	216	17
7	Sulfur	5–100/foliage	352	42	18	15	236	27
8	Sulfur	8–100/foliage	319	28	29	13	185	0
9	Fermate	None	439	78	9	8	369	99

*Micronized sulfur was used at the rate of 5–100 from 1943–48 and Fermate at 1½–100 throughout.

†The crop was measured at harvest in standard eastern apple boxes. There was no crop in 1945 and only a small crop in 1946 because of frost injury at bloom.

‡The soil treatments were made in early April each year.

§The foliage sprays of NuGreen were made at the petal fall, 10-day, and 1st cover periods in combination with the fungicide and arsenate of lead. In 1945 and 1946 only the petal-fall application was made.

Indications are that the yield of scab-free, picked fruit on trees receiving the foliage sprays of NuGreen is greater than that of trees receiving the soil applications. Of the three foliage treatments of NuGreen, the 5–100 concentration was best in total yield of scab-free, picked fruit. These trees showed a 42 per cent increase in total yield and a 27 per cent increase in the yield of scab-free, picked fruit.

Fermate-sprayed trees gave the greatest increase in quality fruit. These trees received no nitrogen during the 6 years. The total yield increase over the trees sprayed with sulfur alone was 78 per cent. The loss from drop and scab totaled only 17 per cent for Fermate compared with 25 per cent for sulfur. Thus, the increase in the yield of scab-free, picked fruit in the Fermate plots was 99 per cent (Table 10).

NuGreen-fungicide compatibility

Micronized sulfur 8–100, Crag 341C 2 pts.–100, Phygon ½–100, and Tag 331 ½ pt.–100 were applied with and without NuGreen 5–100 on paired trees of McIntosh and Cortland adjoining the principal test block in 1949 and 1950 (Table 11). The NuGreen was added only in the first three applications following bloom. The data indicate that the addition of NuGreen may tend to enhance scab control with Micronized sulfur, Fermate, Crag 341C, and Tag, but decreases scab control with Phygon. The differential was more striking on Cortland in 1950 than on McIntosh, probably due to the fact that the main infection period came when McIntosh trees were in bloom before the NuGreen

TABLE 11.—THE COMPATIBILITY OF NUGREEN WITH SULFUR AND ORGANIC FUNGICIDES IN RELATION TO APPLE SCAB CONTROL.

TREATMENT*	PERCENTAGE OF FRUIT SCAB		
	1949	1950	
	McIntosh	McIntosh	Cortland
Micronized sulfur 8–100	9	21	18
Micronized sulfur 8 + NuGreen 5–100	8	22	5
Fermate 1½–100	—	15	22
Fermate 1½ + NuGreen 5–100	—	13	9
Crag 341C 2 pts.–100	11	23†	—
Crag 341C 2 pts. + NuGreen 5–100	8	20†	—
Tag 331 ½ pt.–100	13	10	6
Tag 331 ½ pt. + NuGreen 5–100	7	8	2
Phygon ½–100	7	—	—
Phygon ½ + NuGreen 5–100	13	—	—

*NuGreen at 5–100 was added to the fungicide mixture in the first three sprays after bloom.
†Crag 341 SC at 3 pts.–100 was used in 1950.

had been applied. There were no differences in fruit or foliage injury between the treatments with or without NuGreen.

Fruit color

Picked fruit at harvest time was rated according to the amount of red color. A value of 4 was given to trees with apples of fancy color and 3 indicated most of the fruit had sufficient color for U. S. No. 1 grade. A value of 2 indicated that at least 25 per cent of the fruit was too green for U. S. No. 1 grade and 1 indicated that 50 per cent or more of the fruit was too green for U. S. No. 1 grade.

Fruit from the sulfur and Fermate plots that received no nitrogen had the best color. Fruit from trees that received foliage applications of NuGreen averaged better color than that from trees that received soil applications, except for the plots that had the nitrogen sprayed on the soil. As the rate of soil applications increased, the amount of fruit color decreased (Table 12). There was a close correlation between leaf nitrogen and fruit color. The treatments that showed the lowest leaf nitrogen readings in September also had the best-colored fruit.

TABLE 12.—INFLUENCE OF SOIL AND FOLIAGE APPLICATIONS OF NUGREEN ON MCINTOSH FRUIT COLOR AND NITROGEN CONTENT OF FOLIAGE, 1943–44.

PLOT NO.	FUNGICIDE	NUGREEN, POUNDS	1943		1944	
			Fruit color rating*	Nitrogen, per cent dry weight†	Fruit color rating*	Nitrogen, per cent dry weight†
1	Sulfur	None	3.6	1.84	2.9	2.02
2	Sulfur	2.5/soil	2.6	2.06	2.5	2.48
3	Sulfur	5/soil	2.3	2.13	2.2	2.51
4	Sulfur	7.5/soil	1.9	2.18	1.7	2.52
5	Sulfur	5–100/soil	3.0	1.85	2.9	2.06
6	Sulfur	3–100/foliage	2.9	1.88	3.1	2.19
7	Sulfur	5–100/foliage	2.9	1.99	2.9	2.21
8	Sulfur	8–100/foliage	2.9	2.03	2.8	2.21
9	Fermate	None	3.1	1.81	3.2	1.97

*Fruit color is based on a rating of 4 for fancy red color and 0 for fruit with no red color.
†Leaf samples collected in early September.

Tree growth

Differences in increased trunk circumference were small. The sulfur and Fermate plots receiving no nitrogen showed the smallest increase (39 per cent for sulfur-sprayed trees and 42 per cent for Fermate-sprayed trees) during the 6-year period, 1943–48 (Table 13). Soil applications of NuGreen at the 2.5-, 5-, and 7.5-pound rates resulted in increases of 46, 45, and 46 per cent, respectively. Foliage treatments at the 3–, 5–,

TABLE 13.—INFLUENCE OF SOIL AND FOLIAGE APPLICATION OF NUGREEN ON INCREASE IN TRUNK CIRCUMFERENCE AND TERMINAL GROWTH OF MCINTOSH.

