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Morgantown

EXPERIMENTS IN FERTILIZING PEACH TREES

(TECHNICAL)

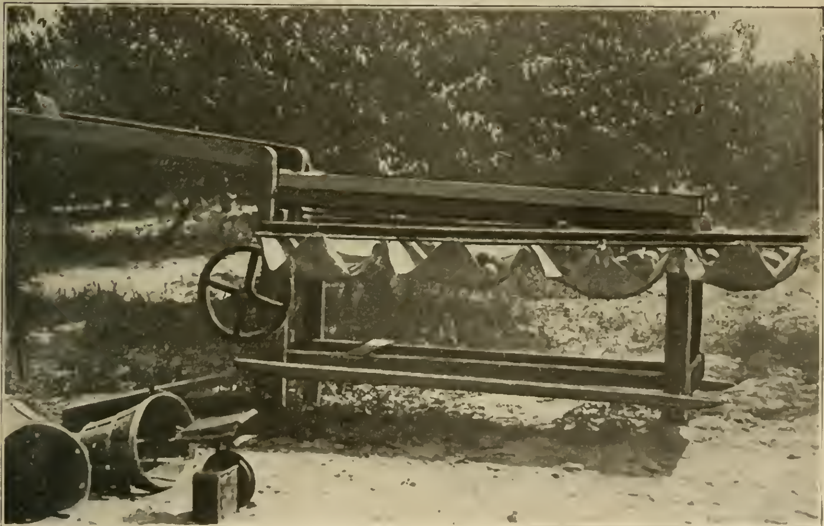

Fig. 1.—Peach Sizer Used in Sizing Peaches From the Various Fertilizer Plots. The Different Grades Were Weighed on the Spring Balances Shown in the Foreground.

BY
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Experiments In Fertilizing Peach Trees

Fertilizer experiments on peach trees have since 1911 been one of the main lines of work of the Department of Horticulture at the West Virginia Agricultural Experiment Station. The first work of this kind at this station has been supplemented by other plots, this bulletin setting forth in considerable detail the results obtained on many phases of the fertilizing of peach trees.

In the first report of the West Virginia experiments in 1915 it was pointed out that there were few experiment stations working on this subject. Since then a number of stations have reported experiments which have contributed valuable information. In order that the growers in West Virginia may have at hand a brief statement of the results of the more recent experiments conducted elsewhere, a short abstract of these investigations is given here. The results of earlier investigations have been reviewed in the earlier report on these experiments.

PEACH FERTILIZING EXPERIMENTS AT OTHER EXPERIMENT STATIONS

The Virginia Experiments

Ralston (6)* reports on the Virginia experiments, the data presented being for the first three crops of a young orchard. There were three series of plots: one under intense cultivation, a second under moderate or what might be termed commercial cultivation, and a third in sod. The following table gives a summary of the three years' work.

* See references on page 72 of this bulletin.

TABLE I.—Yields of Fruit in Pounds on the Plots of Different Treatment—Virginia Experiments.

Treatment	Nitrogen	Phosphorus	Potassium	Check	Nitrogen Phosphorus	Nitrogen Potassium	Nitrogen Phosphorus Potassium	Total Effect of Culture
Intense Cultivation	2708	2996	2848	1943	2914	3059	2181	18649
Moderate Cultivation	1819	1251	934	1285	1298	2095	1442	10124
Sod	1325	1030	1061	712	1319	1344	995	7786
Total Effect of Fertilizers	5852	5277	4843	3940	5531	6498	4618	

It will be seen that nitrogen gave consistent gains over the check plots. Phosphorus and potassium, on the other hand, gave substantial increases in yield only under conditions of intense cultivation where the water content of the soil was presumably higher than in the checks. Under intense cultivation there was practically no difference in the yield produced by any one of the three elements, but under moderate cultivation only nitrogen was of benefit. In the combination plots a very interesting condition was found, nitrogen-potassium gave the greatest total increase; nitrogen-phosphorus yielded more than phosphorus alone. but the yield from the three elements in combination fell below that of any treated plot and was but little above the yield of the checks.

The low yield when potassium was applied to the trees was reported in the work of Alderman (1), Whitten and Wiggans (11), Reimer (7). McCue (3) also found in the Delaware experiments that where phosphorus alone was used in comparatively large amounts it had a tendency to reduce the set of fruit. The results of the Virginia experiments indicate: first, that peaches cannot be grown successfully in sod; second, that good cultivation is more important than fertilization; and third, that under the best culture the application of commercial fertilizer was a profitable practice.

The Ohio Experiments

In 1915 the Ohio Experiment Station (9) started a fertilizer experiment on Catawba Island in an orchard planted in a "gravelly clay loam, probably somewhat low in humus and in only a fair state of fertility." This experiment has run five seasons and during that time on account of adverse weather conditions only one full crop and one light crop have been produced. "The results of these two seasons' work are insufficient in themselves to form a basis for cultural recommendations, but they are worthy of consideration in that they suggest what one might expect, especially as they agree in the main with those of McCue and Alderman." The greatest gains in yield were secured on the plots where nitrogen was used. Nitrogen combined with phosphorus gave a larger yield than nitrogen alone, but when potassium was added the yield was below that of nitrogen. Plots treated with phosphorus or potassium gave poorer returns than the untreated plots, but when they were combined the yield was slightly better than the checks.

The Oregon Experiment

The Oregon Experiment Station (7) conducted one experiment on the fertilizing of peaches "and this owing to frosts some years, lack of uniformity in the trees, and failure to get the yields for one year, has not been very satisfactory. The value of nitrate of soda in this orchard has been so evident, however, that the meager results obtained are worth reporting."

The trees were eighteen years old when the experiment was begun in 1915. The vigor of the trees had been declining for three years before the experiment was started. Analysis of the surface soil showed that it contained an abundance of potassium, calcium, and magnesium and but small amounts of phosphorus, nitrogen, and sulphur. The organic matter was low. The fertilizers were applied from the middle of February to the latter part of March.

In the Oregon experiment no increase in yield was secured from phosphorus and potassium or from 1 to 1½ pounds of nitrate of soda per tree. When the amount of nitrate of soda was increased to three pounds a much larger yield was secured than on the checks. To quote from the report: "While this experiment cannot be considered a very satisfactory one it is, nevertheless, very evident that nitrogen is the chief need of peach trees on this soil."

The Missouri Experiment

The Missouri experiment (11) has been running for a number of years but the crops in most cases were killed during the winter. In the early history of the experiment it was reported that the peach was the only fruit that gave any returns from applications of fertilizers, and that all the plots which received nitrogen alone, or in combination, had the best set of fruit. Furthermore the nitrogen-treated plots had a heavier foliage than the non-nitrogen treated plots. In 1917, Whitten (12) reported that more trees were alive in the nitrogen-treated plots than in any of the others. Whitten and Wiggans (13) in a later report on this project (1919) summarized the work to date and said, "No visible effects are observable where potash or phosphorus has been applied to peaches in past years, either singly or in combination. On young peach trees the use of nitrogen is justified on account of less mortality of the trees in the orchard, stronger, more vigorous growth, better recovery after winter injury, and in some years it has increased the fruit crop fully 50 percent."

