EFFECT OF LATE SUMMER AND EARLY FALL APPLICATIONS OF SODIUM NITRATE UPON THE COLOR AND KEEPING QUALITY OF APPLES THE SAME SEASON, AND UPON THE NITROGEN CONTENT OF THE FRUIT, LEAVES, AND SPURS.

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EFFECT OF LATE SUMMER AND EARLY FALL APPLICATIONS OF SODIUM NITRATE UPON THE COLOR AND KEEPING QUALITY OF APPLES THE SAME SEASON, AND UPON THE NITROGEN CONTENT OF THE FRUIT, LEAVES, AND SPURS.

As a result of the comparatively recent work of Hooker (6)(7), Hodsoll (8), Schrader and Auchter (12)(13), Gourley (3), and Cooper (1) relative to the effect of fall applications of nitrogenous fertilizers upon the growth and spur composition of fruit trees, the question of the effect of such applications upon the color and keeping quality of the fruit the same year has been raised. While the use of fall nitrate is not as yet a widespread practice among fruit growers, the question relative to its effect upon the color and condition of the fruit has assumed great scientific and commercial importance.

Because of these facts careful experiments were begun at the Maryland Experiment Station in 1928 to study this problem. Bearing apple trees in two commercial orchards were fertilized with sodium nitrate at two-week intervals from the middle of August to the time of picking. To determine whether these nitrate applications had any effect on the fruit, the effects of these applications were studied in three ways: (a) red color of the fruit, (b) keeping quality of the fruit, and (c) nitrogen content of the fruit, leaves, and spurs.

1928 EXPERIMENT

Outline of Plots Used

In August a fairly vigorous, fourteen-year-old apple orchard belonging to J. Rust Canby of Colesville, Md., was selected. The trees had been pruned moderately the previous winter, and had received 6 pounds of sodium nitrate in the spring. The trees were planted in the square system, 30 feet apart. The soil, a fertile Upshur loam, had been cultivated occasionally in previous years, but at the time was in a weed sod, which was not mowed until just before the picking commenced.

On August 19, 4 Stayman Winesap, 4 York Imperial, and 3 Rome Beauty trees were given 4 pounds of sodium nitrate, by spreading it uniformly on the ground under the spread of the limbs. On September 3, 6 Stayman Winesap, 4 York Imperial, and 2 Rome Beauty trees were given 4 pounds of sodium nitrate in a like manner. On September 16, 5 Stayman Winesap, 4 York Imperial, and 3 Rome Beauty trees were also given 4 pounds of nitrate each. Adjacent to each group of trees nitrated, one or two trees were designated as checks and received no nitrate. In all cases the nitrate application was followed within a few days by sufficient rain apparently to completely dissolve it. The daily precipitation at College Park, 10 miles distant, is given in Table I.

TABLE I - Dates between Aug. 15 and Nov. 1, 1928, when more than .3 inches of rainfall occurred.

	August				September				October
Dates	16	17	21	25	3	6	19	29	18
Rainfall in Inches	1.36	.43	1.04	1.68	1.01	1.45	.94	.45	.48

Outline of Results Secured

Color - At the start of the experiment, on Aug. 19, there was very little red color on the fruit of any of the trees. What little color there was appeared to be equally distributed throughout all the trees. By Sept. 23 the fruit had developed a considerable amount of red color. Since the fruit coloring this season was earlier and greater than usual, it was thought advisable to secure careful color records before picking, in order that any differences between treatments might be accurately recorded. Consequently, on Sept. 23, the extent of the coloring of the fruit was estimated by examining 100 apples on all nitrated and all check trees. The color of each apple was classified according to the percentage of its surface having the red color characteristic of the variety. In this classification, all fruit was recorded as having its color included in one of the following four color ranges: 0 to 25, 25 to 50, 50 to 75, or 75 to 100 per cent of the fruit's surface with red color.

The percentages of the fruit in each of the four color ranges are given for all three varieties in Tables II, III, and IV.

TABLE II - Effect of late summer and early fall applications of sodium nitrate (4 lbs. per tree) on the extent of color of STAYMAN WINESAP fruit.

Per cent of fruit in each color class

	Check Trees (No nitrate)				Trees Nitrated August 19				Trees Nitrated September 3				Trees Nitrated September 16			
	Color Class Per cent Area with Red Color				Color Class Per cent Area with Red Color				Color Class Per cent Area with Red Color				Color Class Per cent Area with Red Color			
Tree Number	0-25	25-50	50-75	75-100	0-25	25-50	50-75	75-100	0-25	25-50	50-75	75-100	0-25	25-50	50-75	75-100
1	5	9	67	19	24	25	40	11	9	29	42	20	24	23	33	20
2	9	29	42	20	27	29	32	12	5	15	35	45	13	28	38	21
3	24	23	33	20	21	32	25	22	20	27	38	15	12	19	43	26
4	14	12	28	44	29	24	30	18	51	24	24	1	18	27	43	12
5	30	33	25	12					15	22	46	17	13	23	39	25
									16	26	40	18				
Average	16	21	39	23	25	28	32	15	19	24	38	19	16	24	39	21

TABLE III - Effect of late summer and early fall applications of sodium nitrate (4 lbs. per tree) on the extent of color of YORK IMPERIAL fruit.

Per cent of fruit in each color class

	Check Trees (No Nitrate)				Trees Nitrated August 19				Trees Nitrated September 3				Trees Nitrated September 16			
	Color Class Per cent Area With Red Color				Color Class Per cent Area With Red Color				Color Class Per cent Area With Red Color				Color Class Per cent Area With Red Color			
Tree Number	0-25	25-50	50-75	75-100	0-25	25-50	50-75	75-100	0-25	25-50	50-75	75-100	0-25	25-50	50-75	75-100
1	26	23	34	17	43	17	32	8	17	23	37	23	10	24	38	28
2	21	18	32	29	35	24	27	14	9	14	36	41	17	26	30	27
3	15	21	35	29	26	29	34	11	7	22	46	25	5	14	37	44
4	10	13	37	40	46	26	26	2	12	20	46	22	10	21	35	24
Average	18	19	34	29	38	24	29	9	11	20	41	28	13	21	34	32

TABLE IV - Effect of late summer and early fall applications of sodium nitrate (4 lbs. per tree) on the extent of color of ROME BEAUTY fruit.

	Per cent of fruit in each color class															
	Check Trees (No Nitrate)				Trees Nitrated August 19				Trees Nitrated September 3				Trees Nitrated September 16			
	Color Class Per cent Area With Red Color				Color Class Per cent Area With Red Color				Color Class Per cent Area With Red Color				Color Class Per cent Area With Red Color			
Tree Number	0-25	25-50	50-75	75-100	0-25	25-50	50-75	75-100	0-25	25-50	50-75	75-100	0-25	25-50	50-75	75-100
1	35	35	28	2	30	29	36	5	32	30	32	6	45	32	16	7
2	58	32	10	0	26	32	32	10	37	38	23	2	53	20	21	6
3					32	29	30	9					39	37	22	2
Average	47	33	19	1	29	30	33	8	35	34	27	4	46	30	19	5

This data indicates the large variation among the trees as regards the extent of coloring. The color of the fruit on the nitrated trees is, in general, as good as on trees receiving no late summer nitrate. For simplication, Table V is presented, giving the averages of the per cent of fruit in each color range for all trees. This summary indicates that, in the cases of the Stayman Winesap and York Imperial fruit, 4 pounds of sodium nitrate per tree applied on Aug. 19 slightly reduced the extent of the red color of the fruit, while applications of nitrate on Sept. 3 and Sept. 16 did not appear to reduce color formation compared to the check. The Rome Beauty trees nitrated on Aug. 19, however, produced fruit with apparently more red color than the check trees. The Rome Beauty trees nitrated on later dates were similar to the other two varieties, having fruit of equal color to that on the check.

TABLE V - Effect of late summer and early fall applications of sodium nitrate on color of fruit. Summary of Tables II, III, and IV, giving the average percentage of fruit in each color class.

Three Varieties - Color Estimated September 23, 1928.

Per cent of Fruit Surface Having Normal Red Color	Stayman Winesap				York Imperial				Rome Beauty			
	Check	Dates Application 4 lbs. nitrate			Check	Dates Application 4 lbs. nitrate			Check	Dates Application 4 lbs. nitrate		
		8-19	9-3	9-16		8-19	9-3	9-16		8-19	9-3	9-16
0 - 25	16	25	19	16	18	38	11	13	47	29	35	46
25 - 50	21	28	24	24	19	24	20	21	33	34	30	30
50 - 75	39	32	38	39	34	29	41	34	19	33	27	19
75 - 100	23	15	19	21	29	9	28	32	1	8	4	5

Keeping Quality - Fruit for the keeping quality tests was picked at the time of commercial harvest for the respective varieties. On Oct. 5 the Stayman Winesap and York Imperial fruit were picked, while the Rome Beauty was not picked until Oct. 21. For each of the three varieties, two bushels of fruit were hand-picked from one tree of each of the four treatments, making a total of 24 bushels for storage tests. Three of these trees had received 4 pounds of sodium nitrate on the three respective dates, - Aug. 19, Sept. 3, and Sept. 16 - while the fourth tree, which had received no nitrate, was used for a check. Care was exercised in selecting fruit of approximately uniform color and size, similar to that which would be selected by growers who "spot" pick their fruit.

The firmness of 20 apples from each two-bushel sample was immediately determined with a Magness and Taylor (12) pressure tester, which indicated the pressure in pounds necessary to force a rounded plunger, 7/16 of an inch in diameter, into the fruit to a depth of 5/16 of an inch. A disc of skin the size of a dime was always removed, so that only the flesh offered resistance to the plunger. Since three separate tests were made on each apple, the 20 apples provided 60 tests, the average of which was considered the firmness of the sample.

The two bushels were then divided, one bushel being put into common storage in an adjacent storage house, and the

TABLE VI - Effect of late summer and early fall applications of sodium nitrate (4 lbs. per tree) on the firmness * of STAYMAN WINESAP apples at picking time and during storage.

Firmness expressed in pounds

	Common Storage				40° Storage			
	Check	Dates of Nitrate Application			Check	Dates of Nitrate Application		
		Aug. 19	Sept. 3	Sept. 16		Aug. 19	Sept. 3	Sept. 16
Oct. 5	17.2±.08	17.4±.34	17.9±.10	17.3±.17	17.2±.08	17.4±.34	17.9±.10	17.3±.17
Difference from Check		.2±.35	.3±.13	.1±.19		.2±.35	.3±.13	.1±.19
Jan. 4	7.6±.13	7.6±.18	7.2±.18	7.7±.26	8.9±.18	8.5±.56	9.0±.26	8.7±.29
Difference from Check		.0±.27	.4±.22	.1±.30		.4±.60	.1±.32	.2±.34
Feb.10	7.5±.09	6.8±.10	7.2±.17	7.8±.11	7.9±.12	7.7±.07	8.1±.10	8.5±.12
Difference from Check		.7±.13	.3±.19	.3±.14		.2±.14	.2±.16	.6±.17

* Note: The firmness was measured by the Magness and Taylor pressure tester.

other bushel taken 17 miles on a pneumatic tired truck to a 40-degree storage room at the Maryland Experiment Station. The common storage was a ventilated cellar, with its temperature ranging from 45 to 60 degrees. The 40-degree storage had a variable temperature, which ranged from 40 to 45 degrees, and a relatively high humidity.

Throughout the fall and winter a few apples showing decay were removed from the stored lots at each inspection, but a complete record of such decayed fruit showed them to be distributed quite evenly throughout all lots. By the end of January, 1929, all Stayman Winesap and York Imperial fruit had passed their normal storage life. All lots of Stayman Winesap were noticeably shriveled, while the York Imperial had lost their crispness. The Rome Beauty, which had originally been slightly affected with Phoma pomi were covered with the black spots of the disease.

The average firmness for each treatment was determined twice during the winter. The probable error of each mean was then calculated, and is given; also the difference from the check, with probable error of this difference. Such a difference is not considered significant unless it is at least three times its probable error.

Table VI shows the firmness of all Stayman Winesap lots at picking time and during the winter. All lots were equally firm at picking time, and softened equally until January. By

TABLE VII - Effect of late summer and early fall applications of sodium nitrate (4 lbs. per tree) on the firmness * of YORK IMPERIAL apples at picking time and during storage.

Firmness expressed in pounds

Dates of Pressure Testing	Common Storage: Check	Common Storage: Dates of Nitrate Applications: Aug. 19	Sept. 3	Sept. 16	40 degree Storage: Check	40 degree Storage: Dates of Nitrate Applications: Aug. 19	Sept. 3	Sept. 16
Oct. 5	20.0±.05	20.1±.25	22.5±.15	21.3±.21	20.0±.05	20.1±.25	22.5±.15	21.3±.21
Difference from Check		.1±.25	2.5±.16	1.3±.20		.1±.25	2.5±.16	1.3±.20
Jan. 4	10.7±.09	9.8±.25	12.4±.12	10.1±.12	13.8±.15	12.0±.09	16.9±.09	13.3±.08
Difference from Check		.9±.26	1.7±.15	.6±.15		1.8±.17	3.1±.34	.5±.16
Feb.10	11.2±.16	10.1±.33	12.8±.10	10.5±.17	12.7±.12	11.3±.12	15.4±.24	13.7±.13
Difference from Check		1.1±.37	2.3±.19	.7±.24		1.4±.18	2.7±.27	1.0±.17

* Note: The firmness was measured by the Magness and Taylor pressure tester.