PLOT NO.	FUNGICIDE	NUGREEN, POUNDS	TRUNK CIRCUMFERENCE, CM*		AV. TERMINAL GROWTH, CM*			
			1943	1948	1949	1950	1951	Av.
1	Sulfur	None	61	85	20	19	17	19
2	Sulfur	2.5/soil	59	87	24	21	20	22
3	Sulfur	5/soil	61	89	—	—	—	—
4	Sulfur	7.5/soil	63	91	—	—	—	—
5	Sulfur	5–100/soil	61	86	—	—	—	—
6	Sulfur	3–100/foliage	60	84	—	—	—	—
7	Sulfur	5–100/foliage	65	91	24	22	20	22
8	Sulfur	8–100/foliage	58	85	—	—	—	—
9	Fermate	None	59	86	20	20	18	19

*No significant differences at the 5 per cent level. The growth for the 3 years was recorded on the same branches. A total of 25 branches was counted for each of the seven trees. The average trunk circumference in 1943 was approximately 60 cm and in 1951, 91 cm.

and 8–100 rates showed increases of 40, 42, and 46 per cent, respectively. The plots receiving NuGreen 5–100 sprayed on the soil were in the same category. Differences between treatments were not statistically significant. It is to be noted that the trees with the greatest increase in trunk girth did not necessarily produce the most apples.

In 1951 terminal length measurements were made on 25 branches per tree for plots receiving sulfur and Fermate fungicides without nitrogen, sulfur with 2.5 pounds of NuGreen on the soil, and sulfur with NuGreen 5–100 in foliage applications. Branches were selected to include undisturbed growth for 1949, 1950, and 1951 and length of terminal growth for each of these years was recorded separately. The greatest amount of terminal growth occurred in the 1949 season for all four treatments. There was practically no difference in the amount of growth recorded for the sulfur and Fermate plots that received no nitrogen or between the plots that received soil or foliage applications of NuGreen. The use of NuGreen as a ground application or in the foliage spray increased the terminal growth an average of 3 centimeters per year over that of sulfur or Fermate used alone. The differences between treatments were not statistically significant.

Nitrogen and chlorophyll determinations

Leaf nitrogen and chlorophyll determinations were made in 1943, 1944, 1947, 1948, and 1951 to determine the effect of the various NuGreen applications. The correlation between McIntosh fruit color and amount of leaf nitrogen in September is well known and has already been pointed out here (Table 12). The nitrogen and chlorophyll readings made in 1947 are presented as a typical example of the

results found in the other years. Samples for analyses were collected June 2 and 28, July 23, and August 28.[5] The plots receiving the foliage applications of NuGreen 3–, 5–, and 8–100 and the ground spray of NuGreen 5–100 were treated June 2, 9, and 19.

Sulfur and Fermate plots that received no NuGreen applications showed the lowest nitrogen level after first sampling June 2. Plots that received soil applications of NuGreen at rates of 2.5, 5, and 7.5 pounds per tree in April each year showed the highest nitrogen level on June 2, but those that received foliage applications of NuGreen 5–100 and 8–100 showed the highest level on June 28. The nitrogen level of the foliage-sprayed trees dropped below that of the soil-treated trees by July 23. Trees that received foliage treatments of NuGreen 3–, 5–, and 8–100 averaged 2.03, 2.11, and 2.18 per cent nitrogen, respectively, on August 28, while trees that received soil applications of 2.5, 5, and 7.5 pounds of NuGreen averaged 2.10, 2.19, and 2.27 per cent, respectively (Table 14). The chlorophyll readings for the foliage-sprayed plots declined faster in July and August than those for the soil-treated plots. This should and did tend to increase fruit color at harvest which was one of the original objectives of the project.

A comparison of NuGreen 5–100 sprayed on the ground with the same amount applied to the foliage showed a slight increase in nitrogen and chlorophyll through June for the latter treatments but no difference the rest of the season. At the critical period in late June the foliage of the trees receiving NuGreen 5–100 sprayed on the soil had nitrogen and chlorophyll readings of 2.16 per cent and 2.26 mg compared with 2.52 per cent and 2.63 mg, respectively, for the foliage-sprayed trees. This indicates that the nitrogen in the foliage applications was available to the tree much sooner than that applied to the soil.

It is interesting to note that the trees sprayed with Fermate had higher chlorophyll readings throughout the season than corresponding trees sprayed with sulfur. This was also noted in the nitrogen and chlorophyll records for 1944 and 1948. Part of this effect was perhaps due to the reduced amount of foliage scab infection where Fermate was used (Table 9), but there are indications of a more direct effect of Fermate on the production of chlorophyll. It is well known that Fermate-sprayed trees usually appear darker green than sulfur-sprayed trees even where no scab infection is involved.

[5]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 the dried leaves was analyzed by a modified Kjeldahl method. The chlorophyll method was that of Compton and Boynton (3).

TABLE 14.—EFFECT OF FUNGICIDE AND NUGREEN TREATMENTS ON THE NITROGEN AND CHLOROPHYLL CONTENT OF MCINTOSH LEAVES, 1947.*

PLOT NO.	FUNGICIDE	NUGREEN, POUNDS	DATES SAMPLES WERE COLLECTED						
			June 2	June 28		July 23		August 28	
			N, per cent dry weight	N, per cent dry weight	Chlorophyll, mg/100 cm²	N, per cent dry weight	Chlorophyll, mg/100 cm²	N, per cent dry weight	Chlorophyll, mg/100 cm²
1	Sulfur	None	2.98	1.97	1.86	2.02	2.74	1.97	2.46
2	Sulfur	2.5/soil	3.15	2.37	2.46	2.30	3.49	2.10	3.14
3	Sulfur	5/soil	3.10	2.43	2.71	2.43	4.02	2.19	3.46
4	Sulfur	7.5/soil	3.07	2.43	2.75	2.47	4.15	2.27	3.62
5	Sulfur	5–100/soil	2.87	2.16	2.26	2.30	3.35	2.10	2.82
6	Sulfur	3–100/foliage	2.74	2.25	2.28	2.17	3.15	2.03	2.77
7	Sulfur	5–100/foliage	2.91	2.52	2.63	2.33	3.38	2.11	3.06
8	Sulfur	8–100/foliage	2.92	2.58	2.78	2.39	3.65	2.18	3.35
9	Fermate	None	2.85	2.12	2.26	2.10	3.20	1.96	3.03

*The nitrogen is expressed as the percentage of total nitrogen of the dried leaves. The chlorophyll determinations were made from 30 disk leaf samples (65 square cm leaf surface one side).

Soil acidity

In 1948, when the comparison of sulfur and Fermate fungicides on McIntosh trees had been underway for 6 years, soil samples were collected by Boynton and Embleton (1) to determine whether there was any difference in the soil pH under the trees. There were considerable differences in the top 9 inches of soil, but below 12 inches the differences were not very great.

Soil samples were taken from around four trees for each fungicide. Replicate samples were taken from four sides of each tree at 2, 8, and 22 feet from the trunk. The greatest differences were found in samples collected 2 feet from the trunk. The average pH readings at this distance at depths of 0–1, 1–3, 3–6, 6–9, and 9–12 inches were 4.1, 4.4, 4.6, 4.9, and 5.2, respectively, under the sulfur-sprayed trees and 5.4, 5.5, 5.4, 5.2, and 5.4, respectively, under the Fermate-sprayed trees.