The Delaware Experiments

In the early reports of the Delaware experiments (3) it was stated that while phosphorus had little effect upon the receptivity of the stigma, its influence was harmful rather than beneficial especially when the larger amounts were applied. From these studies no conclusions could be drawn as to the influence of nitrogen upon the receptivity of the stigma when alone or in combination with other fertilizers. In their tests on longevity, vitality, and vigor of pollen, the indications were that potash had a greater influence than any of the other fertilizers. Pollen from plots receiving nitrogen seemed to lose its vitality sooner than pollen from any of the other plots.

In a later report (4) on the Delaware experiments, McCue concluded that any effect that nitrogen, phosphorus, or potassium had upon the color of the peaches was secondary, and said that the poorer color of the peaches from the plots receiving nitrogen was due to the dense foliage which followed nitrate applications. The outstanding fact brought out in this experiment was the effect of nitrate of soda on fruit production. He stated that, "There seems to be little danger of over-feeding the peach with nitrogen in the form of nitrate of soda. In brief it may be said that the larger the amount of nitrogen used per tree, the greater the financial returns from the investment."

Nitrogen has been thought by some to produce wood lacking in strength as compared with that produced by phosphorus or potassium or various combinations of the two or by all three. The work of McCue (5) indicates that wood produced on trees heavily fertilized with nitrate of soda was as strong as where phosphorus or potassium was used singly or in combination.

It will be seen from this brief review of the experiments in fertilizing peaches at other stations that the influence of nitrogen is outstanding in increasing growth and yield. In view of the trend of these experiments it will be of interest to follow the results from the use of fertilizers on the peach in the West Virginia experiments.

THE WEST VIRGINIA EXPERIMENTS IN FERTILIZING PEACHES

Three separate experiments are reported in this bulletin. Two of them were started in the spring of 1911, and the third in the spring of 1915. A preliminary report and description of the first two experiments was published as noted above by Alderman (1), and a report of the third is given here for the first time.

The Sleepy Creek Experiment

The Sleepy Creek experiment was carried on in the orchard of the Sleepy Creek Orchard Company at Sleepy Creek, Morgan County, W. Va. The trees of the two varieties used, Waddell and Carman, were six years old at the beginning of the experiment in 1911. The soil is a thin, red, shale loam, low in fertility, belonging to the Upshur gravelly silt loam, a soil type which is widely distributed over the Eastern Panhandle counties of the State.

At the time the experiment was begun nine plots were laid out each consisting of a single row of nine Waddell and eleven Carman trees. Only eight trees of each variety were used as record trees. The others being at the ends of the rows, were discarded. In the spring of 1913 there were more plots added because, as the experiment was originally planned, there were no plots receiving only nitrogen, phosphorus, or potassium. The soil of these three plots, especially that of the Waddell Plots 11 and 12, was much better that that of the older adjacent plots, owing to a slight hollow which caught the wash from the higher land. The treatment of the different plots in this experiment is set forth in Table II.

TABLE II.—Treatment of Plots in Sleepy Creek Experiment.

Plot No.	Treatment	Application in Lbs. Per Tree per Year
1	Nitrate of Soda Acid Phosphate (16%)	1.5 2.5
2	Nitrate of Soda Muriate of Potash	1.5 1.0
3	Nitrate of Soda Acid Phosphate (16%) Muriate of Potash	1.5 2.5 1.0
4	Check	
5	Acid Phosphate (16%) Muriate of Potash	2.15 1.0
6	Nitrate of Soda Acid Phosphate (16%) Muriate of Potash	1.5 2.5 1.0
7	Nitrate of Soda Acid Phosphate (16%) Muriate of Potash	1.5 2.5 2.0
8	Nitrate of Soda Acid Phosphate (16%) Muriate of Potash	1.5 2.5 3.0
9	Caustic Lime	1000 lbs. per acre every third year
10	Nitrate of Soda	1.5
11	Acid Phosphate (16%)	2.5
12	Muriate of Potash	1.0

The Cherry Run Experiment

The second experiment was carried on in the Fulton orchards at Cherry Run in Morgan County. The fertilizers in this test were applied when the trees were first planted in 1911 in order to study the effect of fertilizers upon trees from the time of planting until time of maturity. The variety used was Carman and each plot consisted of a single row of 20 trees. The arrangements of the plots, the fertilizers used, and the rate of application are shown in Table III. As the experiment was originally planned, none of the plots were to receive nitrogen, phosphorus, or potassium alone. Therefore in 1915, as in the Sleepy Creek experiment, three plots were added.

TABLE III.—Treatment of Plots in Cherry Run Experiment.

Plot No.	Treatment	Application in Lbs. Per Tree		
		1911-13	1914	1915-18
1	Nitrate of Soda	.75	1.00	1.50
	Acid Phosphate (16%)	1.25	1.75	2.50
2	Nitrate of Soda	.75	1.00	1.50
	Muriate of Potash	.50	.75	1.00
3	Nitrate of Soda	.75	1.00	1.50
	Acid Phosphate (16%)	1.25	1.75	2.50
	Muriate of Potash	.50	.75	1.00
4	Acid Phosphate (16%)	1.25	1.75	2.50
	Muriate of Potash	.50	.75	1.00
5	Check			
6	Acid Phosphate (16%)			2.50
7	Muriate of Potash			1.00
8	Nitrate of Soda			1.50

The soil in the plots of the Cherry Run experiment is a yellow shale belonging to the DeKalb shale loam, and is low in fertility. Soil analyses from each of the original plots in this experiment, as well as from the one at Sleepy Creek, were published in W. Va. Experiment Station bulletin 150 by Alderman (1).

The Elberta Experiment

The third experiment, also located at Cherry Run, was started in 1915 with four-year-old Elberta trees in the Fulton orchards. The plan of this experiment was somewhat different from that of the others. To avoid cross feeding, plots five trees square were used, while records were taken only on the nine interior trees, the other sixteen forming a guard row about each plot.

The soil in this experiment belongs to the DeKalb shale loam and was originally somewhat more fertile than that of the other two experiments, yellow in color, and contained more sand and gravel.

This orchard was planted in the spring of 1911 and was cropped with corn in 1911 and 1912, and with tomatoes in 1913. In 1914 the orchard was cultivated until mid-summer when a cover crop of crimson clover was sown. This cover failed and there were only a few scattered plants in the spring of 1915 when the experiment was started. The accompanying diagram in Table IV shows the arrangement of the twenty-four plots and the materials and amounts of each fertilizer applied annually to each tree.

TABLE IV.—Diagram of Elberta Experiment Showing Treatment and Rate of Fertilizer Applications per Tree.