Feb. 10 the common storage fruit from the tree receiving nitrate on Aug. 19 was significantly softer than the rest. However, since the 40-degree storage fruit from this same tree showed no unusual softening, little importance can be given to this small variation. All lots of fruit from trees receiving nitrate on Sept. 3 or on Sept. 16 were fully as firm as the check.

Table VII gives the firmness of all York Imperial fruit. At the time of picking the fruit from all trees receiving sodium nitrate was as firm as the fruit from the check tree. Fruit from trees receiving nitrate on Sept. 3 or Sept. 16 remained as firm as the check fruit throughout the winter storage period.

During winter storage the fruit from the York Imperial trees nitrated on Aug. 19, however, in both kinds of storage, became less firm than the check, the decreased firmness being barely significant. This softening is of particular interest, in view of the fact that (see Table V) the color of this fruit had also been reduced by this August nitrate application. Thus it would seem in the case of the York Imperial variety, that 4 pounds of sodium nitrate on Aug. 19 had slightly decreased both color and keeping quality of the fruit.

In Table VIII are given the results with the Rome Beauty fruit. At picking time all fruit from nitrated trees were firmer than the fruit from the check trees, and those lots remained

TABLE VIII - Effect of late summer and early fall applications of sodium nitrate (4 lbs. per tree) on the firmness * of ROME BEAUTY apples at picking time and during storage.

Firmness expressed in pounds

	Common Storage				40° Storage			
	Check	Dates of Nitrate Application			Check	Dates of Nitrate Application		
		Aug. 19	Sept. 3	Sept. 16		Aug. 19	Sept. 3	Sept. 16
Oct. 21	15.5±.15	18.4±.10	16.5±.19	16.3±.19	15.5±.15	18.4±.10	16.5±.19	16.3±.19
Difference from Check		2.9±.18	1.0±.24	.8±.24		2.9±.18	1.0±.24	.8±.24
Jan. 4	7.9±.06	8.6±.16	8.3±.08	7.6±.19	8.5±.07	9.1±.04	8.5±.08	8.6±.07
Difference from Check		.7±.17	.4±.10	.3±.24		.6±.08	.0±.10	.1±.10
Feb. 10	8.0±.07	8.9±.10	8.2±.05	7.7±.10	9.0±.09	10.0±.14	9.3±.08	9.2±.12
Difference from Check		.9±.12	.2±.08	.3±.13		1.0±.16	.3±.12	.2±.15

* Note: The firmness was measured by the Magness and Taylor pressure tester.

firmer throughout the winter in both types of storages. This significantly greater firmness of the fruit from trees receiving sodium nitrate on Aug. 19 is of interest because the color records in Table V show this fruit to have more red color. This variety showed increased firmness in February than a month earlier. Degman (2), working with several large lots of fruit, had observed this same behavior.

Nitrogen Content of the Fruit, Leaves, and Spurs - In addition to studying the effect of late summer and early fall nitrate applications upon the color and keeping quality of the fruit, it was thought desirable to secure data on the nitrogen content of the fruit, in order to determine how quickly the nitrate reached the fruit. In addition to determining whether any nitrogen from the nitrate applications reached the fruit, it seemed likewise of importance to know if any nitrogen changes occurred in the leaves and spurs. The importance of studying leaves and spurs in fruit tree nutritional studies has been demonstrated by many horticultural investigators. Leaves have been found unusually sensitive to nutritional conditions and show a quick response to fertilizers. Spurs have been found (7)(8)(15)(16) to show increases in nitrogen content following nitrate applications.

With this part of the study in mind, fruit, leaf, and spur samples of all three varieties were secured before applying the sodium nitrate, and at two-week intervals thereafter.

Samples of the check trees were secured at the same time. For each variety and for each date of nitrate application one set of samples was taken from each of two nitrated trees and from one adjacent check tree. No check tree was available for the two Rome Beauty trees nitrated on Sept. 3, and no leaf and spur samples were secured for any variety on Sept. 3.

A fruit sample consisted of 10 apples of the same size, taken from well exposed positions on limbs about four feet above the ground. In fact, these apples corresponded closely to those picked at harvest time for storage studies. The spur samples were composed of from 30 to 50 non-bearing spurs of the same length and diameter, of a size characteristic of the majority of spurs on that tree, while the leaf samples were made up of all leaves on the spurs sampled. In lieu of spurs on the Rome Beauty trees, non-bearing terminals of the same length and diameter were secured.

The total nitrogen content for each sample was determined by the Kjeldahl method, with a modification by Gunning, Jodlbawer, and Forester, to include nitrates. This method is described in the Appendix. The analyses of the material from the check (unfertilized) trees indicates the normal changes in the nitrogen content, which can be used as a basis for comparison in determining whether the nitrogen content of similar material on the fertilized trees has been increased by the nitrate applications.

Fruit - The analyses of the Stayman Winesap fruit are given in Table IX. From this data it is evident that the nitrogen content of the fruit on different trees varied even before any treatment were given (on Aug. 19). In every case the per cent of nitrogen in the fruit decreased until Oct. 1, but the absolute amount increased. Although the per cent of nitrogen in the fruit on the check trees was higher at the start, the nitrogen in such trees decreased to a greater extent than did the percentage of nitrogen in fruit from nitrated trees. Check tree A decreased 27.4 per cent as compared to 20.5 and 18.1 per cent decrease of the two adjacent nitrated trees, B and C. Check tree D decreased 26.8 per cent as compared with an .8 per cent decrease of a nearby nitrated tree F. Check tree G also apparently had fruit decreasing 24.0 per cent in nitrogen while the fruit on the nitrated tree I decreased only .5 per cent and fruit on nitrated tree H increased 4.3 per cent. Thus, judging from the figures for nitrogen content calculated as per cent of dry weight, it would seem that more nitrogen had entered the fruit on the nitrated than the check trees. On the other hand, using the data giving the nitrogen in absolute amount per apple, the results would indicate that the actual milligrams of nitrogen going into the fruit on nitrated trees was no greater than that going into fruit on the check trees. However, the figures for the absolute amounts of nitrogen are not strictly comparable, since there were no records made

TABLE IX - Effect of late summer and early fall applications of sodium nitrate (4 lbs. per tree) on the nitrogen content of STAYMAN WINESAP fruit.

Nitrogen expressed in per cent of dry weight

Date of mpling	Check	Nitrate Applied Aug. 19		Check	Nitrate Applied Sept. 3		Check	Nitrate Applied Sept.16	
	Tree A	Tree B	Tree C	Tree D	Tree E	Tree F	Tree G	Tree H	Tree I
g. 15	.274	.244	.249						
pt. 3	.258	.204	.217	.298	----	.235			
pt.16	.208	.203	.218	.278	.194	.218	.258	.188	.221
t. 1	.199	.194	.204	.218	.179	.216	.196	.196	.220
r cent crease llowing rst alysis	27.4	20.5	18.1	26.8	----	.8	24.0	4.3 *	.5

* Increase

Nitrogen expressed in milligrams per fruit

Date of mpling	Tree A	Tree B	Tree C	Tree D	Tree E	Tree F	Tree G	Tree H	Tree I
g. 15	21.05	27.30	27.95						
pt. 3	21.25	27.90	27.60	33.30	----	25.40			
pt.16	41.65	42.55	42.40	49.10	38.90	38.20	29.10	27.30	34.65
t. 1	46.15	49.45	47.30	47.05	53.10	51.30	41.60	45.65	50.35
r cent crease llowing rst alysis	119.2	81.2	68.9	41.3	----	102.0	43.0	67.2	45.3

to show that the apple samples taken from each tree were exactly the same size.

The analyses of the York Imperial fruit are given in Table X. As in the case of the Stayman Winesap apples, the fruit from trees before any nitrate was applied had a different nitrogen content. Thus trees J, K, and L had fruit, on Aug. 19, with a nitrogen content of .286, .271, and .253 per cent respectively. During the six weeks period until picking time, the fruit from the check tree J decreased 14.7 per cent in nitrogen, but the fruit from tree K, receiving 4 pounds of sodium nitrate on Aug. 19, decreased only 5.9 per cent while fruit from tree L, similarly nitrated, increased .5 per cent of its original concentration. The data giving absolute amounts of nitrogen per apple show only a 67.9 per cent increase of nitrogen of apples in check tree J, but show a 104.2 and 128.9 per cent increase for nitrated trees K and L respectively. Thus the nitrogen analyses, calculated either as per cent of dry weight or as milligrams per apple, show a definitely increased nitrogen intake in the fruit on trees receiving nitrate in August.

Nitrate applications made on Sept. 3 likewise caused the fruit on the fertilized trees to take up more nitrogen than fruit on the check tree, although the difference between the fruit from nitrated and from check trees was not as great as with those trees nitrated two weeks earlier. While the nitrogen concentration of the fruit from check tree M decreased 14.9 per

TABLE X - Effect of late summer and early fall applications of sodium nitrate (4 lbs. per tree) on the nitrogen content of YORK IMPERIAL fruit.

Nitrogen expressed in per cent of dry weight

Date of mpling	Check	Nitrate Applied Aug. 19		Check	Nitrate Applied Sept. 3		Check	Nitrate Applied Sept.16	
	Tree J	Tree K	Tree L	Tree M	Tree N	Tree O	Tree P	Tree Q	Tree R
ug. 19	.286	.271	.253						
pt. 3	.258	.272	.312	.261	.178	.212			
pt.16	.266	.269	.252	.217	.212	.225	.218	.241	.227
t. 1	.224	.255	.254	.222	.214	.187	.193	.240	.206
r cent crease llowing rst alysis	14.7	5.9	.5*	14.9	20.2*	11.8	11.5	.5	9.25

* Increase

Nitrogen expressed in milligrams per fruit

Date of mpling	Tree J	Tree K	Tree L	Tree M	Tree N	Tree O	Tree P	Tree Q	Tree R
ug. 19	32.85	26.95	24.20						
pt. 3	46.00	57.50	56.30	58.70	41.40	44.80			
pt.16	55.80	60.90	54.05	55.15	63.85	51.20	52.80	50.00	63.25
t. 1	55.15	55.05	55.40	60.50	57.80	56.60	49.10	66.35	62.70
r cent crease llowing rst alysis	67.9	104.2	128.9	3.1	39.6	26.4	7.0*	32.7	.9*

* Decrease

cent, it decreased only 11.8 per cent for nitrated tree O and increased 20.2 per cent for nitrated tree N. The data for the increase of absolute amount of nitrogen per apple show only a 3.1 per cent increase for check tree M, but show 39.6 and 26.4 per cent increases for nitrated trees N and O respectively.

The fruit of trees Q and R, receiving nitrate on Sept. 16, did not show a similar response of the nitrogen content. The fruit of tree R showed nitrogen changes, calculated both as per cent and as absolute amounts per apple, quite similar to fruit of check tree P, but nitrated tree Q, on the other hand, decreased less in per cent of nitrogen and increased more in milligrams of nitrogen per apple than did the fruit from the check tree. The lack of consistent behavior of the two trees nitrated on Sept. 16 makes it undesirable to attempt any conclusions in this case.

From the data for the York Imperial variety it would seem that the nitrogen content of the fruit was higher following Aug. 19 and Sept. 3 sodium nitrate applications, than fruit from unfertilized trees.

Table XI gives the analyses of Rome Beauty fruit. Here also duplicate nitrated trees do not behave alike. While the fruit of tree T nitrated on Aug. 19 increased in nitrogen more than the fruit from check tree S, the other nitrated tree (tree U) behaved quite similar to the check relative to the percentage of nitrogen in the fruit, but showed only a 108.6 per cent increase in milligrams per fruit as compared with

169.2 per cent increase for the check. The fruit from trees V and W, receiving nitrate on Sept. 3, showed quite similar nitrogen changes, and had a greater nitrogen intake than the fruit from the nearby check tree S during the same period. For trees Y and Z, nitrated on Sept. 16, the fruit analyses calculated as per cent of dry weight show a 23.3 per cent decrease in nitrogen for check tree X during two weeks, and a 29.3 per cent decrease for nitrated tree Z during the same period, but for the other nitrated tree (tree Y) the results show a 3.3 per cent increase. However, when the analyses are calculated as milligrams per fruit, the fruit from nitrated trees Y and Z increase in nitrogen 37.2 and 27.4 per cent respectively, while the fruit on check tree X apparently decreased 5.18 per cent in nitrogen.

The effect of late summer and early fall applications of sodium nitrate on the nitrogen content of the fruit was not consistent for all three varieties of apple studied. For the Stayman Winesap and Rome Beauty varieties, duplicate nitrated trees did not always show similar response; so that the results merely indicate nitrate may increase the nitrogen content of fruit. In the case of the York Imperial trees, however, the results do indicate nitrogen increases in the fruit following Aug. 19 and Sept. 3 sodium nitrate applications.

Although, as previously mentioned, the analyses calculated as absolute amounts per fruit are not strictly compar-

TABLE XI - Effect of late summer and early fall applications of sodium nitrate (4 lbs. per tree) on the nitrogen content of ROME BEAUTY fruit.