The collections made at 8 feet from the tree trunks showed similar trends, but the differences between the sulfur and Fermate trees were not so great. The samples of top soil collected midway between the trees tested near pH 6.0 and were similar in this respect to samples from adjacent fields where no trees were planted.

In the spring of 1949 lime was applied to the soil of all the orchard to raise the pH under the trees to a more satisfactory level. There was little sod under some of the sulfur-sprayed trees before the lime was applied.

Moriello Bros. Orchard (Cortland)

Experimental Procedure

Trees in a Cortland block in the Moriello Brothers orchard at New Paltz, N. Y., were spaced 32 × 38 feet, were 20 years old, in light sod growth, and received a light disc cultivation early each year. The soil was medium heavy with fair drainage. Randomized single tree plots were replicated eight times. The four treatments included trees that received no nitrogen, trees which received soil applications of 2.5 pounds of NuGreen, trees which received 5 pounds of NuGreen in April each year, and trees which received three foliage spray applications of NuGreen 5–100 at 10-day intervals beginning with the petal-fall stage. The nitrogen treatments were made apart from the pesticide applications which were applied by the grower and consisted of sulfur and Fermate combined with arsenate of lead or DDT.

Results

The yield from trees that received no nitrogen was consistently lower than that from trees receiving the other treatments, with an average of

7.2 boxes per tree for the 5 years. However, a smaller initial trunk circumference for the plots receiving no nitrogen may be partly responsible for this difference. Yields of the other three treatments averaged 9, 10, and 11 boxes per tree for the 2.5-pound and 5-pound soil applications of NuGreen and the NuGreen foliage applications, respectively (Table 15).

Fruit size varied considerably from year to year and there was no consistent difference between plots.

TABLE 15.—COMPARATIVE EFFECT OF SOIL AND FOLIAGE APPLICATIONS OF NITROGEN ON YIELD AND QUALITY OF CORTLAND APPLES, MORIELLO BROS. ORCHARD, NEW PALTZ, N. Y., 1944–48.

NUGREEN TREATMENT, POUNDS*	BOXES PER TREE	APPLES PER BOX	FRUIT SCAB, PER CENT	FRUIT COLOR, PER CENT†	TRUNK CIRCUMFERENCE, CM
			1944		
None, 0	8	152	—	75	68
Soil, 2.5	9	146	—	54	69
Soil, 5	8	146	—	40	76
Foliage, 5–100	10	145	—	64	73
			1945		
None, 0	4	113	5	70	75
Soil, 2.5	5	121	13	43	77
Soil, 5	6	127	14	34	82
Foliage, 5–100	6	127	10	61	81
			1946		
None, 0	7	131	—	86	80
Soil, 2.5	9	141	—	66	82
Soil, 5	11	134	—	53	87
Foliage, 5–100	10	119	—	78	86
			1947		
None, 0	12	141	2	92	84
Soil, 2.5	15	150	2	88	87
Soil, 5	16	147	2	73	91
Foliage, 5–100	16	151	2	90	90
			1948		
None, 0	6	127	t	88	92
Soil, 2.5	7	128	1	65	93
Soil, 5	9	128	1	49	101
Foliage, 5–100	10	118	1	73	97
			Av., 1944–48		Increase
None, 0	7	133	2	82	24
Soil, 2.5	9	137	6	63	24
Soil, 5	10	136	6	50	25
Foliage, 5–100	11	132	4	73	24

*Uramon was used 1944–45 and NuGreen 1946–48.
†Fruit color is expressed as percentage of fruit with more than 50 per cent red color.

Fruit color was consistently best on the plots given no nitrogen. The foliage applications of NuGreen resulted in better fruit color than either of the soil applications. Analyses indicated that the initial level of nitrogen in the foliage in July was about the same for the three treatments and the nitrogen level in September or before harvest was about the same for all treatments (Table 16).

TABLE 16.—RELATION OF FOLIAGE AND SOIL APPLICATIONS OF URAMON TO NITROGEN CONTENT OF APPLE FOLIAGE.

TREATMENT*	PERCENTAGE TOTAL NITROGEN ON DRY WEIGHT BASIS			
	July		September	
	1943	1944	1943	1944
Cortland (Moriello Bros., New Paltz, N. Y.)				
Untreated	2.01	2.34	1.83	1.98
Uramon 2 ½/soil	2.17	2.48	2.01	2.24
Uramon 5/soil	2.21	2.53	2.05	2.20
Uramon 5–100/foliage	2.25	2.59	2.09	2.24
Rome Beauty (Moriello Bros., New Paltz, N. Y.)				
Untreated	1.96	1.90	1.98	1.59
Uramon 2 ½/soil	2.04	2.31	2.04	1.75
Uramon 5/soil	2.34	2.54	2.25	1.90
Uramon 5–100/foliage	2.33	2.70	2.38	2.07
McIntosh (Lewis Orchard, Geneva, N. Y.)				
Untreated	2.14	2.21	2.09	1.86
Untreated†	2.45	2.40	2.16	1.90
Sodium nitrate 4/soil	2.31	2.49	2.18	1.99
Sodium nitrate 8/soil	2.40	2.60	2.14	2.10
Uramon 5–100/soil	2.28	2.53	2.16	2.04
Uramon 2–100/foliage	2.12	2.43	2.14	1.97
Uramon 5–100/foliage	2.32	2.56	2.19	2.04
Sodium nitrate 5–100/foliage	1.98	2.33	1.98	1.90
McIntosh (Smart Orchard, Block A, Lyons, N. Y.)				
Untreated	2.11	1.97	1.94	1.84
Untreated†	2.36	2.19	2.10	1.99
Uramon 5–100/soil	2.31	2.57	2.01	2.06
Uramon 5–100/foliage	2.23	2.59	2.04	2.09
Sodium nitrate 5–100/foliage	2.09	2.26	1.88	1.91
McIntosh (Smart Orchard, Block B, Lyons, N. Y.)				
Untreated	2.05	2.04	1.90	1.95
Sodium nitrate 4/soil	2.30	2.39	2.06	2.13
Sodium nitrate 8/soil	2.54	2.72	2.03	2.39
Uramon 5–100/soil	2.24	2.46	2.07	2.33
Uramon 5–100/foliage	2.24	2.52	1.99	2.31

*Three applications were made after bloom to each block, beginning with the petal-fall stage at 10-day to 2-week intervals. The Uramon applications to the soil were broadcast in a 5-foot band around the periphery of the trees. The same number of gallons of Uramon was sprayed on the ground for each tree as was required to spray each tree. The trees were sprayed as thoroughly as possible with a minimum of run-off. Wettable sulfur and arsenate of lead were used as the pesticides.