Plot 4 Crimson Clover Acid Phosphate, 16%, 4 Lbs. Muriate of Potash, 1 Lb.	**Plot 3** Crimson Clover	**Plot 2** Soybeans Acid Phosphate, 16%, 4 Lbs. Muriate of Potash, 1 Lb.	**Plot 1** Soybeans
Plot 8 Nitrate of Soda, 6 Lbs.	**Plot 7** Nitrate of Soda, 4 Lbs.	**Plot 6** Check	**Plot 5** Nitrate of Soda, 2 Lbs.
Plot 12 Check	**Plot 11** Nitrate of Soda, 6 Lbs. Acid Phosphate, 16%, 4 Lbs.	**Plot 10** Nitrate of Soda, 4 Lbs. Acid Phosphate, 16%, 4 Lbs.	**Plot 9** Nitrate of Soda, 2 Lbs. Acid Phosphate, 16%, 4 Lbs.
Plot 16 Nitrate of Soda, 6 Lbs. Acid Phosphate, 16%, 4 Lbs. Muriate of Potash, 1 Lb.	**Plot 15** Nitrate of Soda, 4 Lbs. Acid Phosphate, 16%, 4 Lbs. Muriate of Potash, 1 Lb.	**Plot 14** Nitrate of Soda, 2 Lbs. Acid Phosphate, 16%, 4 Lbs. Muriate of Potash, 1 Lb.	**Plot 13** Check.
Plot 20 Nitrate of Soda, 4 Lbs. Applied June 15.	**Plot 19** Nitrate of Soda, 4 Lbs. Muriate of Potash, 1 Lb.	**Plot 18** Manure, 150 Lbs. Acid Phosphate, 16%, 4 Lbs.	**Plot 17** Manure, 150 Lbs.
Plot 24 Nitrate of Soda, 4 Lbs. Applied July 15	**Plot 23** Nitrate of Soda, 4 Lbs. Applied March 25	**Plot 22** Check	**Plot 21** Acid Phosphate, 16%, 4 Lbs. Muriate of Potash, 1 Lb.

Time and Methods of Applying the Fertilizers

In each of the West Virginia experiments the fertilizers were distributed by hand as evenly as possible around the trees under and beyond the spread of the branches for a distance of two or three feet. The materials were harrowed or disked into the ground by the usual orchard cultivation. The dates of application are shown in Table V, except in the Elberta experiment where nitrate of soda was added earlier or later than the regular time on three plots, in order to study the effect of the time of application on the trees.

TABLE V.—Dates of Fertilizer Applications.

Experiment	1911	1912	1913	1914	1915	1916	1917	1918	1919	1920
Sleepy Creek	May 19	May 22	May 26	May 19	May 27	May 23	May 23	May 28		
Cherry Run	May 19	June 8	June 3	May 20	May 26	May 22	May 24	May 27		
Elberta					May 26	May 22	May 24	May 28	May 26	May 20

The plots in all the experiments were cultivated during the growing season and a non-leguminous cover crop, usually rye, was sown each year, except in the plots indicated where other crops were sown. The growth of the cover crops in most cases was small, and was not sufficient to increase materially the low humous content of the soil.

Methods of Taking Measurements

The circumference of the trunk was measured at a point midway between the head of the tree and the ground. The sum of these circumferences was divided by the number of trees in the plot, and this average used as the trunk circumference of the plots under consideration.

The method of measuring shoot growth was as follows: ten terminal growths were taken at random at different points on each tree. The average length of these ten shoots was entered in the notes as the record for each tree. The average of these tree records was taken as the record for each plot. As noted under each experiment, in some instances shoot and trunk measurements were made annually and in others less frequently.

EFFECTS OF FERTILIZER APPLICATIONS ON GROWTH OF THE TREES

Growth and yield are now regarded as the most accurate measure of tree performance. Growth is expressed in trunk enlargement and shoot extension. Yield, broadly interpreted, may be tentatively measured by the set of fruit buds and the set of fruit, but finally in the quantity and quality of fruit produced. Consequently the results secured on the effect of fertilizers will be considered under two main headings: First, the effect of fertilizers on growth, and second, the effect of fertilizers on fruit production. The data from the three experiments will be presented in detail under each of these subdivisions.

Tree Growth in the Sleepy Creek Experiment

Unfortunately the trunk circumference was not obtained for the trees in this experiment until the fall of 1918, just before the trees were pulled out. When the experiment was started the orchard was seven years old and had produced three crops.

TABLE VI.—Effect of Fertilizers on Trunk Circumference of Carman and Waddell.

Plot No.	Treatment of the Plots	Average Trunk Circumference in Inches, 1918	Gain in Inches Over Checks
1	N P	21.62	4.38
2	N K	18.29	1.05
3	N P K	18.50	1.26
4	Check	17.24	
5	P K	16.25	—.99
6	N P K	20.98	3.74
7	N P K*	18.54	1.30
8	N P K**	20.29	3.05
9	Lime	20.45	3.21
10	N	21.70	4.46
11	P	16.87	—.37
12	K	18.75	1.51

* Doubled
** Tripled

Table VI shows the trunk circumference which resulted from the applications of fertilizers for nine years. Wherever nitrogen was used the trunks were larger than those of the checks. Phosphorus or potassium applied alone had very little effect on trunk circumference. The growth was nearly one inch less, however, when the two were applied in combination. In Plots 7 and 8 where the amount of potassium was increased when applied with nitrogen and phosphorus there was an increase in trunk growth over the check but not over the plot receiving nitrogen alone. The trees in the plots receiving lime had trunks almost as large as in any of the plots receiving nitrogen. As pointed out above, these results are based upon the trunk size at the end of the experiment and do not necessarily indicate the actual gain in each plot.

In addition to taking the trunk circumferences as a measure of growth the terminal shoots on each tree of the different plots were measured annually. The average length of the terminal shoots on each plot is given in Table VII.

TABLE VII.—Effect of Fertilizers on the Growth of Terminal Shoots of Carman and Waddell in the Sleepy Creek Experiment.

Carman:

Plot No.	Treatment	Length of Shoot Growth in Inches 1911	1912	1913	1914	1915	1916	1917	1918	Eight-Year Average	Gain Over Check
1	N P	9.61	30.50	13.16	8.40	4.73	17.40	12.53	2.90	12.40	6.08
2	N K	8.50	25.50	11.06	9.08	8.26	12.80	12.56	3.53	11.41	5.09
3	N P K	8.47	28.00	11.69	8.50	8.86	13.10	11.76	4.16	11.81	5.49
4	Check	5.33	13.50	4.06	5.20	5.33	4.40	10.22	2.53	6.32	
5	P K	6.25	14.50	4.37	5.05	4.86	4.20	10.09	6.26	6.95	.63
6	N P K	10.80	26.00	10.10	9.30	5.13	15.50	11.59	4.13	11.57	5.25
7	N P K*	11.36	28.50	11.80	9.95	5.13	10.40	12.10	1.80	11.38	5.06
8	N P K**	10.48	29.00	11.53	10.32	6.06	15.30	13.16	4.26	12.51	6.19
9	Lime	4.94	15.00	5.20	4.10	5.40	6.10	8.49	3.93	6.64	.32
10	N			14.43	8.20	7.66	11.60	14.10	4.83	10.13	3.81
11	P			5.93	5.02	3.66	10.30	7.26	4.56	6.12	—.20
12	K			5.20	5.03	5.06	5.10	9.06	3.40	5.47	—.85

Waddell:

Plot No.	Treatment	1911	1912	1913	1914	1915	1916	1917	1918	Eight-Year Average	Gain Over Check
1	N P	13.70	30.00	14.16	8.47	8.73	13.40	14.26	3.53	13.28	6.94
2	N K	11.32	27.50	13.50	8.88	10.13	13.10	11.46	3.93	12.45	6.11
3	N P K	12.14	29.00	15.16	8.28	7.93	10.90	11.16	4.86	12.42	6.08
4	Check	5.07	18.25	4.41	4.19	5.00	3.20	8.33	2.26	6.34	
5	P K	7.53	18.50	4.95	4.18	9.60	4.40	7.59	4.90	7.70	1.36
6	N P K	8.95	30.50	13.38	10.03	8.13	13.50	12.10	3.03	12.45	6.11
7	N P K*	11.09	29.50	13.98	9.55	8.40	14.10	12.76	4.03	12.92	6.58
8	N P K**	10.22	30.50	12.90	9.28	10.46	13.70	11.29	4.63	12.87	6.53
9	Lime	6.80	20.50	6.11	3.90	7.60	3.20	7.20	2.90	7.27	.93
10	N			19.60	13.06	13.06	6.90	14.03	8.26	12.48	6.14
11	P			8.45	3.68	9.70	3.20	7.43	2.40	5.81	—.53
12	K			7.46	5.73	5.53	4.00	10.80	3.00	6.09	—.25

* Potassium application doubled.
* * Potassium application trebled.

With both varieties, the plots receiving nitrogen made an average annual shoot growth of from four to seven inches more than did the checks. Waddell responded in terminal growth somewhat better than Carman, making about one inch more growth per year. The growth was a little less than the check when phosphorus or potassium was applied alone. When applied together, however, there was a slight increase in each variety. Lime gave a very slight increase in terminal growth, but this slight increase is interesting in view of the fact that since the peach uses so much calcium it might be expected to respond favorably to lime applications. Wherever nitrogen was applied the terminal growth was increased, even to the end of the experiment when the trees were no longer profitable from a commercial standpoint. The vigor of the trees declined with age, but the application of nitrogen prolonged the period of profitableness, so that when they were pulled out, the trees receiving nitrogen were making more growth and were producing heavier and more profitable crops than the trees which had received no nitrogen.

In order to study the response of trees with low vigor, poor growth, and low production, Plots 4 and 5 were each divided into four parts so that one-half of each variety was left as in the original experiment, and to the other half four pounds of nitrate of soda per tree were applied in each spring, 1916, '17, and '18. The results are shown in Table VIII.

TABLE VIII.—Effect of Nitrogen on the Terminal Shoot Growth of Trees of Low Vigor in Plots 4 and 5 of the Sleepy Creek Experiment.

Waddell:

Plot No.	Treatment	Average Terminal Shoot Growth in Inches			Av. Yearly Growth in Inches	Av. Yearly Gain from Nitrogen
		1916	1917	1918		
4	Check	3.20	8.33	2.26	4.59	
4	4 lbs. N	19.80	13.10	5.00	12.63	8.04
5	P K	4.40	7.59	4.90	5.63	
5	4 lbs. N P K	19.80	14.36	9.07	14.41	8.78

Carman:

4	Check	4.40	10.22	2.53	5.71	
4	4 lbs. N	19.60	11.83	8.30	13.24	7.53
5	P K	4.20	10.09	6.26	6.85	
5	4 lbs. N P K	17.30	12.26	8.36	12.64	5.79

Fig. 2.—Waddell, Check Tree. Notice the Very Short Growth and Sparse Foliage. Picture Was Taken July 27, 1916.

Fig. 3.—Waddell. This Was a Check Tree Until May 23, 1916 When 4 Pounds of Nitrate of Soda Were Applied. Notice the Long Growths, Dense Foliage, and Vigorous Condition of the Tree as Compared to the One in Figure 2. Pictures Were Taken at the Same Distance from the Trees on July 27, 1916.

Fig. 4.—Waddell. This Tree Received Phosphorus and Potassium From 1911 Until Time the Picture Was Taken, July 27, 1916. Observe That the Condition of the Tree Was no Better Than That of the One in Figure 2.

Fig. 5.—Waddell. This Tree Received Phosphorus and Potassium From 1911 Until the Spring of 1916 When 4 Pounds of Nitrate of Soda Were Applied on May 23. Compare With Figure 4. Picture Was Taken July 27, 1916.

The trees of each variety which received nitrogen made consistent gains in growth over the checks and over the trees receiving both phosphorus and potassium. Table VIII shows a great increase in growth following the first application of nitrogen. The trees receiving nitrogen made from 5.79 to 8.78 inches more growth annually than did those which did not receive it. During the last year of the experiment the growth resulting from the nitrogen applications was much reduced in all plots but the same general trend of the influence of nitrogen prevailed. The condition of the plots is further shown in Figures 2 and 4 illustrating the growth of the non-nitrogen treated plots compared with Figures 3 and 5 which illustrate the character of the foliage and the growth in the trees receiving nitrogen. These pictures were taken the last of July, 1916, following the first application of nitrate of soda.

Tree Growth in the Cherry Run Experiment

As noted above, fertilizers were applied to the plots in this experiment from the time of planting in 1911; no trunk measurements were made, however, until the fall of 1914. Table IX shows the trunk measurements in 1914 and in 1918.

TABLE IX.—Effect of Fertilizers on Trunk Circumference of Carman in the Cherry Run Experiment.

Plot No.	Treatment			Circumference in Inches 1914	Circumference in Inches 1918	Increase in Inches in Four Years	Gain Over the Check
1	N	P		7.85	16.65	8.80	4.37
2	N		K	7.44	14.85	7.41	2.98
3	N	P	K	7.91	15.45	7.54	3.11
4		P	K	4.30	9.45	5.15	72
5	Check			5.87	10.30	4.43	
6		P			11.55		
7			K		12.30		
8	N				14.20		

As in the previous experiment, the trunks made the greatest increase in circumference where nitrogen was applied. In Plot 4 the trees were smaller in 1914 than those in the check; by 1918 these trees although still smaller than the check trees, had grown faster. No potassium was applied after 1916.

TABLE X.—Effect of Fertilizers on Terminal Shoot Growth of Carman in the Cherry Run Experiment.

Plot No.	Treatment	Average Length of Terminal Shoot Growth in Inches*						Average Annual Growth in Inches	Average Annual Gain over Check
		1912	1913	1914	1915	1916	1917		
1	N P	54.00	53.30	43.30	42.95	42.96	13.29	41.63	10.94
2	N K	36.00	51.50	43.20	38.36	42.84	13.65	37.59	6.90
3	N P K	46.00	51.50	44.30	37.97	41.28	12.06	38.85	8.16
4	P K	24.00	32.50	32.50	29.40	33.72	9.21	26.89	—3.80
5	Check	30.00	39.90	33.90	36.26	36.96	7.17	30.69	
6	P				34.02	36.00	10.71	26.91	.12
7	K				34.01	34.68	7.95	25.54	—1.25
8	N				41.93	46.56	14.04	34.17	7.38

* No effect of fertilizers evident in 1911.