Nitrogen expressed in per cent of dry weight

Date of mpling	Check	Nitrate Applied Aug. 19		Check	Nitrate Applied Sept. 3		Check	Nitrate Applied Sept.16	
	Tree S	Tree T	Tree U	Tree	Tree V	Tree W	Tree X	Tree Y	Tree Z
g. 19	.367	.210	.286						
pt. 3	.439	.333	.298		.373	.352			
pt.16	.372	.232	.273		.309	.264	.335	.276	.328
t. 1	.341	.272	.268		.249	.255	.257	.285	.232
r cent crease llowing rst alysis	7.1	29.5*	6.3		33.2	30.3	23.3	3.3*	29.3

* Increase

Nitrogen expressed in milligrams per fruit

Date of mpling	Tree S	Tree T	Tree U	Tree	Tree V	Tree W	Tree X	Tree Y	Tree Z
g. 19	24.05	18.05	30.45						
pt. 3	59.20	46.80	46.80		49.10	54.10			
pt.16	68.30	40.25	55.10		56.25	47.70	63.40	42.35	58.40
t. 1	64.80	61.05	63.50		61.90	59.80	60.10	68.10	60.00
r cent crease llowing rst alysis	169.2	238.1	108.6		26.6	10.5	5.18*	37.2	27.4

* Decrease

able, some of the data is nevertheless worthy of particular comment. In a number of cases (Table IX, tree D; Table X, trees J, K, N, P, and R; Table XI, trees S, and X) the absolute amount of nitrogen per apple on Oct. 1 was less than on Sept. 16. While this data does not prove that nitrogen actually leaves the apple, the data suggests that such may occur in some cases. Pfeiffer (13) in 1875 observed similar indications. No explanation can be offered at this time.

Leaves - The total nitrogen content of the leaf samples are given in Tables XII, XIII, and XIV. Applying sodium nitrate to Stayman Winesap on Aug. 19 caused, as shown by Table XII, a 6.3 per cent increase in the nitrogen content of the leaves of tree B by Sept. 16 and a 7.1 per cent increase in the leaves of tree C by Oct. 1, while the check tree (tree A), not receiving any nitrate, had a 3.5 per cent decrease in leaf nitrogen content. The leaves of the nitrated tree B reached their maximum nitrogen content by Sept. 16, the leaves thereafter losing nitrogen. In the other nitrated tree (tree C) there was only a slight increase by Sept. 16, with the greater increase by Oct. 1.

Applying nitrate to Stayman Winesap trees on Sept. 3 caused between Sept. 16 and Oct. 1 a 2.2 per cent increase in leaf nitrogen in tree E and a .6 per cent increase in tree F, while the check tree D decreased 4.0 per cent in nitrogen. Sodium nitrate applied on Sept. 16 did not prevent a 1.1 per cent nitrogen decrease in the leaves of tree H, but did increase the leaf nitrogen of tree I 4.1 per cent. The check tree showed no change. The data show that 4 pounds of sodium nitrate applied as early as Aug. 19 increased the nitrogen content of the leaves as compared to a check tree. Nitrate applied on Sept. 3 apparently increased the leaf nitrogen, although the increases are so small as to be of questionable significance. Nitrate applied as late as Sept. 16 apparently increased the leaf nitrogen of one tree.

The results of applying nitrate to York Imperial trees, given in Table XIII, are somewhat similar to those in the case of the Stayman Winesap trees. One (tree L) of the two trees receiving nitrate on Aug. 19 showed an 8.5 per cent increase in the total nitrogen in the leaves by Sept. 16, the other (tree K) a 2.0 per cent increase by Oct. 1. The leaves showing the earlier increase in nitrogen had lost nitrogen by Oct. 1. Applying nitrate to York Imperial trees on Sept. 3 caused a 5.2 per cent increase in leaf nitrogen in tree N, but apparently did not prevent a 3.4 per cent decrease in tree O. Check tree M had a leaf nitrogen decrease of 5.6 per cent by Oct. 1. Trees receiving nitrate on Sept. 16 did not show as great an increase in nitrogen as did the adjacent check tree. This data for York Imperial substantiates the results with the Stayman Winesap, in that 4 pounds of sodium nitrate applied on Aug. 19 causes an increase in leaf nitrogen by the last of September. The York Imperial results, when nitrate is applied on Sept. 3, are conflicting, one tree showing increase and one showing decrease. As in the case of the Stayman Winesap, York Imperial trees receiving nitrate on Sept. 16 apparently show no increase in leaf nitrogen.

The total nitrogen content of the Rome Beauty leaves is given in Table XIV. Several of the stored samples of Rome Beauty leaves were injured by water from a leaking drain pipe, and had to be discarded. The leaves remained on the trees longer than those of the other two varieties, allowing leaf studies to be continued until Oct. 15, at which time the leaves, trees T and U, nitrated on Aug. 19, had more nitrogen than the check tree S. One nitrated tree (tree U) increased 8.5 per cent in leaf nitrogen. Although the other nitrated tree (tree T) showed a 5.0 per cent decrease in nitrogen, the adjacent check tree (tree S) showed a 15.2 per cent decrease. Nitrate applied on Sept. 16 caused no leaf nitrogen increase. In fact, the trees Y and Z, nitrated on Sept. 16, decreased in nitrogen 17.5 and 5.9 per cent respectively, while the check tree showed no change in either direction. The Rome Beauty results are like those for Stayman Winesap and York Imperial, in that they show that nitrogen applied as early as Aug. 19 or Sept. 3 increased leaf nitrogen by picking time, and that nitrate applied on Sept. 16 did not increase leaf nitrogen over the check.

Although the leaves had too deep a green color initially to show any apparent change in color of the foliage following late summer nitrate applications, the chemical analyses of the leaves for total nitrogen have shown that nitrate applications made on Aug. 19 increased the leaf nitrogen in the three varieties; and therefore such applications must have resulted in increased nitrogen absorption by the tree. The leaf analyses of trees receiving nitrate on Sept. 3 are not as conclusive in showing nitrogen absorption, but they do indicate that in some trees a slight amount of absorption of the applied nitrate did take place. In the case of the trees nitrated on Sept. 16, the data do not show any more nitrogen in the leaves on Oct. 1 than in the leaves of the check tree.

When increased absorption of nitrogen by the leaves does follow nitrate applications, it would seem as if more nitrogen might enter the fruit as well as the leaves. That late summer nitrate applications can increase the nitrogen content of the fruit as well as the leaves has already been shown for York Imperial trees nitrated on Aug. 19. In the case of Stayman Winesap and Rome Beauty the leaf analyses indicating more nitrogen absorption following the Aug. 19 nitrate application, than in the check, strengthens the indications (in Tables IX and XI) that the nitrogen content of the fruit of these two varieties was slightly increased also.

BLE XII - Effects of late summer and early fall applications of sodium nitrate (4 lbs. per tree) on the nitrogen content of STAYMAN WINESAP leaves on non-bearing spurs.

Nitrogen expressed as per cent of dry weight

Date of mpling	Check	Nitrate Applied Aug. 19		Check	Nitrate Applied Sept. 3		Check	Nitrate Applied Sept.16	
	Tree A	Tree B	Tree C	Tree D	Tree E	Tree F	Tree G	Tree H	Tree I
g. 19	1.70	1.74	1.83						
pt.16	1.64	1.92	1.85	1.99	1.80	1.73	1.92	1.83	1.97
t. 1	1.64	1.85	1.96	1.91	1.84	1.72	1.92	1.81	1.89
r cent ange llowing rst alysis	-3.5	6.3	7.1	-4.0	2.2	.6	0	-1.1	-4.1

TABLE XIII - Effects of late summer and early fall applications of sodium nitrate (4 lbs. per tree) on the nitrogen content of YORK IMPERIAL leaves on non-bearing spurs.

Nitrogen expressed as per cent of dry weight

Date of Sampling	Check	Nitrate Applied Aug. 19		Check	Nitrate Applied Sept. 3		Check	Nitrate Applied Sept.16	
	Tree J	Tree K	Tree L	Tree M	Tree N	Tree O	Tree P	Tree Q	Tree R
Aug. 19	1.83	2.05	2.05						
Sept.16	1.78	2.03	2.20	1.77	1.74	1.77	1.73	1.95	1.75
Oct. 1	1.80	2.14	2.09	1.67	1.83	1.71	1.88	1.92	1.79
Per cent Change Following First Analysis	-1.6	4.4	2.0	-5.6	5.2	-3.4	8.6	-1.5	2.3

TABLE XIV - Effects of late summer and early fall applications of sodium nitrate (4 lbs. per tree) on the nitrogen content of ROME BEAUTY leaves on non-bearing terminals.

Nitrogen expressed as per cent of dry weight

Date of Sampling	Check	Nitrate Applied Aug. 19		Check	Nitrate Applied Sept. 3		Check	Nitrate Applied Sept.16	
	Tree S	Tree T	Tree U		Tree V	Tree W	Tree X	Tree Y	Tree Z
Aug. 19	1.91	1.82	1.65						
Sept.16	1.96	1.86	1.90		1.91	2.06	1.94	2.12	1.87
Oct. 1	----	----	1.59		1.85	1.91	----	----	----
Oct. 15	1.62	1.73	1.79		1.75	----	1.95	1.75	1.76
Per cent Change Following First Analysis	-15.2	-5.0	8.5		-8.4	----	.5	-17.5	-5.9

Spurs - Since the analyses of fruit and leaf samples have shown that nitrogen absorption occurs in some trees, it would seem that the spurs through which the increased nitrogen passed might have an increased nitrogen content. Tables XV, XVI, and XVII give the total nitrogen content of the current season's growth of non-bearing spurs. The sample analyses include one set taken on Nov. 5, about a month after the fruit harvest. It was hoped the analysis of spurs taken at this time would indicate whether any increased nitrogen absorption had taken place during the warm weather immediately following the removal of the fruit from the tree.

The analyses of the Stayman Winesap spurs are given in Table XV. The nitrogen content of the spurs on trees A, B, and C varied from a low percentage value of .86 for tree B to 1.21 for tree A. The nitrogen in the spurs of all three of these trees increased between Aug. 19 and Sept. 16. During the last of September the spurs on the check tree A decreased in nitrogen, while the spurs from the two trees B and C, receiving 4 pounds of nitrate on Aug. 19, continued to increase in nitrogen. By Nov. 5, the check tree A had decreased 11.6 per cent in spur nitrogen, while the nitrated tree B had increased 19.8 per cent and nitrated tree C had increased 7.3 per cent. Evidently the Aug. 19 nitrate application increased the nitrogen content of the spurs over that in the check.

Trees receiving nitrate on Sept. 3 do not show any such nitrogen increase in the spurs. However, since there are no analyses to show the nitrogen content of the trees on Sept. 3, before any nitrate was applied, there is no way of knowing whether the spurs on nitrated tree increased, up to Sept. 16, more than the checks. Between Sept. 16 and Nov. 5 the spurs of the nitrated trees showed no more nitrogen increase than did the check, for while check tree D showed a spur nitrogen decrease of 3.0 per cent, one of the nitrated trees (tree E) showed a spur nitrogen increase of 2.1 per cent, and the other (tree F) showed a decrease of 8.3 per cent during the same 7-week period.

Applying nitrate on Sept. 16 increased the spur nitrogen, for while the nitrated tree H showed a .7 per cent increase, and the nitrated tree I a 6.9 per cent increase, the adjacent check tree G showed a nitrogen decrease of 9.9 per cent. This spur nitrogen increase following Sept. 16 nitrate applications did not occur by Oct. 1, but apparently took place sometime between Oct. 1 and Nov. 5.

These results show, that in the case of Stayman Winesap, nitrate applied on Aug. 19 resulted in more nitrogen in the spurs as well as in the leaves. Apparently no spur nitrogen increase over the check followed Sept. 3 nitrate applications, but nitrogen increases did follow nitrate on Sept. 16.

TABLE XV - Effects of late summer and early fall applications of sodium nitrate (4 lbs. per tree) on the nitrogen content of the current season's growth of STAYMAN WINESAP non-bearing spurs.

Nitrogen expressed as per cent of dry weight

Date of Sampling	Check	Nitrate Applied Aug. 19		Check	Nitrate Applied Sept. 3		Check	Nitrate Applied Sept. 16	
	Tree A	Tree B	Tree C	Tree D	Tree E	Tree F	Tree G	Tree H	Tree I
Aug. 19	1.21	.86	1.10						
Sept.16	1.38	.98	1.24	1.67	1.44	1.61	1.51	1.46	1.44
Oct. 1	1.02	1.04	1.65	1.56	1.37	1.41	1.30	1.35	1.47
Nov. 5	1.07	1.03	1.18	1.62	1.47	1.46	1.36	1.47	1.54
Per cent Change Following First Analysis	-11.6	19.8	7.3	-3.0	2.1	-8.3	-9.9	.7	6.9

In Table XVI are presented the spur analyses for York Imperial. The spurs on trees K and L, receiving sodium nitrate on Aug. 19, showed a larger nitrogen increase by Sept. 16 than did spurs of the check tree J. After Sept. 16, however, the spur nitrogen of the check tree J increased more rapidly than the spur nitrogen of either of the nitrated trees K and L, until by Nov. 5 the check tree had made a 36.6 per cent increase in spur nitrogen as compared with 26.3 and 17.1 per cent increases for nitrated trees K and L respectively.

In trees nitrated on Sept. 3 the spur nitrogen did not change materially from Sept. 16 to Oct. 1, while the spur nitrogen of the check tree decreased; but from Oct. 1 to Nov. 5, although the spur nitrogen in all three trees increased, the nitrogen of the check spurs increased by far the most. It would seem that only at picking time did the Sept. 3 nitrate applications result in more nitrogen in the spurs of these nitrated trees than in the check.