†10 pounds of ammonium sulfate were applied to the ground in 1942 only, the year the experiment began.

The use of NuGreen on the soil at 5 pounds per tree resulted in the greatest increase in trunk circumference, but the differences were small and not significant.

Good control of apple scab was obtained each year, except 1945. All three nitrogen treatments tended to increase the amount of fruit scab, but the soil treatments had a greater influence than the foliage treatment. In 1945, plots that received 2.5-pound and 5-pound soil applications averaged 13 and 14 per cent fruit scab, respectively, compared with the 5 per cent where no nitrogen was applied and 10 per cent where foliage applications of NuGreen 5–100 were used.

Moriello Bros. Orchard (Rome Beauty)

Experimental Procedure

The Rome Beauty trees in the Moriello Brothers orchard at New Paltz, N. Y., were spaced 20 × 32 feet, were 25 years old, and were in grass sod culture in heavy soil with poor drainage. Three-tree replicates were randomized throughout five rows and repeated seven times. Approximately 16 trees were used for records in each of the four treatments. The treatments, number and timing of applications, and their relationship to the spray program were the same as stated above for the Moriello Cortland block.

Results

The yield from the Rome Beauty trees that received no nitrogen was consistently lower than that from the other three treatments that received either soil or foliage applications of NuGreen. There was no significant difference in yield between the soil-treated and foliage-sprayed plots. The trees receiving no nitrogen had an average yield of 5.7 boxes of fruit for the 6-year period. Yields for the plots receiving ground applications of 2.5 and 5 pounds of NuGreen per tree and the foliage applications of 5–100 were 8.2, 7.6, and 8.0 boxes per tree, respectively (Table 17).

Fruit size varied considerably from year to year, depending upon the season and the set of fruit. There is indication that by delaying the first foliar applications until after fruit set an excessive load of fruit could be avoided and better size obtained. There was a greater difference in yield in 1944, 1946, and 1948 than in 1943, 1945, and 1947. In 1944, 1947, and 1948, the trees receiving no nitrogen produced the largest apples due to the reduced set of fruit. In 1943, 1945, and 1946, the foliage-sprayed trees had larger fruit than the unfertilized trees even though they carried more boxes per tree.

TABLE 17.—COMPARATIVE EFFECT OF SOIL AND FOLIAGE APPLICATIONS OF NITROGEN ON YIELD AND QUALITY OF ROME BEAUTY APPLES, MORIELLO BROS. ORCHARD, NEW PALTZ, N. Y., 1943–48.

NUGREEN TREATMENT, POUNDS*	BOXES PER TREE	APPLES PER BOX	FRUIT COLOR, PER CENT†	TRUNK CIRCUMFERENCE, CM
		1943		
None, 0	6	182	—	70
Soil, 2.5	8	176	—	74
Soil, 5	8	175	—	74
Foliage, 5–100	8	168	—	72
		1944		
None, 0	6	166	89	75
Soil, 2.5	9	194	48	79
Soil, 5	9	222	23	78
Foliage, 5–100	10	193	66	76
		1945		
None, 0	4	105	80	77
Soil, 2.5	6	101	56	82
Soil, 5	4	112	55	81
Foliage, 5–100	5	101	87	79
		1946		
None, 0	7	110	85	79
Soil, 2.5	10	118	44	84
Soil, 5	10	124	37	82
Foliage, 5–100	10	107	76	81
		1947		
None, 0	10	171	—	81
Soil, 2.5	13	181	—	86
Soil, 5	11	184	—	85
Foliage, 5–100	11	176	—	83
		1948		
None, 0	2	148	80	87
Soil, 2.5	4	157	31	91
Soil, 5	4	173	20	90
Foliage, 5–100	5	156	59	88
		Av., 1943–48		Increase
None, 0	6	144	83	17
Soil, 2.5	8	155	45	16
Soil, 5	8	165	34	17
Foliage, 5–100	8	150	72	16

*Uramon was used 1943–45 and NuGreen 1946–48.
†Fruit color is expressed as percentage of fruit with more than 50 per cent red color.

Fruit color records made in 4 of the 6 years indicated superior fruit color on the unfertilized trees, except for 1945 when the foliage-sprayed plots produced the best-colored fruit. In the other 3 years, the foliage-sprayed trees rated second in fruit color. The use of NuGreen as a

foliage application doubled the percentage of fruit with fancy color compared with soil application at the 5-pound rate. Analyses of the foliage from the three treatments indicate, as for the Cortland, that the initial amount of nitrogen and the extent of reduction as the season progressed may not be the same for any two years. It also was apparent that the foliar application of NuGreen was at least as satisfactory as the ground applications, but, as stated, the success with foliage applications would depend on the initial nitrogen level (Table 16).

There was no significant difference between treatments in increase of trunk circumference. Apple scab was so well controlled in this orchard that no differences in amount of fruit infection were found.

Lewis Orchard (McIntosh)

Experimental Procedure

The McIntosh block in the Alfred Lewis orchard at Geneva was uniform and vigorous. This 20-year-old block was planted in clay loam and was in mulched sod. It was used in 1942 to evaluate possible sources of nitrogen as foliage sprays and the role of minor elements but was consolidated to the outlined program in 1943, at which time it was found that the urea source of nitrogen was the best lead (8).

The four replications of the main treatments were so arranged in the experimental block as to equalize any possible differences in soil properties. Foliage-sprayed plots of 2–100 and 5–100 were replicated in three-tree units. There were two trees receiving Uramon 5–100 sprayed on the ground at the same rate as was sprayed on the foliage and one tree each with broadcast applications of sodium nitrate, 4 and 8 pounds per tree, between each of the replications. In addition, there were 11 untreated trees and 11 trees receiving one application of 10 pounds of ammonium sulfate per tree in 1942. There were only three nonreplicated trees receiving sodium nitrate 5–100 sprayed on the foliage. Three applications of the nitrogen carrier were made each year at approximately petal fall, the 10-day, and the first or second cover sprays. Terminal growth was nearing completion when the last application was made. Approximately 75 gallons per tree were applied each season. Wettable sulfur and arsenate of lead were the pesticides. DuPont Spreader-Sticker was added to insure thorough wetting of the leaf.