It will be seen from Table X that the trees which received nitrogen made the longest terminal shoot growth. The leaves on these trees were larger, more numerous, and of a darker color, and in the fall they held on later. The combined application of phosphorus and potassium in Plot 4 decreased shoot growth as compared with the check. When the effect of phosphorus in Plot 6 is compared with the growth of check Plot 5 for the same years, there is a very slight gain. On the other hand, in Plot 7 from 1915 to 1917 the use of potassium resulted in a retardation of 1,25 inches compared with the checks for the same years. No benefits were secured from the addition of phosphorus or potassium or both in combination with nitrogen.

Tree Growth in the Elberta Experiment

In this experiment the trunk circumferences were measured at the start and once each year thereafter. The average trunk circumference of the trees in each plot is given in Table XI.

TABLE XI.—The Effect of Fertilizers on Trunk Circumference in the Elberta Experiment at Cherry Run.

Plot. No.	Treatment	Average Trunk Circumference in Inches							Increase in Six Years	Gain Over Average of all Checks
		1914	1915	1916	1917	1918	1919	1920		
1	Soybeans				Discarded					
2	Soybeans P K	8.05	10.91	12.52	14.29	15.26	17.41	17.68	9.63	1.27
3	Crimson Clover	7.95	10.69	12.52	14.94	15.66	17.22	18.15	10.20	1.84
4	Crimson Clover P	7.82	10.23	12.23	13.02	14.72	16.42	17.79	9.97	1.61
5	2 Lbs. N	8.52	11.27	12.54	12.70	13.35	14.47	15.15	6.63	—1.73
6	Check	8.75	11.34	11.80	12.71	13.39	15.29	16.00	7.25	
7	4 Lbs. N	9.48	13.01	13.86	15.25	17.37	18.32	18.98	9.50	1.14
8	6 Lbs. N	9.97	13.29	14.75	16.57	17.10	18.32	19.11	9.14	.78
9	2 Lbs. N P	8.00	10.76	13.07	14.50	16.25	17.85	18.80	11.80	2.44
10	4 Lbs. N P	9.15	13.08	14.87	16.53	17.64	19.20	20.18	11.33	2.67
11	6 Lbs. N P	9.45	12.47	13.37	14.46	15.28	16.28	16.71	7.26	—1.10
12	Check	8.11	10.60	11.02	11.65	12.39	13.52	13.79	5.68	
13	Check	7.90	10.16	11.76	13.25	14.21	15.14	16.23	8.33	
14	2 Lbs. N P K	7.91	11.07	12.14	13.94	14.63	15.67	16.25	8.34	—.02
15	4 Lbs. N P K	8.33	11.65	13.39	15.87	16.66	18.43	19.11	11.78	2.42
16	6 Lbs. N P K	10.18	13.65	14.83	17.40	18.47	20.01	21.09	10.91	2.55
17	Manure	7.52	10.82	13.20	14.62	17.55	19.65	20.80	13.38	4.92
18	Manure P	8.43	11.91	12.66	16.59	17.75	19.62	20.20	11.77	3.41
19	4 Lbs. N K	7.88	10.76	13.08	14.94	15.55	16.75	17.27	9.39	1.03
20	4 Lbs. N on 6-15	8.25	11.22	13.26	15.14	15.73	16.88	17.54	9.29	.93
21	P K	7.86	10.77	12.55	13.55	14.86	15.62	16.34	8.48	.12
22	Check	7.88	10.81	13.03	15.43	16.70	18.09	20.06	12.21	
23	4 Lbs. N on 3-25	8.83	12.84	14.33	15.39	16.42	17.85	18.55	9.02	.66
24	4 Lbs. N on 7-15	6.82	9.88	11.73	14.03	15.25	17.95	19.19	11.13	2.77
	Av. of all checks	8.16	10.72	11.90	13.26	14.17	15.51	16.52	8.36	

Unfortunately Plot 1 had to be discarded at the end of the second year because borers had killed all of the trees except one. Plot 5, which was adjacent to Plot 1, lost four record trees from the same cause. The soil of these plots was light and borers were hard to control. Although the orchard was "wormed" regularly each season, borer injury may account for the smaller growth of the trunks of Plot 5, also for the shorter terminal shoot growth in this plot.

Plot 11 lost, early in the experiment, three of the record trees from peach yellows. This plot received 6 pounds of nitrate of soda per tree and Plot 14, which received a complete fertilizer, failed to show a gain over the average of the check plots, but both showed a slight gain when compared with the nearest check.

Fig. 6.—Average Tree in Plot 2. Received Soybeans as Cover Crop, Phosphorus, and Potassium. *

Fig. 7.—Average Tree in Plot 3. Received Crimson Clover Alone. Notice That the Trees in This Plot Were Large and More Vigorous Than Those of Plots 2 or 4 Which Received Phosphorus and Potassium. Smaller Size of Trees May be Due to Toxic Effect of These Materials or to Lessened Soil Moisture due to Greater Cover Crop Growth. *

* Picture taken August 1921 after the experiment had been discontinued.

Fig. 8.—Average Tree in Plot 4. Received Crimson Clover, Phosphorus, and Potassium. Compare With Figure 7. *

Fig. 9.—Plot 1 in the Foreground and Plot 2 in the Background. Notice the Very Poor Stand and Growth of Soybeans on Plot 1 as Compared to Plot 2. This Difference was Due to the Phosphorus That Plot 2 Received. Picture was Taken August, 1916.

* Picture taken August 1921 after the experiment had been discontinued.

Even though the cover crops of soybeans and crimson clover were not heavy, significant gains were made in trunk circumferences over the nearest check. The greatest growth in cover crops was on the plots which received acid phosphate and muriate of potash. The cover crops would probably have been better on Plots 2 and 4 had the fertilizer been applied uniformly over the plots rather than in a circle around the trees. Plot 21 which received acid phosphate and muriate of potash made a greater growth than the average of all checks, but a lesser growth than Plot 22, the nearest, and strongest growing check.

The greatest increase in trunk circumference was made by the trees receiving stable manure alone. When acid phosphate was applied with the manure to Plot 18 the resulting growth was slightly less than with manure alone. Plot 18 made more terminal growth, however, than Plot 17, and out-yielded it considerably.

The effects of fertilizers on the increase in trunk circumference in this experiment are not clear-cut as many inconsistencies are evident from a study of the gains in trunk circumference in the various plots as compared with that of the nearest checks. The preponderance of the evidence regardless of how the increase in trunk circumference is considered, however, is in favor of trees receiving nitrogen. Check Plot 22 was adjacent to Plot 18 of Table IV. These plots made a similar increase in trunk circumference. On the other hand, Plot 18 which received manure and acid phosphate yielded approximately 75 percent more than did the check plots. The trees of Plot 16, which received 6 pounds of nitrate of soda, 4 pounds of acid phosphate, and 1 pound of muriate of potash per tree made an increase in trunk circumference during the six year period of 1.31 inches less than that of check Plot 22. This plot yielded about 80 percent more peaches than did the check plot. Several other similar cases could be pointed out. From these data there is an indication that the increase in trunk circumference was not as good an index of the vegetative condition or of the fruitfulness of the trees as it has been shown to be with the apple.