York Imperial trees nitrated on Sept. 16 did not show any nitrogen increase in their non-bearing spurs, which is quite contrary to the results with Stayman Winesap nitrated at the same time. The fact that the Stayman Winesap showed nitrogen increases, when the York Imperial did not, may be explained by the fact that the Stayman Winesap trees were smaller in size, and were growing in a part of the orchard having slightly poorer soil. Under such conditions, applications of nitrate would be expected to show prompter and more noticeable effects.

TABLE XVI - Effects of late summer and early fall applications of sodium nitrate (4 lbs. per tree) on the nitrogen content of the current season's growth of YORK IMPERIAL non-bearing spurs.

Nitrogen expressed as per cent of dry weight

Date of Sampling	Check	Nitrate Applied Aug. 19		Check	Nitrate Applied Sept. 3		Check	Nitrate Applied Sept. 16	
	Tree J	Tree K	Tree L	Tree M	Tree N	Tree O	Tree P	Tree Q	Tree R
Aug. 19	.90	1.14	1.11						
Sept.16	1.05	1.41	1.38	1.12	1.22	1.24	1.08	1.10	1.21
Oct. 1	1.11	1.34	1.23	1.07	1.27	1.22	1.15	1.07	1.08
Nov. 5	1.23	1.44	1.30	1.25	1.40	1.33	1.29	1.30	1.33
Per cent Increase Following First Analysis	36.6	26.3	17.1	11.6	14.7	7.3	19.4	18.2	9.9

Table XVII gives the total nitrogen content of the Rome Beauty non-bearing terminals. The terminals of the trees (T and U) nitrated on Aug. 19, showed, as did the spurs of the Stayman Winesap and York Imperial trees, an increase in nitrogen by Sept. 16. At the same time the Rome Beauty check tree S showed a loss of nitrogen. The increase of nitrogen in the nitrated trees continued until Oct. 15, and by Nov. 5 this increase was 67.7 per cent for tree T and 36.5 per cent for tree U. During this time check tree S showed only a 4.6 per cent increase.

Between Sept. 16 and Nov. 5 the other check tree (tree X) showed a 9.4 per cent nitrogen increase. During the same period, trees V and W, nitrated on Sept. 3, showed nitrogen increases of 38.9 and 19.5 per cent respectively; while trees Y and Z, nitrated on Sept. 16, had nitrogen increases of 19.3 and 18.5 per cent respectively. Thus it would seem that, in the care of the Rome Beauty trees, all late summer nitrate applications resulted in increased nitrogen in terminals as compared with check tree terminals.

TABLE XVII - Effects of late summer and early fall applications of sodium nitrate (4 lbs. per tree) on the nitrogen content of entire current season's growth of ROME BEAUTY terminals.

Nitrogen expressed as per cent of dry weight

Date of Sampling	Check	Nitrate Applied Aug. 19		Check	Nitrate Applied Sept. 3		Check	Nitrate Applied Sept. 16	
	Tree S	Tree T	Tree U		Tree V	Tree W	Tree X	Tree Y	Tree Z
Aug. 19	.87	.65	.63						
Sept.16	.81	.80	.82		.72	.82	.85	.88	.81
Oct. 1	.92	.85	.93		.84	.80	.86	.79	.73
Oct. 15	.83	1.07	.93		.98	.93	.86	.79	.74
Nov. 5	.91	1.09	.86		1.00	.98	.93	1.05	.96
Per cent Increase Following First Analysis	4.6	67.7	36.5		38.9	19.5	9.4	19.3	18.5

Summary of the 1928 Experiment - In an orchard of fairly vigorous trees, which had received 6 pounds of sodium nitrate in the spring, the effect of Aug. 19, Sept. 3, and Sept. 16 applications of sodium nitrate (4 pounds per tree) upon the color, keeping quality, and nitrogen content of the fruit was studied. The fruit color was reduced slightly in the case of Stayman Winesap and York Imperial trees nitrated on Aug. 19. The keeping quality was decreased only in the case of the York Imperial trees nitrated on Aug. 19. Nitrate applied on Sept. 3 or on Sept. 16 reduced neither the color nor the keeping quality, although nitrate applied to Rome Beauty on Aug. 19 apparently did increase both the color and keeping quality of the fruit. From the chemical analyses it would seem that nitrate applications made on Aug. 19 resulted in an increased nitrogen intake by the fruit, as compared with the check, but only in the case of the York Imperial trees nitrated then did this fruit nitrogen increase occur to any marked extent by the middle of September. It will be recalled that this fruit had poorer color on Sept. 23, and that it had poorer keeping quality.

Leaf analyses show that in all varieties sodium nitrate applied on Aug. 19 was absorbed by the tree at least within 30 days. If analyses had been made of leaves on Sept. 3, they might have indicated that there was even more rapid nitrogen absorption by the tree. Leaves on trees receiving nitrate on

Sept. 3 or Sept. 16 apparently did not increase in nitrogen as compared with the check, but this situation might have been due to the more rapid translocation of nitrogen out of the leaves in the nitrated trees than in the check, which prevented any nitrogen accumulation. Spur and terminal analyses show that in most cases such late summer nitrate applications resulted in increased nitrogen in the spurs and terminals before the end of October.

The fact that some trees did not show increased nitrogen following late summer or early fall nitrate applications was probably due to the fact that in such trees nitrogen from the 6-pound spring application of sodium nitrate was still available in sufficient quantities to maintain the tree in high vigor. This explanation has been substantiated by further work in this orchard, in the course of which it was found that many of the trees showed no increase in spur nitrogen following nitrate applications, even when the nitrate was applied the following spring. The results of this work just mentioned will be published in a separate report.

Since the vigor of the trees in this orchard apparently in many cases obscured the effects of these late summer and early fall nitrate applications, it was thought that less vigorous trees, showing apparent nitrogen deficiency, would be more suitable for conducting further experiments. Accordingly, the following year another orchard, rather low in vigor, was selected for the second year's work.

1929 EXPERIMENT

Outline of Plots Used

The orchard used in the second year's experiments was located on the edge of the J. Pumphrey orchard, near Glenburnie, Md. A devitalized block of fifteen-year-old York Imperial apple trees growing in a weed sod were selected. Having received neither nitrate nor pruning, the trees were extremely low in vigor, with a terminal growth hardly an inch long and with sparse foliage of a yellowish green color. The top soil was a poor sandy loam, underlaid by a heavy clay subsoil. All the trees used in the experiment were bearing a moderately heavy crop.

Six pounds of sodium nitrate was applied to each of six trees on Aug. 15, to six more trees on Sept. 1, and to six more on Sept. 15. Six trees, distributed throughout the block and in all cases on slightly higher ground, were designated as checks and were not nitrated. It was felt that if fall nitrate applications had any detrimental effect on the crop of fruit, such effects would readily be noticed in this orchard.

Outline of Results Secured

Color - General observations on the color of the fruit were made from time to time. On Aug. 15, before any nitrate had been applied, there was almost no color on any of the fruit. Thereafter, the fruit on all trees, regardless of treatment, colored apparently equally well and developed a high "finish." To secure more accurate data on the amount of fruit color, 100 apples on each tree in the experiments were classified as to color by the same method as used in the 1928 experiment. On Sept. 1 such a classification of the fruit was made for all the six check trees and the six trees which had received nitrate on Aug. 15. The per cent of fruit found in each color class for each tree is given in Table XVIII. On Sept. 14 the color records were again obtained, the group of trees nitrated on Sept. 1 being included also. These results are given in Table XIX. It is evident that the color variation between different trees treated alike was much less than in the 1928 experiment. The average for each group of six trees is given in Table XX.

In Table XX there is a very slight indication that on Sept. 1, two weeks after applying 6 pounds of sodium nitrate, fruit on the nitrated trees had a little more red color than the fruit on trees not receiving nitrate (check). This increased color following 6 pounds of nitrate would not be worthy of consideration but for the fact that on Sept. 14 the same color difference was still indicated. The trees receiving nitrate on Sept. 1, however, had fruit with practically the same color as the check trees.

One explanation for this increase in color following the Aug. 15 nitrate application might be, that the increased nitrogen absorption by the tree increased leaf activity. If such a leaf activity as photosynthesis were thus increased, there would be more carbohydrates produced, and thus more carbohydrates would be available to the fruit for pigment development. The fact that the leaves of the trees receiving nitrate showed a very noticeable darkening in color strongly supports this explanation.

Another possible explanation, which should be mentioned, is that the late summer nitrate application might have increased the cambial growth in the trunk and limbs. This cambial growth might supply more and bigger conductive tissue to provide the fruit with an increased water supply; and there is much practical evidence to indicate that water may be a limiting factor in the coloring of fruit.

TABLE XVIII - Effect of late summer and early fall applications of sodium nitrate (6 lbs. per tree) on the extent of color of YORK IMPERIAL fruit on nitrogen deficient trees.

Per cent of fruit in each color class on September 1.

Tree Number	Check --- No Nitrate Applied				6 lbs. Nitrate Applied Aug. 15			
	Per cent Area with Red Color				Per cent Area with Red Color			
	0-25	25-50	50-75	75-100	0-25	25-50	50-75	75-100
1	58	21	18	3	42	36	15	7
2	62	24	11	3	35	32	33	10
3	49	21	25	5	25	19	33	23
4	64	28	5	3	37	24	24	24
5	55	23	13	9	65	27	8	0
6	39	18	31	12	60	29	7	4
Average	55	22	17	6	43	28	20	11

TABLE XIX - Effect of late summer applications of sodium nitrate (6 lbs. per tree) on the extent of the color of YORK IMPERIAL fruit on nitrogen deficient trees.

Per cent of fruit in each color class on September 14

Tree Number	Check ----- No Nitrate				6 lbs. Nitrate Aug. 15				6 lbs. Nitrate Sept. 1			
	Per cent Area with Red Color				Per cent Area with Red Color				Per cent Area with Red Color			
	0-25	25-50	50-75	75-100	0-25	25-50	50-75	75-100	0-25	25-50	50-75	75-100
1	25	33	29	13	19	28	30	23	23	37	30	10
2	9	32	45	14	32	32	30	8	45	24	25	6
3	43	27	26	4	3	16	31	50	20	29	35	16
4	21	30	33	16	25	22	41	12	39	32	26	3
5	48	27	18	7	14	19	33	34	13	27	41	19
6	29	29	30	12	13	20	40	27	16	33	39	12
Average	29	30	30	11	13	23	34	16	26	30	34	11

TABLE XX - Effect of late summer and early fall applications of sodium nitfate (6 lbs. per tree) on the extent of color of YORK IMPERIAL fruit on nitrogen deficient trees.

Summary of Tables XVIII and XIX.

Per cent of fruit (average of 6 trees) in each color class.

Per Cent of fruit Surface Having Red Color	Color Estimated Sept. 1		Color Estimated Sept. 14		
	Check No Nitrate	6 lbs. Nitrate on Aug. 15	Check No Nitrate	6 lbs. Nitrate on Aug. 15	6 lbs. Nitrate on Sept. 1
0-25	55	45	29	13	26
25-50	22	28	30	23	30
50-75	17	20	30	34	34
75-100	6	11	11	16	11

<u>Keeping Quality</u> - The 1929 experiment gave an opportunity to further study the effect of late summer applications of sodium nitrate on fruit firmness and keeping quality. In order to determine whether any undue softening occurred while the fruit was on the tree, fruit taken for chemical analysis on Sept. 1 and Sept. 15, was tested for firmness by the same method used in the 1928 experiment. The figures for firmness are not entirely accurate, since in a number of cases the firmness was greater than 30 lbs., the maximum limit on the scale of the pressure tester. Such readings had to be considered "30" in calculating the mean for a given treatment.

On Sept. 28 the fruit for storage tests was picked by hand, one bushel being removed from each of the trees in the experiment. Since there were six trees for each treatment, each storage sample contained six bushels. Each storage sample was thoroughly mixed and divided in half. One 3-bushel portion from each sample was put in common storage at the Canby orchard, while the other 3-bushel portion was put in cold (32°) storage at Arlington Farm, Va. The firmness of all lots of fruit were tested when picked, and on Nov. 23, Jan. 10, and March 20 respectively. The mean firmness, with its probable error, for each lot is given in Table XXI.

TABLE XXI - Effect of late summer and early fall applications of sodium nitrate (6 lbs. per tree) on the firmness* of YORK IMPERIAL apples just before picking time and thereafter during storage.

Firmness expressed in pounds

	Date	Check trees (Unfertilized)		Trees Nitrated Aug. 15		Trees Nitrated Sept. 1		Trees Nitrated Sept. 15
On the tree previous to picking	Sept. 1	27.9 ± .3		29.3 ± .1		27.7 ± .2		
		Difference from Check		1.4 ± .3		.2 ± .4		
	Sept.14	26.9 ± .6		27.6 ± .3		27.0 ± .8		
		Difference from Check		.7 ± .6		.1 ± 1.0		
At Picking Time	Sept.28	24.3 ± .3		24.5 ± .4		24.4 ± .4		25.1 ± .3
		Difference from Check		.2 ± .5		.1 ± .5		.8 ± .5
		Common	Cold	Common	Cold	Common	Cold	Cold
During Common and Cold Storage	Nov. 28	15.9 ± .6	23.6±.3	14.6±.2	23.2±.2	14.7±.3	23.2±.2	20.5±.2
		Difference from Check		1.3±.6	.4±.3	1.2±.7	.4±.3	3.1±.3
	Jan. 18	16.2 ± .3	23.0±.1	15.8±.1	22.2±.2	15.5±.1	22.6±.1	22.9±.1
		Difference from Check		.4±.3	.8±.2	.7±.3	.4±.2	.1±.2
	Mar. 20		18.2±.2		18.3±.1		17.1±.2	17.4±.1
		Difference from Check	.1±.2		.1±.2		1.1±.3	.8±.3

* Firmness was measured by the Magness and Taylor pressure tester.