Results

The data indicate that none of the treatments significantly affected measurable growth or yield (Table 18). No opinion can be expressed as to the comparative effect of the treatments on color as the individual

trees varied from plain red to heavy striping. Any application of nitrogen decreased color. Grading of fruit at harvest was further invalidated by the application of fruit-drop sprays. It was definite that the foliage of trees sprayed with nitrogen-carrying materials decreased in greenness much more rapidly than the trees receiving the ground applications. If the response from a treatment were slightly inferior for a given year, it was in general somewhat higher the following year. The point seems to be that outstanding results are not to be expected in an orchard with too high a nitrogen level.

Observations indicated that the Uramon 5–100 foliage application would maintain the production level of the tree with a maximum of color and a minimum of injury. The sodium nitrate caused too much injury even though spray lime was added. The addition of mixtures of minor elements, such as the fritted material HW 325 and Es-men-el, did not seem to add to the performance of the urea.

There was no visible carry-over from one season to the next with the foliage application of Uramon 5–100 as far as intensity of chlorophyll formation was concerned. While it was thought, and supported by previous observation, that the fruit color would be improved by the more rapid loss of nitrogen from the foliage of the nitrogen-sprayed trees than of those receiving ground applications, the analyses of the foliage indicate the greatest value of foliar spraying is that it is a ready means of regulating the amount of nitrogen applied to the tree (Table 16). Clear responses occur only when the initial nitrogen status of the tree is fairly low (leaf content below 2 per cent). A careful appraisal of the data presented in this bulletin indicates that the fruit from trees receiving the foliar application of nitrogen has a higher color than that of those receiving the soil application, regardless of the leaf nitrogen content.

The visual differences between the treatments in a given season varied with the amount of rainfall and its relationship to stage of tree development. That is, the foliage sprayed with nitrogen-carrying materials showed a definite increase in greenness in 1 to 2 weeks, but the response from the ground applications, whether broadcast or sprayed, might be several weeks depending upon the time and amount of rainfall. One discing eliminated the visual difference in foliage color. The greatest foliage response was noticeable on trees heavily loaded with fruit.

In a typical year, the unsprayed trees were full of yellow leaves by mid-October. The foliage of the trees receiving 4 pounds of sodium nitrate on the ground looked like that of the untreated trees, whereas

TABLE 18.—COMPARATIVE EFFECT OF FOLIAGE AND SOIL APPLICATIONS OF NITROGEN ON YIELD AND TREE GROWTH OF McINTOSH, LEWIS ORCHARD, GENEVA, N. Y., 1942–45.

NITROGEN APPLICATION, POUNDS PER TREE OR 100 GALLONS OF WATER*	BOXES PER TREE†	APPLES PER BOX	TRUNK CIRCUMFERENCE, CM	TERMINAL GROWTH, CM
	1942			
Untreated	23	109	90	—
Untreated‡	26	97	93	—
Sodium nitrate 4/soil	19	108	87	—
Sodium nitrate 8/soil	22	116	89	—
Uramon 5–100/soil	24	104	91	—
Uramon 2–100/foliage	27	106	95	—
Uramon 5–100/foliage	27	98	94	—
Sodium nitrate 5–100/foliage	27	97	90	—
	1943			
Untreated	22	149	94	—
Untreated‡	25	149	97	—
Sodium nitrate 4/soil	28	162	90	—
Sodium nitrate 8/soil	24	137	95	—
Uramon 5–100/soil	22	150	95	—
Uramon 2–100/foliage	25	141	99	—
Uramon 5–100/foliage	23	137	98	—
Sodium nitrate 5–100/foliage	18	133	96	—
	1944			
Untreated	24	144	96	27
Untreated‡	26	151	99	27
Sodium nitrate 4/soil	23	141	92	25
Sodium nitrate 8/soil	27	156	97	32
Uramon 5–100/soil	26	149	98	26
Uramon 2–100/foliage	26	139	102	26
Uramon 5–100/foliage	27	145	100	29
Sodium nitrate 5–100/foliage	30	150	98	—
	1945			
Untreated	—	—	100	23
Untreated‡	—	—	104	23
Sodium nitrate 4/soil	—	—	96	26
Sodium nitrate 8/soil	—	—	101	25
Uramon 5–100/soil	—	—	104	23
Uramon 2–100/foliage	—	—	106	26
Uramon 5–100/foliage	—	—	104	26
Sodium nitrate 5–100/foliage	—	—	105	—
	Av., 1943 and 1944			
Untreated	23	147	95	—
Untreated‡	25	150	98	—
Sodium nitrate 4/soil	25	152	91	—
Sodium nitrate 8/soil	25	147	96	—
Uramon 5–100/soil	24	150	97	—
Uramon 2–100/foliage	25	140	101	—
Uramon 5–100/foliage	25	141	99	—
Sodium nitrate 5–100/foliage	24	142	97	—

*Nitrogen materials were broadcast at the designated rate around the periphery of the tree or applied at the given number of pounds per 100 gallons of water to the foliage at the rate of 75 gallons per tree for the season. Equivalent amounts of spray were applied to the trees receiving the

those receiving 8 pounds had only an occasional yellow leaf. Foliage of trees sprayed with Uramon 5–100 was green without anthocyanescence, whereas the color of foliage on trees receiving an equivalent amount of nitrogen sprayed on the ground was intermediate between that of the untreated trees and those receiving Uramon 5–100. Uramon at 10–100 applied the third week in October did not delay normal leaf fall.

It was impossible to ascertain the influences of nitrogen applications on scab control because the fungicidal programs were completely effective in themselves.

Smart Orchard (McIntosh)

Experimental Procedure

The data presented here were compiled from two complementary McIntosh blocks in the James Smart orchard near Lyons, N. Y. The trees were selected in a 22-year-old orchard. One experiment was begun in 1942 and the other in 1943. This orchard was chosen because the trees tended to be in biennial bearing and the rainfall had been considered lower than that for the surrounding area. It was reasoned that the method of supplying nitrogen through the foliage of the tree would favor inducement of annual bearing. Low rainfall, which is unfavorable for good root absorption of nitrogen, presumably would make the results of foliar absorption more striking. A deep rich Palmyra stony loam supported the vigorous growth of this orchard in sod culture. The trees had not been fertilized for 7 years. They gave a tremendous response to even moderate pruning.

There were only three treatments carried throughout the 6-year period, 1943–48, in both blocks. These were (a) a combination of 4 pounds of sodium nitrate (1½ pounds of Uramon in 1947 and 1948) broadcast on the ground with Uramon 3–100 in the first three after-bloom foliage sprays, (b) the application of Uramon 5–100 to the foliage in the three after-bloom sprays, and (c) Uramon 5–100 sprayed on the ground under the trees in amounts equivalent to that applied to the foliage. NuGreen was substituted for Uramon in the liquid application in 1946–48.