As in the case of the trunk measurements, record was made of shoot growth in each plot annually. These data show that the plot receiving manure and acid phosphate made each year about two inches more growth than did the plot receiving manure alone. Plot 24 receiving four pounds of nitrate of soda applied about July 15, and Plot 3 receiving nothing but a cover crop of crimson clover, made the best terminal growth. The application of nitrate of soda

Fig. 10.—Average Tree in Plot 14. Received 2 Pounds Nitrate of Soda, 4 Pounds 16 Percent Acid Phosphate, and 1 Pound Potassium Chloride per Tree.

Fig. 11.—Average Tree in Plot 15. Received 4 Pounds Nitrate of Soda, and Phosphorus and Potassium the Same as Plot 14, Figure 10.

to Plot 24 after the normal season's growth had taken place prolonged the growing season and produced a greater terminal growth than was produced in any of the other plots. The smaller increase in Plot 23 was probably due to leaching away of the nitrate of soda before active root absorption began. Plots 3 and 4 made a growth nearly equal to that of the plots receiving the heaviest application of nitrogen, which was probably due to the organic matter added to the soil which was rich in nitrogen, both of which would produce good growth. Plot 3 made more growth than did Plot 4 which received applications of acid phosphate and muriate of potash. This may have been due to a retarding action of these fertilizers as suggested in this and the other experiments. It will be recalled that Plot 3 made a larger increase in trunk circumference than did Plot 4.

TABLE XII.—The Effect of Fertilizers on the Terminal Shoot Growth in the Elberta Experiment at Cherry Run.

Plot No.	Treatment	Growth in Inches Average Length of Terminal						Average Annual Growth for Six Years	Average Annual Gain Over Av. of all Checks
		1915	1916	1917	1918	1919	1920		
1	Soybeans*								
2	Soybeans P K	39.34	28.04	24.96	11.54	23.20	13.68	23.46	3.19
3	Crimson Clover	37.58	38.24	28.79	13.83	25.16	15.47	26.51	6.24
4	Crimson Clover P K	34.75	32.42	15.71	10.37	22.50	12.30	21.34	1.07
5	2 Lbs. N	34.40	24.42	13.02	8.60	17.28	8.58	17.72	—2.55
6	Check	33.45	32.27	17.78	10.18	14.95	8.91	19.59	
7	4 Lbs. N	41.42	35.84	22.00	10.21	18.99	13.63	23.68	3.40
8	6 Lbs. N	40.50	31.97	20.31	9.84	17.57	12.17	22.06	1.81
9	2 Lbs. N P	39.32	31.00	14.61	12.78	22.15	12.42	22.05	1.78
10	4 Lbs. N P	45.37	37.02	15.73	11.71	20.43	14.23	24.08	3.81
11	6 Lbs. N. P	39.42	31.68	15.15	11.04	15.47	14.54	21.22	.95
12	Check	37.17	37.63	13.82	10.86	15.47	11.25	21.03	
13	Check	40.97	29.30	8.61	9.31	15.90	7.60	18.62	
14	2 Lbs. N P K	40.57	31.27	13.12	12.13	22.35	12.82	22.04	1.78
15	4 Lbs. N P K	46.04	36.55	19.01	11.12	23.08	13.98	24.96	4.69
16	6 Lbs. N P K	41.53	29.06	20.98	12.95	25.68	14.58	24.13	3.86
17	Manure	43.66	36.25	14.53	14.26	22.62	13.44	24.13	3.86
18	Manure P	46.62	42.20	22.30	12.66	22.27	11.44	26.25	5.98
19	4 Lbs. N K	44.49	40.91	40.91	11.64	18.76	11.51	28.04	3.97
20	4 Lbs. N on 6-15	43.75	38.77	17.18	12.10	19.29	10.70	23.63	3.36
21	P K	42.69	31.04	9.31	7.85	12.65	8.44	18.66	—1.61
22	Check	41.07	37.55	15.08	10.57	16.37	10.50	21.86	
23	4 Lbs. N on 3-25	44.44	36.36	15.63	10.48	19.55	11.44	22.98	2.71
24	4 Lbs. N on 7-15	43.93	42.31	20.77	14.82	25.46	12.04	26.56	6.29
	Average of all checks	38.16	34.18	13.82	10.23	15.67	9.57	20.27	

* Discarded.

** None of the plots received muriate of potash in 1917, 1918, 1919.

Fig. 12.—Average Tree in Plot 16. Received 6 Pounds Nitrate of Soda, and Phosphorous and Potassium in the Same Amounts as Plots 14 and 15, Figures 10 and 11. Pictures Taken August, 1921. Camera Same Distance From the Trees in all Cases. Notice That the Growth of the Trees and Density of the Foliage has Been in Proportion to the Amount of Nitrogen Applied.

Fig. 13.—Average Tree in Plot 21 Which Received 4 Pounds 16 Percent Acid Phosphate and 1 Pound Chloride of Potash per Tree. Compare With Figure 14. Picture Taken August, 1920.

Fig. 14.—Average Tree in Plot 22 (check). Notice That This Tree Is Larger Than Those of Plot 21, Figure 13.

Fig. 15.—Average Tree in Plot 23 Which Received 4 Pounds Nitrate of Soda on March 25 of Each Year. Notice the Longer Growths and Denser Foliage of This Tree as Compared to the One in Figure 14.

Fig. 16.—Average Tree in Plot 24 Which Received 4 Pounds Nitrate of Soda on July 15 of Each Year. Trees Receiving Late Applications of Nitrogen Made More Growth Than Those Receiving the Application Early in the Season. Picture taken August, 1920.

Whenever nitrogen was applied, an increase in terminal growth was secured, with the one exception, Plot 5, which, as has already been pointed out, was probably due to injury from borers. In those instances where different applications of nitrate of soda were given the data show that four pounds of nitrate of soda per tree produced slightly more growth than either two or six pounds. Plot 21 which received acid phosphate and muriate of potash made an average terminal growth of more than one and one-half inches less than the average of the checks, and 3.2 inches less than the nearest check. The results substantiate those of the other experiments in that no increase in growth resulted from applications of phosphorus or potassium. On the other hand wherever nitrogen was used, except in Plot 5, there was a marked increase in growth.

EFFECTS OF FERTILIZERS ON AMOUNT AND TIME OF FRUIT PRODUCTION

The value of commercial fertilizers for orchard purposes must ultimately be measured by the increase in yield of merchantable fruit. In considering the effects of fertilizers on fruit production, three points only will be considered: the number of fruit buds set, total yield of fruit, and the grades of peaches produced.

The Effects of Fertilizers Upon the Set of Fruit Buds

The set of fruit buds may be of value in interpreting the results of experiments. In fact, in some instances, the set of fruit buds may be a better index of the tendency of a tree to bear fruit than is the yield, since the latter is affected by other factors such as fungous diseases, and insects. This is especially true of the peach because the fruit buds may also be winter-killed or seriously injured by spring frosts. Consequently in these experiments considerable attention has been given to the set of fruit buds.