From Table XXI it is evident that on Sept. 1 the fruit on the trees receiving 6 lbs. of nitrate on Aug. 15 were 1.4 pounds firmer than the fruit from the check trees. Since the probable error of this difference is .3, the coefficient of odds are 4.6 to 1 that this increased firmness is significant. The firmness of the fruit on trees nitrated Sept. 1 is practically the same as check. Thereafter, however, in both common and cold storage the difference between the fruit from trees nitrated on Aug. 15 and the fruit from check trees never became significant. The fruit from the trees receiving nitrate on Sept. 1 had practically the same firmness at picking time and during the storage period until March 20, when the fruit from the nitrated trees was significantly softer by a coefficient of odds of 3.6 to 1. Fruit on trees nitrated on Sept. 15 had at picking time a firmness nearly equal to that of the check fruit. Although this nitrated fruit seemed significantly softer than the check fruit on Nov. 28, pressure test determinations on Jan. 18 and March 20 showed no significant differences.

Thus, in three cases the fruit from nitrated trees was shown to be significantly different in firmness from the check fruit. In one case the fruit was firmer on Sept. 1; in another case fruit from trees nitrated Sept. 1 was not softer than the check until the end of the storage period, and in the third and last case the fruit from trees nitrated on

Sept. 15 was softer than check fruit at the Nov. 28 examination only. These three cases do not seem to be in any way related, and can not be considered as showing any particular effect of the sodium nitrate applications upon fruit keeping quality. The fruit in common storage was completely destroyed by mice the last of January, but up to that time no scald or decay had appeared. All cold storage fruit remained without decay or scald until May 1, when it was discarded. The conclusion to be drawn from the 1929 keeping quality studies is, therefore, that a six-pound nitrate application to nitrogen deficient York Imperial trees, made on Aug. 15, Sept. 1, or Sept. 15, did not effect the keeping quality of the fruit that season.

Nitrogen Content of the Fruit, Leaves, Spurs, and Bark - Samples for chemical analysis for nitrogen were taken before adding the sodium nitrate and thereafter at two-week intervals, in much the same manner as was used in the 1928 experiment. However, since the variability of the analyses in the 1928 experiment had emphasized the necessity of obtaining very uniform material, particular pains were taken to make all samples strictly comparable. Instead of using for one sample material from a single tree, as was done in 1928, each sample was a composite of an equal amount of material from each of the six trees under a given treatment. Spur uniformity was used as a basis for securing comparable samples of not only spurs, but also fruit and leaves. Since Harley (5) has demonstrated that spurs of aproximately the same yearly growth in length are much more constant in chemical composition than spurs of varied lengths, only spurs of uniform growth lengths were taken.

Twelve bearing spurs were taken from each tree. Since all the trees had been chosen for their uniformity of vigor, spurs of exactly the same length and diameter of current season's lateral growth were selected for all samples. In an endeavor to secure fruit growing under aproximately similar nutritional conditions, fruit growing on these uniform spurs were taken. The two most uniform apples among the 12 on the spurs from each tree were used, the entire sample being a composite of 12 apples, 2 from each of the six trees. The leaf samples were composed of all the leaves on the spurs selected. Only the cluster base and current season's lateral growth were used to make the spur samples.

The bark samples were of two kinds: trunk bark and scaffold limb bark. A trunk bark sample was the composite of 6 sections of bark, 3 inches long and ½ inch wide, one section being taken from the trunk of each of six trees. The limb bark sample was likewise a composite, using sections 3 inches by 3/8 inches, and securing a single section from each of two scaffold limbs.

The seeds were separated from the fruit samples, were counted, and preserved separately by drying them. In all other respects the fruit, leaves, and spurs were preserved in the same manner as in the 1928 experiment. The bark samples were preserved by drying, in a manner similar to that used for the spurs. Alcohol insoluble as well as total nitrogen was determined by the Kjeldahl method, with a modification by Gunning, Jodlbauer, and Forester, as described in the Appendix. The method of extracting the alcohol soluble nitrogen is also given in the Appendix. Alcohol soluble nitrogen was calculated as the total minus the alcohol insoluble nitrogen.

Fruit - The results of the analyses of the fruit, including all of the apple except the seeds, are given in Table XXII. The nitrogen content has been calculated both as per cent of dry weight and as milligrams of nitrogen per apple. The data giving milligrams of nitrogen per fruit is not strictly comparable, for the apples sampled from the uniform spurs were not always of the same size. However, large differences in absolute amounts are indicative, even if not conclusive.

The fruit analyses for total nitrogen show much less variation than those for the 1928 experiment. On Aug. 15 the fruit of both the check trees and those to be given the nitrate showed the same per cent of total nitrogen, but the fruit from the trees to be nitrated had 4.3 milligrams less per apple than the check fruit. On Sept. 1 the per cent of total nitrogen in the fruit of the check trees had an increase of only 1.8 per cent over its original concentration, while the fruit from the trees receiving nitrate on Aug. 15 had a nitrogen increase of 7.9 per cent. In terms of absolute amounts, the fruit from the check trees had a 5.3 milligram increase, and the fruit from the Aug. 15 nitrated trees had an 8.1 milligram increase. It would seem that the fruit on trees receiving a 6-pound sodium nitrate application on Aug. 15 took up a little more nitrogen than did the fruit on trees not nitrated. Apparently this increase was due to increased soluble nitrogen. Following Sept. 1 both lots of fruit had exactly the same increase in per cent total nitrogen, and both apparently took up about 14 milligrams of nitrogen.

The fruit from trees nitrated on Sept. 1 was initially comparatively high in nitrogen, which decreased thereafter, both in per cent of dry weight and in milligrams per apple. Between Sept. 15 and Sept. 28, in the fruit from both check and Aug. 15 nitrated trees, there was a rather large nitrogen increase, due to an increase in soluble nitrogen. This increase can not well be explained, although it might have been caused by the nitrogen moving into the fruit from the leaves at this time.

It will be noted that fruit on trees receiving nitrate on Sept. 1 and on Sept. 15 showed the decrease in absolute amounts of nitrogen, which was suggested in the 1928 experiment.

TABLE XXII - Effect of late summer and early fall applications of sodium nitrate (6 lbs. per tree) on the nitrogen content of YORK IMPERIAL apples,* including the core, flesh and skin.

Dates of Sampling	Alcohol Soluble Nitrogen				Alcohol Insoluble Nitrogen				Total Nitrogen			
	Check	Dates of application of Nitrate			Check	Dates of application of Nitrate			Check	Dates of application of Nitrate		
		Aug.15	Sept.1	Sept.15		Aug.15	Sept.1	Sept.15		Aug.15	Sept.1	Sep.15
Nitrogen expressed in per cent of dry weight												
Aug. 15	.007				.160	.169			.167	.165		
Sept. 1	.036	.058	.110		.134	.120	.144		.170	.178	.254	
Sept.15	.011	.025	.044	.072	.125	.120	.138	.130	.136	.145	.182	.202
Sept.28	.040	.044	.054	.003	.125	.130	.131	.133	.165	.174	.184	.136
Per cent Increase Following First Analysis					-21.9	-23.0			1.2	5.5		
Nitrogen expressed in milligrams per apple												
Aug. 15	1.92				28.23	26.55			30.15	25.80		
Sept. 1	7.91	11.21	20.25		27.51	22.70	25.75		35.42	33.91	45.90	
Sept.15	2.50	5.12	8.61	14.45	24.88	23.66	26.53	25.55	27.38	28.78	35.14	40.00
Sept.28	15.38	12.51	11.48	6.34	24.92	25.20	27.40	26.48	40.30	37.73	38.88	32.82
Per cent Increase Following First Analysis					-11.7	-5.10			33.7	46.3		

* Sample is composite of two apples from each of six trees.

Seeds - The seeds of the fruit were analyzed separately, the results in Table XXIII being presented in three ways: nitrogen as per cent of dry weight, nitrogen in milligrams per fruit, and nitrogen in milligrams per seed. The figures giving the per cent of total nitrogen show nitrogen increased in all cases following nitrate applications to the trees. The check, with the exception of the Sept. 15 analysis, showed a decrease in nitrogen. From Aug. 15 to Sept. 28 the seeds from the check trees lost 6.5 per cent of their total nitrogen, while seeds from fruit on trees nitrated on Aug. 15 showed 8.9 per cent gain in nitrogen.

If the nitrogen enters the apple under a force within the tree, then it would seem that the absolute amount of nitrogen per fruit would give a better indication of the effect of increased nitrate supply. These results in Table XXIII show a steady, 18.5 per cent nitrogen decrease in seeds from unfertilized trees, while the seeds from the trees nitrated on Aug. 15 show a rather irregular 6.5 per cent increase.

If, on the other hand, the nutrient supply to the fruit is determined to some extent by the number or size of the seeds, the absolute amount of nitrogen per seed should be the best criterion. These results show 33 per

TABLE XXIII - Effect of late summer and early fall applications of sodium nitrate (6 lbs. per tree) on the nitrogen content of YORK IMPERIAL seeds.

Dates of Sampling	Alcohol Soluble Nitrogen: Check	Alcohol Soluble Nitrogen: Dates of application of Nitrate: Aug.15	Sept.1	Sept.15	Alcohol Insoluble Nitrogen: Check	Alcohol Insoluble Nitrogen: Dates of application of Nitrate: Aug.15	Sept.1	Sept.15	Total Nitrogen: Check	Total Nitrogen: Dates of application of Nitrate: Aug.15	Sept.1	Sep.15
Nitrogen expressed in per cent of dry weight												
Aug. 15	.77	.04			4.56	4.67			5.23	4.71		
Sept. 1	.09	.15	.10		4.89	4.84	4.98		4.98	4.99	4.98	
Sept.15	.21	.14	.17	.24	4.91	4.95	4.96	4.89	5.12	5.09	4.96	4.89
Sept.28	.21	.07	.29	.09	4.68	5.06	4.83	5.14	4.89	5.13	5.12	5.23
Per cent Change Following First Analysis					+2.6	+8.4			-6.5	+8.9		
Nitrogen expressed in milligrams per fruit												
Aug. 15	18.3	.9			125.0	120.0			143.3	120.9		
Sept. 1	2.4	5.0	2.6		128.9	148.8	124.1		131.3	153.8	126.7	
Sept.15	5.2	3.2	4.4	6.5	121.7	111.4	124.4	130.3	126.9	114.6	128.8	136.8
Sept.28	5.1	1.9	6.8	1.8	111.7	126.9	120.2	108.0	116.8	128.8	127.0	109.8
Per cent Change Following First Analysis					-10.6	+5.8			-18.5	+6.5		
Nitrogen expressed in milligrams per seed												
Aug. 15	.216	.012			1.422	1.501			1.688	1.513		
Sept. 1	.011	.054	.034		1.872	1.753	1.705		1.903	1.807	1.739	
Sept.15	.077	.053	.063	.078	1.739	1.857	1.830	1.630	1.816	1.910	1.893	1.708
Sept.28	.097	.028	.104	.036	2.148	1.982	1.715	2.077	2.245	2.010	1.819	2.113
Per cent Change Following First Analysis					+50.6	+32.0			+33.3	+33.1		

cent total and insoluble nitrogen increases by the seeds from both the check and the Aug. 15 nitrated trees, although the increase in the case of the nitrated trees was the more regular.

The results of analyzing the seeds are not altogether conclusive, but they do show that following the Aug. 15 nitrate application there was slightly more nitrogen taken up by the seeds of the fruit than in the case of the check trees. More precise methods of sampling fruit will have to be used before it will be possible to measure any small increases of nitrogen which might follow nitrate applications.

Leaves - Although the late summer nitrate applications did not materially increase the nitrogen in the fruit, it did temporarily increase the insoluble nitrogen in the leaves. The soluble nitrogen was not affected. From Table XXIV, it is apparent that the per cent of nitrogen in both the check and Aug. 15 nitrated trees increased until Sept. 1. After Sept. 1, in the case of the normal (check), unfertilized trees the leaf nitrogen decreased. Apparently the nitrogen moved out of the leaves, as Lincoln (9) and others have suggested. This hypothesis is further advanced by the fact that these check leaves, showing the greatest nitrogen decrease, have a very high soluble nitrogen content, which would indicate a preparatory stage in nitrogen translocation.

In the case of trees receiving nitrate on Aug. 15, on the other hand, the leaves continued to increase in nitrogen from Sept. 1 until Sept. 15, and then showed a decrease. Evidently the nitrate application delayed this decrease in nitrogen content. With trees receiving nitrate on Sept. 1, the leaves showed the same nitrogen increase by Sept. 15, as did the leaves on the Aug. 15 nitrated trees; and likewise showed a decrease in nitrogen after Sept. 15. In the case of trees receiving nitrate on Sept. 15, however, there was no resulting leaf nitrogen increase, but rather a decrease similar to that in the trees nitrated on the preceding dates.