The foliage-sprayed plots were five-tree units replicated three times. Between these replicates and at either end were arranged the other two

Uramon sprayed on the soil as to those that received the foliage applications. DuPont Spreader-Sticker was added to insure complete wetting of the leaf. The data for 1942 do not necessarily mean that these trees received these particular treatments for this given year, but they did receive approximately the same amount of nitrogen. The plots of 1942 were changed to conform to this program in 1943. The treatments were applied throughout 1943, 1944, and 1945. There was no fruit in 1945.

†Yield corrected for trunk circumference.

‡Ammonium sulfate, 10 pounds per tree, was applied to the soil in 1942 only.

treatments in two-tree plots. Other plots were included, such as those receiving nothing, Uramon 8–100, and sodium nitrate broadcast 4 and 8 pounds per tree. The data from these plots are not presented in this bulletin because the trees were too few in number and did not occur in both blocks.

Three applications of the nitrogen carrier were made each year at approximately 10-day to 2-week intervals beginning with petal fall. The amounts applied were approximately 10 to 15 gallons per tree at petal fall, 16 gallons at the 10-day stage, and 16 to 25 gallons in the first or second cover, which was generally the last week in June or when terminal growth was showing signs of stopping. Wettable sulfur and arsenate of lead were the pesticides. DuPont Spreader-Sticker was added to insure thorough wetting of the leaf.

Results

The data indicate that at the end of 7 years, the foliage application of Uramon 5–100 had maintained the trees in good vigor as measured by trunk and terminal growth (Table 19). The yield was comparable to that of trees that had the same amount of Uramon sprayed on the ground or those that had the combination soil and foliage treatment. The general conclusion in regard to the comparative effect on color was that any addition of nitrogen to the tree tended to decrease color. Pruning decreased color. The over-all picture indicated that foliage application of Uramon 5–100 was most favorable. There were seasons when the color was high for all plots.

Observations on the differences between the treatments indicated a direct correlation between the intensity of foliage color during the growing period and rate of maturity in the fall and the amount of nitrogen applied. Actually, the nitrogen level in this block was higher than necessary for the prevailing loads of fruit. Unfavorable pollinating conditions occurred each year. Visual differences between treatments were not striking during wet seasons. Generally speaking, the greenness of the foliage of the trees with the nitrogen sprayed on the ground was about midway between that of the foliage of the untreated trees and those sprayed with Uramon 5–100.

The rapidity with which foliage showed response to the foliage application was striking. The foliage of trees sprayed with Uramon began to lose color in August unlike the trees with the higher soil applications. The foliage of the plots receiving 4 pounds of sodium nitrate broadcast per tree along with the foliage application of Uramon 3–100 was distinctly greener than that of trees receiving foliage appli-

TABLE 19.—COMPARATIVE EFFECT OF FOLIAGE AND SOIL APPLICATIONS OF NITROGEN ON YIELD AND TREE GROWTH OF McINTOSH, SMART ORCHARD, LYONS, N. Y., 1943–49.

NITROGEN APPLICATION, POUNDS PER TREE OR 100 GALLONS OF WATER*		BOXES PER TREE†	APPLES PER BOX	FRUIT COLOR, PER CENT‡	TRUNK CIRCUMFERENCE, CM	TERMINAL GROWTH, CM
			1943			
Soil and foliage	1½ and 3–100	15	240	—	89	—
Soil	5–100	15	224	—	91	—
Foliage	5–100	16	235	—	88	—
			1944			
Soil and foliage	1½ and 3–100	6	165	—	92	22
Soil	5–100	11	161	—	94	29
Foliage	5–100	11	156	—	90	27
			1946			
Soil and foliage	1½ and 3–100	17	171	60	98	28
Soil	5–100	14	184	62	101	30
Foliage	5–100	15	173	52	99	32
			1947			
Soil and foliage	1½ and 3–100	13	156	48	102	27
Soil	5–100	13	163	47	106	28
Foliage	5–100	14	155	50	103	30
			1948			
Soil and foliage	1½ and 3–100	10	167	—	105	28
Soil	5–100	10	172	—	109	27
Foliage	5–100	10	167	—	106	27
			1949			
Soil and foliage	1½ and 3–100	21	190	50	106	23
Soil	5–100	22	200	40	111	23
Foliage	5–100	20	212	41	108	23
			Average 1943–48		Increase	
Soil and foliage	1½ and 3–100	12	180	53	15	26
Soil	5–100	12	181	50	19	29
Foliage	5–100	13	177	48	18	29

*Sodium nitrate, 4 pounds per tree, was broadcast on the trees receiving the combination soil and foliage applications 1943–46. They received 1½ pounds of Uramon in 1947 and 1948. Uramon was used in the foliage spray 1943–45 and NuGreen 1946–48. Equivalent amounts of spray were applied to the trees receiving Uramon sprayed on the soil as those that received the foliage applications. DuPont Spreader-Sticker was added to insure complete wetting of the leaf. The treatments were applied in 1945, although there was no fruit. No treatments were put on in 1949.

†Yield corrected for trunk circumference.

‡Percentage of fruit with three-fourths or more of the area colored.

cation of Uramon 5–100, but not that of the trees receiving a foliage spray of Uramon 8–100. The foliage of the trees receiving 8 pounds of sodium nitrate per tree was greener than that of trees receiving a foliage spray of Uramon 8–100. Uramon 8–100 as a foliage spray caused too much injury. Both the ground application of 4 pounds of sodium nitrate and the foliage application of Uramon 3–100 mildly increased the greenness of the foliage and were considered as the level at which

the nitrogen applications began to affect the tree visually. The effect of the foliage application was generally observed in a week or so, whereas the ground application might not give any noticeable effect for 3 or 4 weeks.

Analyses indicate that the nitrogen level of the trees receiving the foliar spray of nitrogen is about the same as that of those receiving the same amount sprayed on the ground. Uramon 5–100 sprayed on the foliage is approximately equivalent to the soil application of 4 pounds of sodium nitrate per tree in the two McIntosh orchards in western New York (Table 16).

While the trees bloomed heavily every year, pollination was not favorable so that no specific data were obtainable on the possible value of using foliage sprays as a means of minimizing biennial bearing.

The addition of a soluble complete fertilizer (Startrite), 10–52–17, to NuGreen did not appear to alter the nitrogen complex as far as McIntosh were concerned (Table 20). There was an indication that the color of the fruit was improved, but this requires confirmation.