Method of Determining the Set of Fruit Buds.—The method of estimating the set was to observe carefully the distribution of buds upon the terminal as well as upon the spur-like growths. If two buds to each node were set along the entire length of the bearing wood, the percent was recorded as 100. If the growths did not have buds set at each node and the set was not so heavy on the short spur-like laterals the record was correspondingly reduced. The standard, therefore, for a set of fruit buds of 100 percent was taken to be two buds at each node, or twice as many buds as nodes. Instances in these plots where three buds or more were borne at a node occurred so seldom that only a slight error could have resulted on this account. Tree-by-tree estimates for each plot were made and the average of these entered in the tables as the percent for each plot. Care was taken to see that the winter-killed fruit buds had not fallen before the records were taken. These fruit buds drop some seasons before much growth has taken place in the live buds. Consequently records as to set of fruit buds can be taken any time between leaf fall and the abscission of the winter-killed fruit buds in the spring. With care and experience the set of fruit buds can be estimated quite accurately and by this method data can be secured on a much larger scale than is possible by actual counts.

The Set of Fruit Buds in Sleepy Creek Experiment.—The data on the set of fruit buds are presented in Table XIII. The two varieties included, Carman and Waddell, responded somewhat differently to the treatment.

TABLE XIII.—The Effect of Fertilizers on the Set of Fruit Buds in the Sleepy Creek Experiment.

Plot No.	Treatment	Estimated Percent Fruit Buds Set							Average Percent Set[1]	Gain Over Check
		1912	1913	1914	1915	1916	1917	1918		
Carman:										
1	N P	74.0	100.0	100.0	40.0	25.0	71.1	81.6	70.2	26.0
2	N K	73.0	100.0	90.0	25.0	56.6	82.1	85.1	73.1	28.9
3	N P K	62.0	100.0	90.0	20.0	61.6	45.7	66.6	63.7	19.5
4	Check	28.0	60.0	50.0	75.0	10.0	45.5	41.3	44.2	
5	P K	58.0	60.0	50.0	65.0	20.0	48.8	43.3	49.3	5.1
6	N P K	83.5	94.0	90.0	25.0	43.3	61.6	61.6	65.5	21.3
7	N P K*	88.0	92.0	85.0	25.0	26.6	78.7	85.0	68.6	24.4
8	N P K**	84.5	98.0	85.0	25.0	63.3	75.7	65.0	70.9	26.7
9	Lime	32.0	75.0	70.0	80.0	33.3	44.2	51.6	55.1	10.9
10	N			80.0	40.0	70.0	53.7	88.3	66.4	22.0
11	P			75.0	50.0	41.6	63.7	36.6	53.3	8.9
12	K			50.0	65.0	28.3	55.0	56.6	50.9	6.5
Waddell:										
1	N P	96.0	100.0	100.0	35.0	80.0	86.2	83.3	82.9	20.0
2	N K	100.0	100.0	90.0	25.0	78.3	70.0	71.6	76.4	13.5
3	N P K	100.0	100.0	90.0	30.0	80.0	75.0	75.0	78.5	15.6
4	Check	57.0	60.0	50.0	85.0	43.3	75.5	70.0	62.9	
5	P K	60.0	60.0	50.0	80.0	66.6	82.7	50.0	64.1	1.2
6	N P K	96.0	94.0	90.0	40.0	78.3	51.1	83.3	76.1	13.2
7	N P K*	100.0	92.0	85.0	35.0	76.6	68.8	71.6	75.5	12.6
8	N P K**	100.0	98.0	85.0	35.0	86.6	71.1	80.0	79.3	16.4
9	Lime	48.0	75.0	70.0	65.0	70.0	81.6	66.6	68.0	5.1
10	N			80.0	45.0	93.3	78.1	91.6	77.6	12.8
11	P			75.0	35.0	91.6	70.0	91.6	72.6	7.8
12	K			50.0	35.0	80.0	81.4	70.0	63.2	—1.6

[1]While by the usual methods of figuring percentage this column may not appear correct, it should be kept in mind that in this instance the figures as given are estimates, and consequently this method of comparison is believed to be justifiable.
* K Doubled.
** K Tripled.

Wherever nitrogen was applied the trees set a higher percent of fruit buds on both varieties. In 1915, however, the plots receiving no nitrogen set a much higher percent than did the plots receiving it. Alderman (1) noted this and ascribed it to a severe drouth during the growing season and to heavy fruit production on the plots receiving nitrogen. In both varieties the limed plots set a slightly larger percent of fruit buds than did the checks. Phosphorus and potassium produced a somewhat larger percent set of buds on Carman than on Waddell although in neither case was the increase as great in general as with nitrogen. Acid phosphate or muriate of potash alone or together with nitrogen, did not result in a significant increase in the percent set of fruit buds.

Applications of 4 pounds of nitrate of soda to the trees which had been in a low state of vigor decreased the set of fruit buds on the Carman and increased it on the Waddell, as shown in Table XIV.

TABLE XIV.—Effect of Applications of Nitrate of Soda on the Estimated Percent Set of Fruit Buds on Trees of Low Vigor, Sleepy Creek Experiment.

Plot No.	Treatment	Estimated Percent of Fruit Buds Set	
		1917	1918
Carman:			
4	Check	45.5	41.3
4	N	32.5	40.0
5	P K	48.8	43.3
5	N P K	45.0	28.3
Waddell:			
4	Check	75.5	70.0
4	N	72.0	80.0
5	P K	82.7	50.0
5	N P K	85.0	81.6

The decreased percent set of fruit buds of the Carman trees receiving nitrate of soda was probably due to the heavy fruit production of those plots, together with the increased vegetative growth of the trees.

The Set of Fruit Buds in Cherry Run Experiment.—Data were taken on the effects of fertilizers on the set of fruit buds in the Cherry Run experiment for five years beginning in 1914.

TABLE XV.—Effect of Fertilizers on the Set of Fruit Buds in the Cherry Run Orchard.

Carman:

Plot No.	Treatment	Est'd Percent of Fruit Buds Set 1914	1915	1916	1917	1918	Percent Set Annually[1]	Percent Gain Over Checks
1	N P	89.0	95.0	45.5	71.0	73.2	74.74	1.88
2	N K	87.0	95.0	25.7	82.0	77.3	73.41	.55
3	N P K	93.0	95.0	48.5	78.0	71.7	77.24	4.38
4	P K	81.0	97.0	49.2	75.0	65.0	73.45	.59
5	Check	81.0	97.0	52.5	70.0	63.8	72.86	
6	P		97.0	54.7	72.0	64.1	71.96	1.14
7	K		97.0	34.7	74.0	65.5	67.81	—3.01
8	N		97.0	65.5	79.0	72.4	78.48	7.66

[1] While by the usual methods of figuring percentage this column may not appear correct, it should be kept in mind that in this instance the figures as given are estimates, and consequently this method of comparison is believed to be justifiable.

While the influence of fertilizers was slight, nitrate of soda increased the percent of fruit buds set. The percentage of fruit buds set, however, was relatively high except in 1916. The set was lighter on the plot receiving muriate of potash alone than on the checks. The complete fertilizer did not increase the percent set over nitrogen alone. As a whole, while the increase in the set of fruit buds in the nitrated plots was slight, a study of this table shows that these data are consistent with the results obtained in other experiments.