The fact that late summer and early fall nitrate applications were absorbed by the tree and affected the leaves was indicated by leaf color observations. On Sept. 1 casual observations showed a deeper green color of the leaves of trees nitrated Aug. 15. Two weeks later, on Sept. 15, trees fertilized on Sept. 1 had as great an increase in deep green color of the leaves as trees fertilized on Aug. 15. On Sept. 28 the differences in leaf color were not as conspicuous. To verify the observations on leaf color, the catalase activity of terminal branch leaves was measured.

TABLE XXIV - Effect of late summer applications of sodium nitrate (6 lbs. per tree) on the nitrogen content of leaves from the current season's growth of YORK IMPERIAL bearing spurs.

Nitrogen expressed in per cent of dry weight

Dates of Sampling	Alcohol Soluble Nitrogen				Alcohol Insoluble Nitrogen				Total Nitrogen			
	Check	Dates of application of Nitrate			Check	Dates of application of Nitrate			Check	Dates of application of Nitrate		
		Aug.15	Sept.1	Sept.15		Aug.15	Sept.1	Sept.15		Aug.15	Sept.1	Sep.15
Aug. 15	.194	.206			.861	.879			1.055	1.085		
Sept. 1	.194	.178	.168		.958	.980	.961		1.152	1.158	1.129	
Sept.15	.190	.194	.108	.173	.896	1.009	1.061	.893	1.086	1.203	1.169	1.066
Sept.28	.215	.183	.017	.165	.875	.982	1.129	.880	1.090	1.165	1.146	1.045
Per cent Change Following First Analysis	+10.8	-11.1			+1.6	+11.7			+3.3	+7.4		

Also, the number of leaves on three limbs of four trees in each group was determined on Sept. 28, and then again on Oct. 20, to estimate which group of trees held their leaves longest. The results of these leaf studies are given in Table XXV. The nitrogen analyses of leaves from bearing spurs, taken from Table XXIV, are given for comparison with catalase activity. The fact that increased catalase activity is paralleled by increased nitrogen content bears out the statements of Heinicke (5). The effect of the late summer nitrate in delaying leaf abscission is shown in Plates I to IV, inclusive, showing the appearance of typical trees in each group on Oct. 20.

TABLE XXV - Effect of late summer applications of sodium nitrate on the color, catalase, total nitrogen, and abscission of leaves.

Date of Observation	Type of Observation	Check Trees	Trees Receiving 6 lbs. of Nitrate Aug. 15	Sept. 1	Sept. 15
Sept. 28	Foliage Color	Dull Green	Dark Green	Bright Green	Dull Green
Sept. 28	Catalase ** Activity #	2.71 2.12	4.50 4.82	6.21 7.33	2.40 3.91
Sept. 28	Total Nitrogen @	1.090	1.165	1.146	1.045
Oct. 20	Per cent of Leaves Left on Tree	30.4	37.0	54.9	62.1

NOTES:

** Activity is expressed in cubic centimeters of oxygen liberated during the first minute of contact with hydrogen peroxide.

The two figures for each determination represent the results on samples from two different trees.

@ The total nitrogen is expressed in per cent of dry weight.

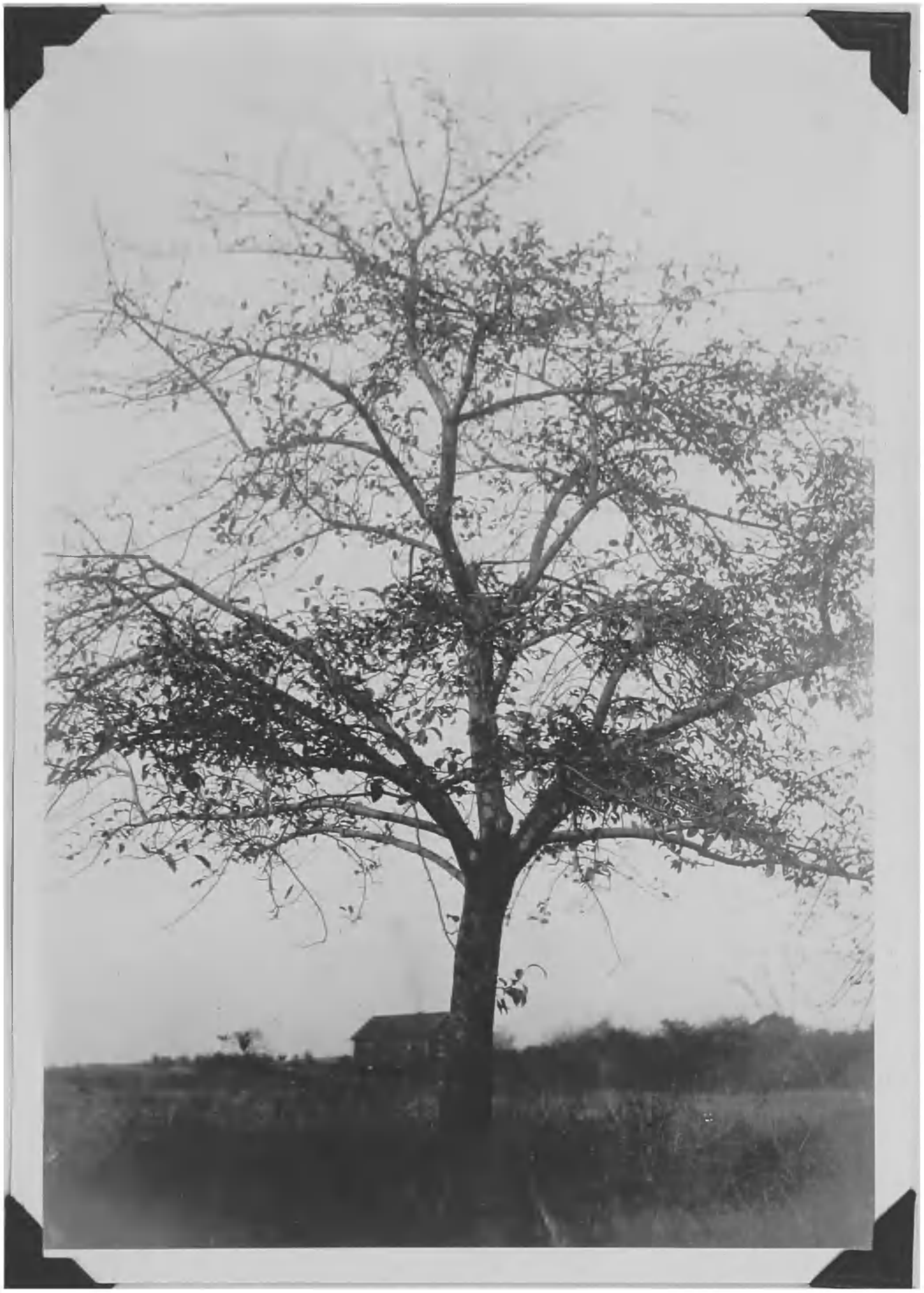

Plate I - Nitrogen deficient York Imperial trees on October 20. This tree has never received any sodium nitrate.

Note the extent of the normal fall defoliation.

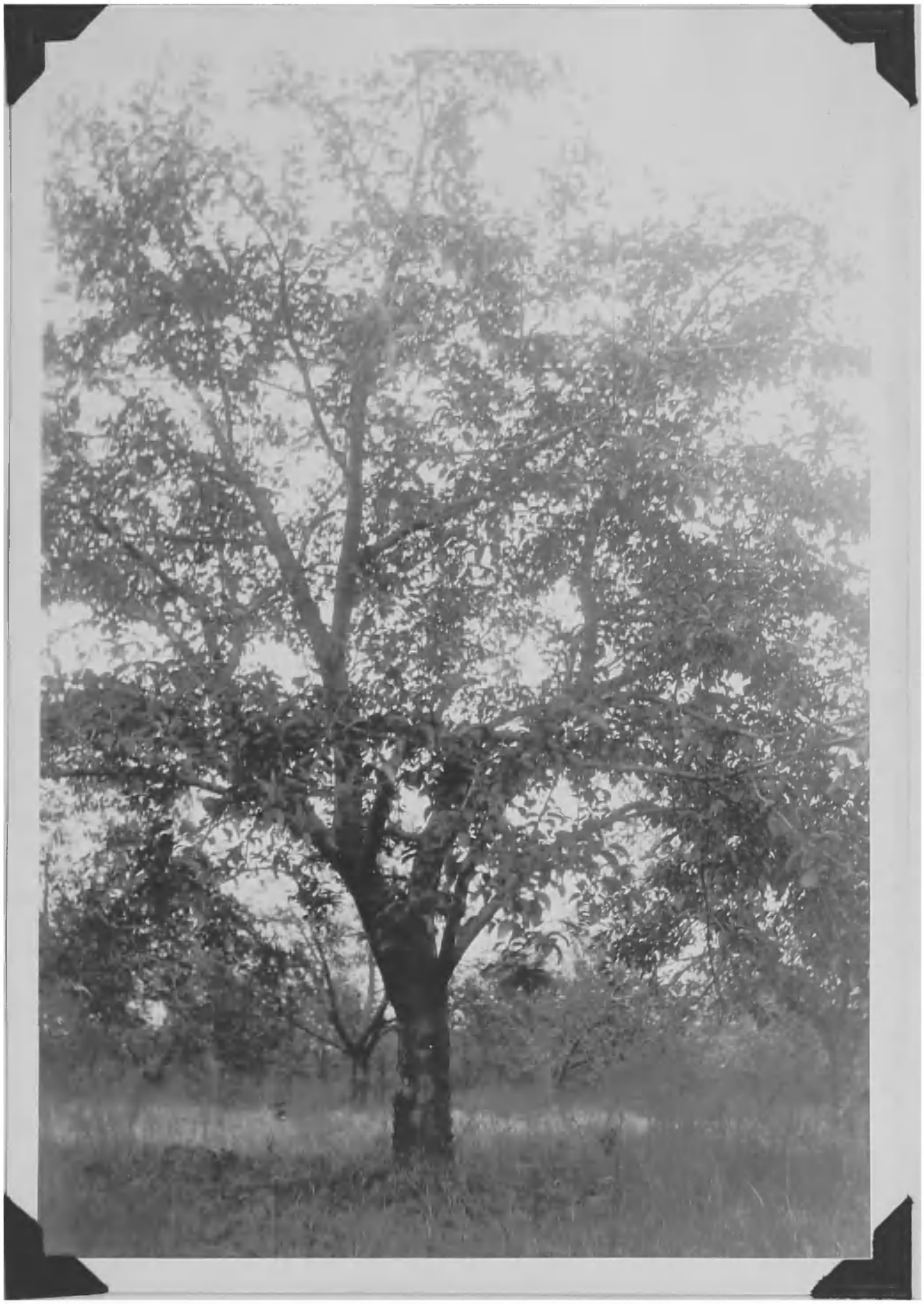

Plate II - Nitrogen deficient York apple tree on October 20. This tree received 6 lbs. of sodium nitrate on Aug. 15.

Note that this tree has more foliage than the tree in Plate I which received no nitrate.

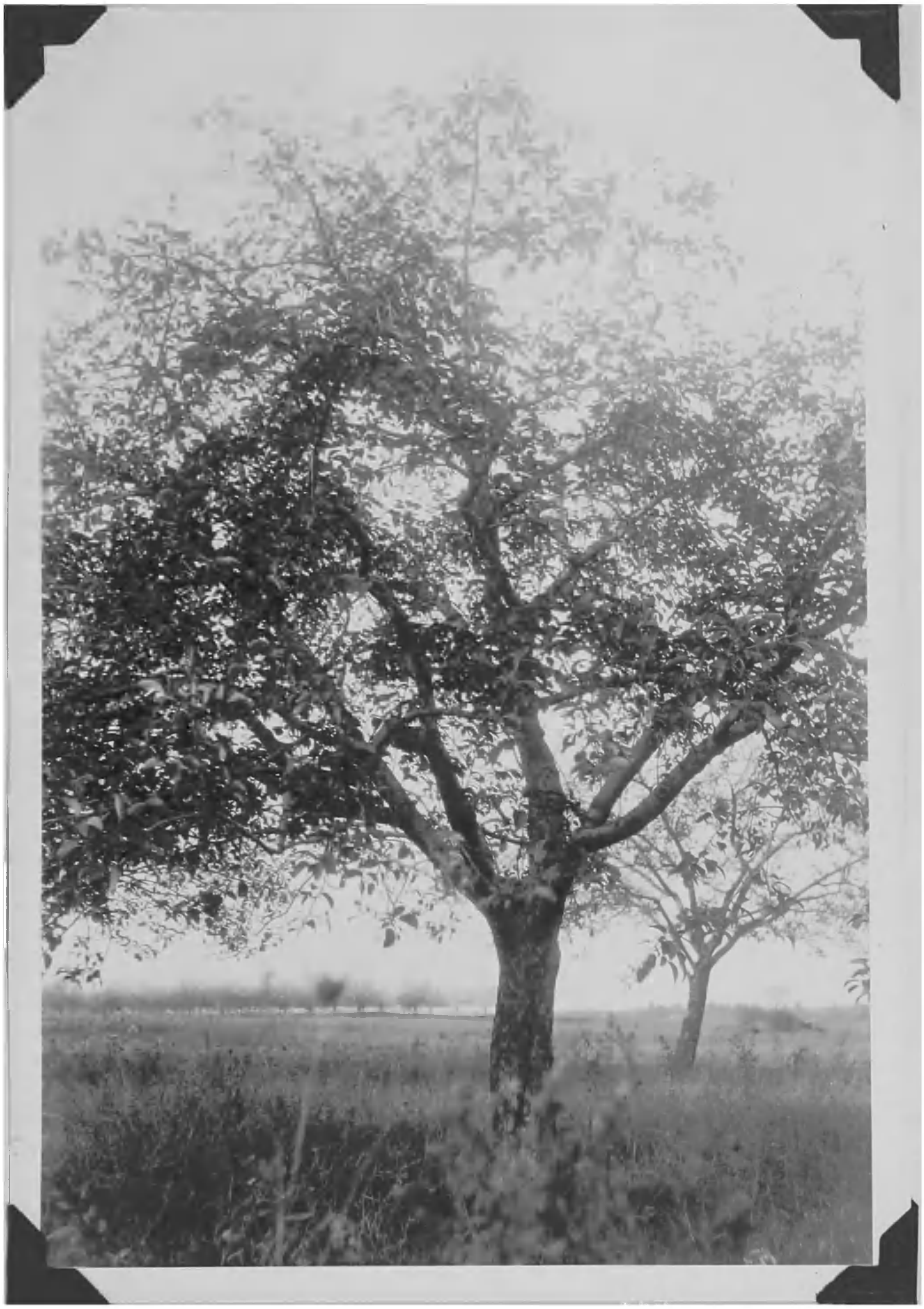

Plate III - Nitrogen deficient York apple tree on October 20. This received 6 lbs. of sodium nitrate on Sept.1.