TABLE 20.—RELATION OF APPLICATION OF NUGREEN AND STARTRITE TO CONSTITUENTS OF MCINTOSH FOLIAGE, BROWNLEE ORCHARD, 1949.

TREATMENT*	PERCENTAGE OF LEAF CONSTITUENTS ON A DRY WEIGHT BASIS				FRUIT COLOR†
	N	K	Ca	Mg	
		July			
Untreated (A)	1.98	1.43	0.99	0.30	—
NuGreen 5–100	2.30	0.96	0.92	0.32	—
NuGreen-Startrite 4–4–100	2.28	0.96	0.85	0.28	—
Untreated (B)	1.83	1.33	0.78	0.27	—
		October			
Untreated (A)	1.64	0.96	1.14	0.27	27
NuGreen 5–100	1.92	0.61	1.16	0.35	7
NuGreen-Startrite 4–4–100	1.89	0.69	1.18	0.34	21
Untreated (B)	1.62	1.38	0.97	0.23	26

*Untreated A and B are duplicate seven-tree rows on either side of sprayed rows. Startrite was 10–52–17 formula completely soluble.
†Percentage of fruit with full color.

Sodium nitrate, potassium nitrate, calcium nitrate, guanidine, and biuret were tested on Rome Beauty in the Smart orchard, but they were all too injurious for further work, particularly the biuret. Urea formaldehyde and dimethyl urea did not appear to have any advantage over Uramon. Certain latex materials were added to Uramon with the thought of increasing the uptake and decreasing the washing off of the water-soluble urea, but the effectiveness of the spray was not consistently increased.

NuGreen was tested as a spray concentrate on Baldwin, Greening, Rome Beauty, McIntosh, and Cortland in the Smart orchard in 1951. NuGreen was applied at 3–100 and 5–100 as a standard spray and at 8X concentration. Applications were made in the pink bud stage, at petal fall, and 2 weeks later. There was no injury with hand spraying at either concentration of the dilute spray. Injury with the concentrate was the most serious in the pink application. Petal injury was appreciable at the full pink stage. The injury was greatest on branches closest to the concentrate air blast machine and on weak trees.

Briefly, NuGreen 24–100 is as high a concentrate as can be used commercially, irrespective of variety, and there may be some injury at that concentration. It is well to note here that, since this test, biuret has been found in NuGreen. The biuret, which resulted when the NuGreen was made into pellet form, may have caused the injury. Analyses and observations indicate that the nitrogen uptake from the concentrate may be less than from the standard concentration.

It was impossible to ascertain the influences of nitrogen applications on scab control because the fungicidal programs were completely effective in themselves.

Discussion and Conclusions

The results of experiments carried out over a period of 9 years show that urea 5–100, included in the first 3 pesticide applications after bloom, satisfactorily maintained the nitrogen level in the apple tree as expressed by yield and growth measurements. Lower concentrations without the addition of a minimum soil application did not supply enough nitrogen to the foliage and higher concentrations caused too much injury. Marginal leaf burn did occur when applications were made just prior to near-freezing temperatures. Urea was used with reasonable safety at the rate of 3–100 concentrated 8 times. The over-all tree performance with urea 5–100 was comparable to that obtained with annual soil applications of about 2½ pounds per tree. The foliage treatment showed an increase of 27 per cent in yield of scab-free, picked fruit during a 4-year period over the sulfur plots receiving no nitrogen.

There was a slight but insignificant difference in trunk girth increase in favor of the soil treatment. There were no differences in the length of terminal growth except that shown between those with and those without nitrogen. A combination of soil application of urea at the rate of 1½ pounds per tree and 3 post-bloom foliage sprays at the rate of 3–100 is suggested as a satisfactory commercial practice for the average orchard.

The results of the tests have suggested the usefulness of urea sprays in solving special problems of nitrogen fertilization where control of

the amount of nitrogen and timing of application may be of paramount importance. Under these conditions, the foliar sprays of urea were similar to those of ground applications in causing fruit drop. On the other hand, fruit color was reduced to a greater extent by soil application of nitrogen than by foliage applications. This appears to be correlated with the more rapid loss of nitrogen in the leaves prior to harvest with the foliage treatments.

Analyses and observations indicate that the nitrogen response is greatest in the young developing leaves, especially when they are slightly below the optimum nitrogen level. The uptake of urea is greatest before terminal growth is complete. Later application may increase fruit size but also tend to decrease color.

There was indication that by delaying the first foliar application until after fruit set, an excess load of fruit could be avoided and better size obtained. It is presumed that it would have practical significance with late varieties where color is not a limiting factor.

The nitrogen and chlorophyll levels for a given amount of nitrogen were higher in June, prior to cessation of terminal growth, for the foliar sprays than for the soil application. They were found to be about the same at harvest. There is no apparent translocation from leaf to leaf or carry-over from one season to another. It was found that such factors as the initial nitrogen level, tree vigor, discing, mulching, pruning, pollination, variation in scion strains, sub-soil conditions, load of fruit, and amount of rainfall determined the end-result so far as the desired nitrogen level was concerned. Furthermore, it was recognized that the value of foliar sprays would become more evident during dry seasons and that the comparative response of the several treatments was, in a measure, dependent upon the relationship between the amount and time of rainfall to the time of application and stage of tree development.

The results from the experimentation by Fisher, Boynton, and Skodvin (5), Fisher and Cook (6), and Fisher (7) on various McIntosh orchards in western New York between 1947 and 1950 corroborate the major findings reported in this bulletin as to the comparative effects of foliar and soil applications of urea on nitrogen and chlorophyll levels of leaves, yield, and color of fruit. They indicate that the more rapid response of fruit trees to the foliar method of application may show to advantage from the standpoint of good fruit set, yield, and color, but it is possible that a heavy set with the low nitrogen reserve could result in small-sized fruit, decreased fruit bud formation, and slower trunk diameter growth.

The plots receiving foliage applications of urea showed a lower

incidence of scab infection than did those receiving soil treatments with sulfur as the fungicide. These differences in scab level are evident when the concentration of the fungicide and the frequency and thoroughness of application are such that the control, on the basis of fungicidal action only, would be marginal. The differences would tend to be more pronounced in years when scab inoculum is heavy.

A reduction in the amount of scab by the addition of urea to a wettable sulfur fungicide has been reported by Palmiter (10), Stoddard (15), and Poulos and Heuberger (11).

Richards (12) reported a substantial increase in scab when he used NuGreen with Kolospray, a bentonite-sulfur material, but that the differential was not great when the NuGreen was added to Phygon XL and Puratized Agricultural Spray.

Data obtained in 1949 and 1950 indicate that the addition of urea to Micronized sulfur, Fermate, Crag 341C, and Tag enhanced their scab control, but, when used with Phygon, there was a decrease in control. Further information is needed on this point as the effect is more striking in some years than in others, perhaps due to the timing of urea applications in relation to scab infection periods.

Trees sprayed with Fermate throughout the season for the period 1943–51 had an average annual yield increase of 9.9 boxes per tree over the 1941–42 average. Those sprayed with wettable sulfur had an average increase of 5.1 boxes. Neither the trees receiving urea 5–100 with sulfur spray program nor those receiving 2½ pounds of urea per tree broadcast on the soil outyielded those sprayed with Fermate without the inclusion of urea.

The average percentage of fruit drop from the wettable sulfur- and Fermate-sprayed trees was about the same when no nitrogen was used. Fruit size was slightly larger for the Fermate program. Control of fruit scab was better with Fermate than with sulfur. Control of leaf scab was better with Fermate in 3 of the 5 years the data were taken. This is not in accord with usual findings when nitrogen is supplied. During the first 6 years of the experiment, the trees sprayed with Fermate without additional nitrogen yielded 99 per cent more scab-free, picked fruit than those sprayed with sulfur without nitrogen.

The nitrogen level of the foliage of the trees sprayed with Fermate was practically the same as that of the foliage of the trees sprayed with wettable sulfur without the addition of nitrogen. Chlorophyll readings were somewhat higher for the foliage of the trees sprayed with Fermate, which corresponds in a measure with its darker appearance.

Weed, McCallan, and Miller (17) have reported that Fermate breaks

down into carbon disulfide and they have shown that this carbon disulfide is taken into the leaves and used in the metabolism of the plant.

Fermate, unlike wettable sulfur, maintained the yield without raising the nitrogen level of the tree, thereby increasing the resistance to scab infection. The fruit of the trees sprayed with Fermate without additional nitrogen dropped less at harvest, had better color, was more firm, and still had better size than that from trees sprayed with sulfur and treated with nitrogen to maintain yield.

It has been suggested that the beneficial responses from ferbam are entirely nutritional through provision of nitrogen or some beneficial degradation product of the ferbam molecule. The evidence at hand, however, is not sufficient to support this theory although it may be partly responsible for the results. One explanation of the data obtained from these experiments is that wettable sulfur in combination with arsenate of lead causes sufficient foliage injury to reduce its efficiency below the point of maximum yield unless sufficient nitrogen is supplied to stimulate the production of more leaf surface. The foliage applications of urea can furnish the needed nitrogen at the critical time for maximum shoot, leaf, and fruit growth without building up a high nitrogen level late in the season. Soil applications may do the same job but the amount of nitrogen received by the tree at any particular time of the season is more difficult to regulate. Fermate is less injurious to apple leaves than sulfur fungicides under high temperature conditions. Fermate is also known to reduce arsenical injury on apple trees. As used in this experiment, it also gave better control of scab between 1943 and 1948 which would influence the efficiency of the leaves. Under the conditions of this experiment, therefore, one might expect trees sprayed with Fermate to outyield those sprayed with sulfur. The fact that the chlorophyll readings for leaf samples from Fermate-sprayed trees were higher than those for sulfur-sprayed trees when the nitrogen level was the same tends to substantiate this view.

The prevailing conditions in individual orchards determine the advisability of following a complete ferbam spray schedule to attain the fullest beneficial responses reported here. The responses probably would be less spectacular if the nitrogen level of the trees were either above or well below the optimum. In the former case, any additional use of nitrogen with ferbam might result in soft green fruit and increased pre-harvest drop. In the latter case, the effect of the ferbam probably would give some beneficial response but might still not result in satisfactory yields unless supplemental ground or foliar applications of nitrogen were made. The situation is further complicated by some

growers' preference for using ferbam at reduced rates with other fungicides for apple-scab and cedar apple-rust control.

Presumably, the greatest effect of the ferbam is derived from the sprays following bloom. The substitution of some other fungicide for ferbam in the late cover sprays to improve fruit finish and to conform to the residue tolerance is not likely to change the over-all beneficial effect of ferbam. Due to the variations the grower may encounter in maintaining satisfactory production and quality of fruit, it is suggested that a supplemental ground or foliar application of nitrogen be made proportionate to the amount of ferbam used in the spray schedule.

The continuous use of sulfur and arsenate of lead without lime for 6 years resulted in an undesirable reduction in the pH of the soil, thereby predisposing the trees to magnesium deficiency. Fermate with arsenate of lead did not reduce the soil pH to any extent during the same period of time.

Summary

Results are presented for a long-term experiment on the effect of various soil and foliage applications of nitrogenous materials, particularly urea (Uramon or NuGreen), in combination with a wettable sulfur, on apple yields, fruit quality, orchard vigor, and apple scab control. Fermate (ferbam) was included as one of the foliage spray treatments.

It was found that inclusion of urea 5–100 in the first three pesticide applications following bloom was sufficient to maintain a satisfactory nitrogen level in an apple orchard of moderate vigor.

Foliar spray applications resulted in higher nitrogen and chlorophyll levels during the period of greatest terminal growth activity than were obtained with equivalent amounts of nitrogen applied to the soil, but they were about the same at harvest.

Early applications before June drop result in greater fruit set and better color and the later applications in more size and probably poorer color, depending on the lateness of maturity.

The more rapid nitrogen effect induced by leaf sprays of urea can show to advantage in good fruit set, yield, and fruit color.

The usefulness of foliage applications of urea lies in their flexibility as they can be modified to suit local conditions.

A combination soil and foliage program is suggested.

Urea was found to be compatible with the standard pesticides and can be used within limitations as a concentrate. Factors that may determine the success or failure of such a program are discussed.

Trees receiving foliage applications of urea produced more scab-free fruit than those receiving soil treatments with the same sulfur spray program. However, this was dependent upon such factors as vigor of the tree, inoculum potential, and protective level of the fungicide.

Trees that were sprayed with Fermate but otherwise given no nitrogen had a greater yield than those of wettable sulfur-treated plots with or without nitrogen. The continuous use of sulfur and arsenate of lead without lime lowered the pH of the soil to an undesirable level.

Fermate-sprayed trees maintained their yield without raising the nitrogen level and, thus, were more resistant to scab infection. The fruit from trees sprayed with Fermate dropped less at harvest, had better color, and was more firm and larger than that from trees sprayed with sulfur and treated with nitrogen to maintain yield.

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A publication of the
New York State Agricultural Experiment Station
Geneva, N. Y.
New York State College of Agriculture
A unit of the State University of New York
at Cornell University