Note that this tree has more foliage than other trees in Plates I, II and IV.

Plate IV - Nitrogen deficient York apple tree on October 20. This tree received 6 lbs. of sodium nitrate on Sept. 15.

Note that the amount of foliage is intermediate between that on the tree not receiving any nitrate (Plate I) and that on the tree receiving 6 lbs. of nitrate on Aug. 15 (Plate II).

Spurs - The nitrogen content of the spurs, bearing the leaves and fruit analyzed, is given in Table XXVI. Between Aug. 15 and Sept. 1 both the soluble and insoluble nitrogen content of the spurs, on both check trees and those nitrated on Aug. 15, showed a decrease. Apparently, the decrease in soluble nitrogen was less in the nitrated trees than in the check trees, which might indicate a slight effect from the nitrate application. Between Sept. 1 and Sept. 15 the soluble nitrogen of the check spurs, as compared with the spurs of the Aug. 15 nitrated trees, showed a slightly greater increase; but between Sept. 15 and Sept. 28 this soluble nitrogen increase was very much greater. The insoluble nitrogen, on the other hand, decreased equally in the spurs of both treatments between Sept. 1 and Sept. 15, but between Sept. 15 and Sept. 28, the insoluble nitrogen of the Aug. 15 nitrated trees increased so much more than did the insoluble spur nitrogen of the check trees that the total nitrogen in these nitrated trees was greater than in the check spurs.

These nitrogen changes just outlined seem rather closely related to the leaf nitrogen changes. The increases in soluble nitrogen of the check spurs occurred at the same time that the insoluble nitrogen of the check leaves decreased. The final large increase in soluble nitrogen in the check spurs occurred the last of September when the leaves showed a sudden rise in soluble nitrogen. It would seem, then, that the spur nitrogen changes in the check trees support the theory that the nitrogen of the leaves moved out into the spurs.

It will be noted in Table XXVI that the spur nitrogen of trees nitrated on Sept. 1 showed increases in insoluble nitrogen between Sept. 1 and Sept. 28, greater than occurred in the check, but less than occurred in the trees nitrated on Aug. 15. Thus these trees nitrated on Sept. 1 showed spur nitrogen increases as compared with the check trees, but the increases were not as great as in trees receiving nitrate on Aug. 15.

In the case of trees receiving nitrate on Sept. 15, the data shows no definite spur nitrogen increase following the nitrate application.

TABLE XXVI - Effect of late summer applications of sodium nitrate (6 lbs. per tree) on the nitrogen content of YORK IMPERIAL bearing spurs (current season's growth only).

Nitrogen expressed in per cent of dry weight

Dates of Sampling	Alcohol Soluble Nitrogen				Alcohol Insoluble Nitrogen				Total Nitrogen			
	Check	Dates of application of Nitrate			Check	Dates of application of Nitrate			Check	Dates of application of Nitrate		
		Aug.15	Sept.1	Sept.15		Aug.15	Sept.1	Sept.15		Aug.15	Sept.1	Sep.15
Aug. 15	.395	.440			1.210	1.175			1.605	1.615		
Sept. 1	.240	.315	.375		1.195	1.155	1.100		1.435	1.470	1.475	
Sept.15	.415	.450	.415	.455	1.155	1.105	1.155	1.225	1.570	1.555	1.570	1.680
Sept.28	.525	.400	.330	.325	1.160	1.380	1.340	1.280	1.685	1.780	1.670	1.605
Per cent Change Following First Analysis	+32.9	-10.0			-4.1	+17.4			+5.0	+9.7		

Bark - The analyses of the bark from the trunks of the trees are given in Table XXVII. The per cent of nitrogen in the trunk bark did not change during the period Aug. 15 to Sept. 1, in either the check or Aug. 15 nitrated trees. From Sept. 1 to Sept. 28 the nitrogen in the bark of nitrated and check trees showed essentially similar increases in insoluble or total nitrogen, except in the case of trees nitrated on Aug. 15, which showed a nitrogen decrease on Sept. 28. The data, while being fairly consistent, shows no nitrogen increase following the nitrate applications.

The analyses of the scaffold limb bark are given in Table XXVIII. The nitrogen content of these scaffold limb bark samples was apparently quite variable, with the result that no correlation can be obtained between nitrate applications and changes in bark nitrogen.

The variability of the bark analyses was probably due to the difficulty in securing comparable samples from the individual trees in each treatment. The nitrogen content of a single section of bark was probably more affected by the activity of the roots directly below than by the amount of nitrate available in the soil. Since the same tree had to be sampled repeatedly, only small sections of bark could be taken each time; and these small sections of bark undoubtedly did not give samples representative of the entire tree.

TABLE XXVII - Effects of late summer applications of sodium nitrate (6 lbs. per tree) on nitrogen content of the trunk bark of nitrogen-deficient YORK trees.

Nitrogen expressed in per cent of dry weight

Dates of Sampling	Alcohol Soluble Nitrogen				Alcohol Insoluble Nitrogen				Total Nitrogen			
	Check	Dates of application of Nitrate			Check	Dates of application of Nitrate			Check	Dates of application of Nitrate		
		Aug.15	Sept.1	Sept.15		Aug.15	Sept.1	Sept.15		Aug.15	Sept.1	Sept.15
Aug. 15	.041	.032			.412	.449			.453	.481		
Sept. 1	.023	.017	.090		.435	.465	.465		.458	.482	.555	
Sept.15	.003	.017	.021	.022	.504	.502	.448	.446	.507	.519	.469	.468
Sept.28	.017	.024	.019	.018	.507	.473	.528	.543	.524	.497	.547	.561

TABLE XXVIII - Effects of late summer applications of sodium nitrate (6 lbs. per tree) on the nitrogen content of the scaffold limb bark of nitrogen-deficient YORK trees.

Nitrogen expressed in per cent of dry weight

Dates of Sampling	Alcohol Soluble Nitrogen				Alcohol Insoluble Nitrogen				Total Nitrogen			
	Check	Dates of application of Nitrate			Check	Dates of application of Nitrate			Check	Dates of application of Nitrate		
		Aug.15	Sept.1	Sept.15		Aug.15	Sept.1	Sept.15		Aug.15	Sept.1	Sept.15
Aug. 15	.211	.105			.309	.497			.520	.602		
Sept. 1	.093	.063	.040		.389	.496	.442		.482	.559	.482	
Sept.15	.096	.035	.038	.033	.536	.514	.480	.462	.632	.549	.518	.495
Sept.28	.014	.041	.046	.095	.475	.574	.419	.475	.489	.615	.465	.570

Summary of the 1929 Experiment - In the 1929 experiment, a sodium nitrate application of 6 pounds per tree, made on Aug. 15, Sept. 1, or Sept. 16, did not cause any decrease in the color or keeping quality of the fruit that same season. Chemical analyses showed no greater increase in nitrogen in fruit (minus seeds) on nitrated trees than in fruit on check trees. In the case of trees receiving nitrate on Aug. 15, the data indicates a very slight nitrogen increase over the check, but this increase was so slight as to be of questionable significance. The seeds of this fruit, however, apparently did increase in nitrogen following all nitrate applications, while the seeds of check fruit decreased in nitrogen. The leaves unquestionably showed the effects of the nitrate by a deeper green color within two weeks after its application. The effects of nitrate on the leaves by Sept. 28 were deeper green color, higher nitrogen content, higher catalase activity, and a retardation of leaf abscission, as compared with the check. The spurs showed increased nitrogen over the check only in the case of trees nitrated on Aug. 15 and on Sept. 1, and the increases were very slight. Neither the trunk nor the scaffold limb bark showed any nitrogen increases following nitrate applications. It would seem, therefore, that the leaves are the principle part of the tree affected following late summer nitrate applications.

GENERAL DISCUSSION OF RESULTS

Recent horticultural investigations have reported the effect of fall applications of sodium nitrate in apple production. Experiments extending over a two-year period have been conducted to determine the effect of fall applications upon the color and keeping quality of the fruit. In interpreting the effects of such nitrate applications, the time of application, amounts used and the vigor and age of the trees involved must be carefully considered.

Neither the color nor the keeping quality of the fruit from vigorous trees of Stayman Winesap, York Imperial, and Rome Beauty varieties of apple were affected by early fall (Sept. 3 and Sept. 16) sodium nitrate applications. Furthermore, in the case of nitrogen deficient York Imperial trees, the color and keeping quality of the fruit was not affected by early fall nitrate applications.

The fruit color was slightly affected when the nitrate applications were made in the late summer about Aug. 15. The red color of Stayman Winesap and York Imperial fruit on vigorous trees nitrated on Aug. 19 was somewhat less than on adjacent vigorous check trees. However, this decreased color was so slight, as compared with the check, that it could not be noticed by casual inspection of the fruit, either on the tree or after being picked. Careful detailed records of the amount of color on 100 apples on each tree were necessary to show color differences.

On the other hand, the color of the fruit on vigorous Rome Beauty trees and on nitrogen deficient York Imperial trees was increased, as compared with the check, by mid-August nitrate applications. The color increase of the Rome Beauty fruit was easily apparent at first glance, not only because the fruit had more of its surface colored, but because the color was a much deeper red. The color increase in the nitrogen deficient York Imperial fruit was very slight, and could not be observed by casual inspection. Since the leaves were conspicuously greener in this case, they may have been more active photosythetically, with the result that more carbohydrates were produced; and the increased carbohydrates might have resulted in a slightly greater pigment formation. A study of these leaves on Sept. 28 showed the deeper green color to be associated with a higher catalase activity.

The keeping quality of fruit from each treatment was tested in common and cold storage. The keeping quality of Stayman Winesap and Rome Beauty fruit from vigorous trees, and of York Imperial fruit from nitrogen deficient trees, was not decreased by sodium nitrate applications made in the early fall (Sept. 3 and 16). Only in the case of a sodium nitrate application made in the late summer on Aug. 19, to vigorous York Imperial trees, was there any decrease in keeping quality as compared with the check fruit. This decrease in keeping quality was exhibited as a greater decrease in flesh firmness than with the check fruit. Although this decrease in firmness was significant, the reduced firmness would hardly have been apparent to the fruit "trade".

Thus the 1928 and 1929 results have shown no effect on either the color or the keeping quality of fruit following sodium nitrate applications made in September. It was only when the nitrate applications were made in August that the color or keeping quality were affected. Since nitrate, when used in commercial orchards in the fall, is applied about the middle of September or later rather than in August, its application at that time should have no deleterious effect on the fruit color or keeping quality.

With all three varieties studied the nitrogen in the sodium nitrate applications was absorbed by the roots of the trees before picking time (about Oct. 1), as was shown by the total nitrogen analyses of the fruit, leaves, and spurs. In the case of the vigorous trees receiving nitrate on Aug. 19, the fruit of the Rome Beauty trees had increased in nitrogen over the check by Sept. 1; the fruit of the York Imperial trees had a nitrogen increase over the check by Sept. 16; while the fruit of the Stayman Winesap did not show any nitrogen increase as compared with the check until Oct. 1. The apparent differences in the time required for the increased nitrogen to reach the fruit are probably due not so much to varietal differences as to differences in the vigor of the individual trees. This explanation is borne out by the varying response of the duplicate nitrated trees, one of which would show a decided nitrogen increase as compared with the check, while the other would behave in a manner similar to the check.

Increased nitrogen in the fruit was also found in the case of Rome Beauty trees nitrated on both Sept. 3 and on Sept. 16, but in the case of York Imperial no nitrate application made after Sept. 3 caused any fruit nitrogen increase. The Rome Beauty fruit, ripening fully two weeks later than the York Imperial, would be expected to show increased nitrogen from a later application of nitrate.

The fruit on the nitrogen deficient York Imperial trees showed no nitrogen increase over the check following Sept. 1 or Sept. 16 nitrate applications, but did show a very slight insoluble nitrogen increase within two weeks after the Aug. 15 application.

It is interesting to note, that while it has been shown that nitrate applications have in many cases resulted in an increased amount of nitrogen in the fruit, in only one case did the fruit show a lessened keeping quality. Evidently the nitrogen in the fruit may be increased slightly without its keeping quality being affected. In the one instance that the keeping quality was reduced, the increase in amount of nitrogen in the fruit was greater than in any other case. However, Gourley and Hopkins (3a) have shown that the nitrogen content of apples may be increased 100 per cent following spring nitrate applications without any apparent injury to the keeping quality. The results obtained in 1929, when the seeds were analyzed separately from the fruit, indicated practically no increased nitrogen over the check in the case of the combined flesh, skin, and core, but did show nitrogen increases over the check in the seeds from those same apples. The increased nitrogen in the seeds rather than in the fruit flesh may offer one explanation why increasing the nitrogen in the whole fruit does not affect the condition of the flesh.

Nitrogen increases in the leaves and spurs of the vigorous trees, following the sodium nitrate applications, were not consistently shown. Leaf nitrogen was increased over the check, following nitrate applications, in a sufficient number of cases to indicate that in general the trees had been absorbing the nitrate. In some cases, however, there were no nitrogen increases, as compared with the check, either in the spurs or in the leaves. The reason for this apparent lack of response in 1928 was that there may have been sufficient nitrogen available from the 6-pound spring application to maintain a high nitrogen content of these trees.

In September, according to the leaf analyses, there apparently is a movement of nitrogen out of the leaves, as shown by Lincoln (9) and others. The large increase in soluble nitrogen in the check spurs at this time seems to lend proof to this theory. This apparent nitrogen translocation took place earlier in September in the nitrogen deficient trees than in the vigorous trees. This earlier nitrogen translocation in the nitrogen deficient trees was probably due to their earlier maturity and earlier leaf fall. In the 1929 experiments, the nitrate applications retarded this nitrogen decrease in the leaves and also retarded the leaf fall. In the case of the more vigorous leaves in the 1928 experiments, the nitrogen decrease was slightly retarded by nitrate applications, but the results were not as pronounced.

There may be two explanations for this effect of nitrate applications upon nitrogen movement out of the leaves. The nitrate applications may supply enough nitrogen to the spurs to reduce any nitrogen deficit that may normally result in an earlier movement of nitrogen out of the leaves, with the result that the nitrogen does not move out of these leaves as early as it does in the leaves of the check trees. The other explanation is that in the nitrated trees there is a period following the nitrate application during which the nitrogen may move into the leaves as rapidly as it moves out, but that after this period the movement out of the leaves becomes the greater.

The two years' experiments have shown that early fall sodium nitrate applications (Sept. 1 to Sept. 16) have not resulted in any measurable effect upon the color and keeping quality of the fruit of three varieties of apple, - Stayman Winesap, York Imperial, and Rome Beauty. Late summer applications (Aug. 15 to 19) increased the fruit color of vigorous Rome Beauty trees and nitrogen deficient York Imperial trees, but slightly decreased the fruit color of vigorous Stayman Winesap and York Imperial trees. Only in the case of vigorous York Imperial trees did the late summer applications cause any injury to keeping quality.

SUMMARY AND CONCLUSIONS

1928 Experiment

1 - On bearing apple trees in the fall of 1928 sodium nitrate was applied (4 pounds per tree) to one plot on Aug. 19, on another plot on Sept. 3, and on still another plot on Sept. 16 of each of the three varieties, - Stayman Winesap, York Imperial,and Rome Beauty. One tree in each plot was left unfertilized as a check. All these trees had received a spring application of 6 pounds of sodium nitrate.

2 - Early fall nitrate applications made on Sept. 3 and on Sept. 16 had no effect on the fruit color or keeping quality in common or cold storage.

3 - The Aug. 19 application of sodium nitrate slightly decreased the red color of the Stayman Winesap and York Imperial fruit, but increased the color of Rome Beauty fruit.

4 - Only in the case of the York Imperial trees nitrated on Aug. 19 did the nitrate application result in slightly decreased firmness of the fruit during storage, as compared with the check fruit.

5 - In the case of the Stayman Winesap and Rome Beauty trees, the late summer (Aug. 19) nitrate application had no effect on the keeping quality of the fruit in either common or cold storage.

6 - From the analyses of the fruit of all varieties for total nitrogen, it would seem that in most cases nitrate applications on Aug. 19 and on Sept. 3 resulted in increased nitrogen in the fruit before picking time as compared with the check. In the case of Rome Beauty, the Sept. 16 nitrate application also increased the fruit nitrogen over the check.

7 - In the case of the York Imperial fruit on trees fertilized on Aug. 19 which showed both decreased color and keeping quality as compared with the check, the fruit nitrogen increase over the check was much larger than in any other case.

8 - With all three varieties sodium nitrate applied on Aug. 19 increased the total nitrogen in the leaves and spurs, as compared with the check, within a period of from one to five weeks following the nitrate application, the greater increase occurring in the leaves.

9 - The data does not show conclusively that nitrate applications on Sept. 1 or Sept. 16 increased either the leaf or spur nitrogen by Oct. 1.

<u>1929 Experiment</u>

10 - In the fall of 1929, sodium nitrate was applied (6 pounds per tree) to six nitrogen deficient York Imperial apple trees on Aug. 15, to six more on Sept. 1, and to six more on Sept. 15. Six trees were left unfertilized as checks.

11 - The Aug. 15 nitrate application slightly increased the red color of the fruit by Sept. 1, as compared to the check, which was contrary to the results with vigorous trees in 1928.

12 - The Sept. 1 and Sept. 15 nitrate application had no effect on the color of the fruit, similar to the results in 1928 with vigorous trees of three varieties.

13 - None of the sodium nitrate applications had any effect on the keeping quality of the fruit in common or cold storage.

14 - Analyses of the fruit (minus the seeds) for insoluble and total nitrogen did not show that the nitrate applications had increased the nitrogen of the fruit appreciably.

15 - Analyses of the seeds showed nitrogen increases as compared with the check, following nitrate applications on all three dates.

16 - Sodium nitrate applications on Aug. 15 and on Sept. 1 affected the leaves within two weeks, and by Sept. 28 had increased the green color, the catalase activity, and the nitrogen content, as compared to the check.

17 - Nitrate applications on all three dates decreased the rate of normal fall defoliation.

18 - In normal (check) trees the nitrogen apparently began to move out of the leaves into the spurs after Sept. 1.

19-- The nitrate applications had the effect of delaying this decrease in leaf nitrogen about two weeks.

20 - Nitrate applications on Aug. 15 and on Sept. 1 slightly increased the insoluble nitrogen in the spurs.

21 - The bark samples from the trunk and from the scaffold limbs did not show any increased nitrogen following the nitrate applications.

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APPENDIX

Preservation of Samples for Analysis

Fruit - The apples of each sample were sliced into 2-quart preserving jars containing enough hot, 95-per cent, ethyl alcohol to give (assuming the apples to be 85 per cent water) a final alcoholic concentration of 60 per cent. The jar was then put in a water bath, and the contents heated with slight bubbling for 30 minutes.

Leaves - The leaves were removed from the spurs, placed in paper trays (using the lower 4 inches of manila bags), dried for 48 hours at 70 degrees (Centrigrade) in an electric oven, and then stored.

Spurs - The current season's growth on the spurs was separated from the remainder of the spur, placed in an evaporating dish, and dried in the oven at 70 degrees for 72 hours. The spurs were then put in envelopes and stored.

Terminals - The terminals were cut pieces one-half inch in length and dried as were the spurs.

Bark - All bark samples were dried as were the spurs.

Preparation of Sample for Analysis

Fruit - The alcoholic extract in the jars of each fruit sample was decanted off, leaving only the last portion, which contained more or less sediment, and was placed in a 2000 cc. volumetric flask. The fruit slices and the remaining alcoholic extract were put in two large crockery soup plates, and placed in an electric oven at 70 degrees for 48 hours. At the end of this time all the shrivelled slices could be crowded into three weighed aluminum sampling cans. The dried residue on the plate was scrapped loose with a spatula and brushed into the weighing cans. The soup plate was then washed with 60 per cent alcohol, the washings being added to the alcoholic extract, which was then made up to volume. The dried sample was replaced in the oven and dried for 12 hours. The cans were then covered tightly, cooled in a dessicator, and weighed to 5 milligrams. The sample was again dried for 12 hours, and then reweighed. If both weighings agreed within 10 milligrams the material was considered completely dry. The sample was then ground in a hand mill until about 95 per cent of it would pass through a 40-mesh sieve, put in a glass bottle, dried for 10 hours in the oven to remove hygroscopic moisture, and finally cooled and stored in a dessicator.

Leaves - Each sample was heated in the oven for 3 hours to render the tissue crisp. The tissue was then crushed by the fingers, put in an aluminum weighing can, and dried to within 5 milligrams of constant weight. This dried sample was put through a hand mill once, put in a glass bottle, redried to remove hygroscopic water, and stored in a dessicator.

Spurs, Terminals, and Bark - These samples were put in weighing bottles and dried once for 12 hours in a vacuum oven at 70 degrees and 28 mm. pressure. Each sample was then cooled, weighed to .1 of a milligram, and ground in a hand mill until 95 per cent of it would pass through a 40-mesh sieve. The ground sample was dried for 5 hours and stored in a dessicator.

Method of Analysis for Nitrogen

The dry weights of the leaves, spurs and bark were given by the final weights in each case. The dry weight of the fruit was the final weight of the dried fruit, plus the dry weight of the alcoholic extract, obtained by evaporating an aliquot to constant weight.

A sample of fruit for analysis was obtained as follows: An aliquot of the thoroughly shaken extract was pipetted into a 500 cc. Kjeldahl flask, which was placed over the aperture on a steam bath, with the neck of the flask at an angle. When the steam had reduced the extract to a gummy mass, still fluid enough to run slowly when the flask was turned, the flask was removed and allowed to stand in warm air until the neck of the flask was perfectly dry. To the flask was then added a similar aliquot of the dried residue.

Samples of all other material for analysis were obtained by weighing out an aliquot (approximately 1.5 grams) of the ground material, and adding it to a perfectly dry Kjeldahl flask.

Digestion - The Gunning-Jodlbauer-Forester modification of the Kjeldahl method to include nitrates was utilized in the following manner. To the sample in the flask was added 30 cc. (50 cc. in the case of the larger fruit sample) of a sulphuric-salicylic acid mixture (1 gram of salicylic to 30 cc. of concentrated sulphuric acid). The flask was shaken gently to secure complete mixing, using great care not to splash any material into the neck of the flask. In case any of the material remained stuck to the bottom of the flask, untouched by the acid, the flask was heated a few minutes over a tiny flame, until the mixture was warm enough to loosen all material. After being allowed to stand about 30 minutes, the flask was again shaken gently, and set aside for at least 10 hours.

Five grams of sodium thiosulphate were added with a measuring dipper, and the mixture shaken and heated very gently until dense white fumes were given off, whereupon heating was stopped. When the flask had cooled to about 60°, 10 grams of potassium sulphate were added with a measuring dipper, and the mixture heated with a very small flame. When the black mixture had all been dissolved from the sides, the flame was increased to medium intensity. Heating was then continued at moderate intensity until the solution was colorless, and thereafter for one hour. When the flask had cooled, 230 cc. of distilled water was added.

Distillation - 20 cc. of standardized sulphuric acid (approximately .1 normal) was run into a 600 cc. flask from a burette, and enough distilled water added to bring the liquid level 3/4 inch above the bottom of the flask. Three drops of the indicator methyl red were added. This flask was placed with the glass delivery tube of the distillation apparatus reaching within 1/4 inch of the bottom.

To the completely cooled Kjeldahl was added a little powdered zinc with a shaker, and 3 drops of phenolphthalein. After the neck of the flask was rinsed with distilled water, 60 cc. (100 cc. when 50 cc. of acid mixture had been used in digestion) of saturated sodium hydroxide was poured slowly down the side of the flask. The flask was immediately connected with the distillation apparatus, the rubber stopper being pushed very firmly into the neck. Lastly, the previously lighted burner was increased in intensity, and a second or so later the flask shaken to completely mix the contents. If the solution in the flask had become alkaline, as desired, the phenolopthalein turned pink.

The distillation was continued until nearly all the water had been removed, as indicated by the commencement of frothing of the alkali in the bottom. The flame was then cut off and the receiving flask removed, care being taken to rinse out the delivery tube.

The acid in the receiving flask, remaining unneutralized by the ammonia in the distillate, was titrated with standardized sodium hydroxide (approx. .1 normal), using as the endpoint the transition of pink to yellow color of methyl red.

Alcohol Insoluble Nitrogen - An aliquot of the dried residue was put in an asbestos cone, and extracted in a Soxhlet with 65% (approx.) alcohol for 4 hours, making sure that the extractor alcohol syphoned out of the Soxhlet at least 6 times per hour. The dried residue after this extraction was handled just as was the material for total nitrogen.

Alcohol Soluble Nitrogen - The soluble nitrogen fraction was calculated by subtracting the insoluble nitrogen from the total nitrogen.

APPROVED E.C. Muchler

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