The Set of Fruit Buds in the Elberta Experiments.—Data on the percent set of fruit buds were obtained from 1915 to 1918 only in the Elberta experiment. These data are given in Table XVI. It will be noticed that no fertilizer treatment had an outstanding effect in increasing the set of fruit buds.

TABLE XVI.—Effect of Fertilizer on the Set of Fruit Buds in the Elberta Experiment.

Plot No.	Treatment	Estimated Percent of Fruit Buds Set				Percent Set Annually[1]	Percent Gain Over Checks
		1915	1916	1917	1918		
1	Soybeans (2)						
2	Soybeans P K	67.77	68.88	70.00	43.33	62.49	.81
3	Crimson Clover	71.66	65.55	68.33	46.11	62.91	1.23
4	Crimson Clover P K	78.88	80.00	81.11	63.75	75.93	14.25
5	2 Lbs. N	80.00	63.33	68.00	52.00	65.83	4.15
6	Check	83.75	64.33	83.57	31.42	65.76	
7	4 Lbs. N	86.87	51.11	76.66	27.50	60.53	—1.15
8	6 Lbs. N	89.44	57.14	84.28	31.42	65.57	3.89
9	2 Lbs. N P	67.50	66.25	75.00	43.33	63.02	1.34
10	4 Lbs. N P	68.33	72.22	80.55	51.11	68.05	6.37
11	6 Lbs. N P	68.33	80.00	71.42	41.42	65.29	3.61
12	Check	70.00	46.43	71.00	34.00	55.35	
13	Check	63.33	71.25	66.42	47.14	62.03	
14	2 Lbs. N P K	71.11	71.25	83.12	45.00	67.62	5.94
15	4 Lbs. N P K	75.55	72.50	82.50	36.87	66.85	5.17
16	6 Lbs. N P K	75.00	71.87	86.25	43.75	69.21	7.53
17	Manure	51.66	72.50	80.83	44.00	62.24	.56
18	Manure P	67.77	76.25	85.62	46.25	68.97	7.29
19	4 Lbs. N K	55.55	71.11	76.66	37.77	60.27	—1.41
20	4 Lbs. on 6-15	63.33	71.11	71.66	26.66	58.19	—3.49
21	P K	75.55	67.77	77.77	54.28	68.84	7.16
22	Check	71.25	73.75	59.28	50.00	63.57	
23	4 Lbs. N on 3-25	75.55	75.55	71.43	32.85	63.84	2.16
24	4 Lbs. on 7-15	67.77	79.00	72.77	11.66	57.80	—3.68
Average of all checks		72.08	63.94	70.06	40.64	61.68	

[1] While by the usual methods of figuring percentage this column may not appear correct, it should be kept in mind that in this instance the figures as given are estimates, and consequently this method of comparison is believed to be justifiable.
(2) Discarded.

In some years the application of fertilizers increased the percent set of buds over that of the untreated plots, while in other years the reverse was true. This is to be expected, in view of the work of others which shows that plants grown under an abundance of nitrate may set fewer buds than plants grown under similar conditions but with a smaller amount of nitrate present. Kraus and Kraybill report that, "withholding moisture from plants grown under conditions of relative abundance of available nitrogen results in much the same condition of fruitfullness and carbohydrate storage as the limiting of the supply available nitrogen."

The data of this experiment indicate that there is very little if any correlation between the set of fruit buds and the fruitfulness of the trees. Heavy production has not followed the year of a large percentage set of fruit buds. In fact the data suggest the opposite, i. e. in the year of heavy fruit production there has also occurred a large set of fruit buds, while the opposite was true in years of lighter yields. It would seem then that the formation of fruit buds has been affected by the crop borne at the time of their formation.

The outstanding fact brought out in this experiment is that increased fruitfulness is not a result of a higher percent set of fruit buds, but that it is apparently due to a larger bearing area of the trees combined perhaps with a better set of fruit. Under the conditions of these experiments many more buds have been set than was necessary for a maximum production of fruit.

The Influence of Fertilizers on Total Yield

In view of the general trend of the influence of fertilizers on the set of fruit buds it will be of interest next to consider yield in the different experiments. This phase of the subject will be taken up separately for each experiment.

The Sleepy Creek Experiment.—In Table XVII the total yields for the two varieties, Carman and Waddell, are summarized for the entire period of the experiment (1913 to 1918 inclusive).

TABLE XVII.—Effect of Fertilizers on the Total Yield in the Sleepy Creek Orchard with Carman and Waddell.

Plot No.	Treatment	Total Yearly Yield in Pounds for Each Plot 1913	1914	1915	1916††	1917	1918	Average Yearly Yield	Gain Over Check
Carman:									
1	N P	883.18	592.31	1132.00	595.68	424.50	385.60	668.87	232.65
2	N K	1202.59	698.12	1240.31	650.81	433.00	380.16	767.50	331.28
3	N P K	735.72	618.62	971.50	546.62	263.25	398.00	588.95	152.73
4	Check	657.62	†	641.00	212.25	369.25	301.00	436.22	
5	P K	528.17	†	621.60	324.00	375.50	430.64	455.98	19.76
6	N P K	1210.85	620.00	1325.20	703.25	375.50	497.56	788.72	352.50
7	N P K*	1296.53	676.12	1153.00	673.50	421.00	429.25	774.90	338.68
8	N P K**	1186.32	643.75	1340.00	647.93	326.75	493.50	773.04	336.82
9	Lime	707.70	†	656.25	323.62	377.37	248.00	462.58	26.36
10	N	1015.20	941.63	1244.00	647.80	423.75	723.50	832.64	396.42
11	P	564.67	†	687.00	242.75	288.68	426.00	441.82	5.60
12	K	808.80	†	962.25	395.36	521.00	162.56	570.00	133.78
Waddell:									
1	N P	655.10	750.81	1028.00	638.68	330.32	287.75	615.11	328.42
2	N K	418.00	697.37	1002.25	579.42	363.37	335.00	565.90	279.21
3	N P K	301.00	743.43	1039.75	561.00	411.75	348.25	567.53	280.84
4	Check	163.55	402.75	408.12	332.00	218.00	195.75	286.69	
5	P K	146.12	276.93	434.62	319.81	183.25	323.75	280.75	—5.94
6	N P K	241.36	836.16	1040.96	719.25	395.68	368.32	600.29	313.60
7	N P K*	298.29	753.93	950.00	616.32	394.43	234.88	541.31	254.62
8	N P K**	541.19	725.60	1036.00	615.75	409.00	289.43	602.83	316.14
9	Lime	228.76	673.56	700.80	516.00	255.44	313.56	448.02	161.33
10	N	266.19	651.25	794.00	470.56	233.21	231.06	441.04	154.35
11	P	197.52	268.00	731.60	587.12	395.12	308.00	414.56	127.87
12	K	183.04	566.64	740.00	369.43	220.56	402.43	413.68	126.99

† Crop harvested before records could be secured.
†† Brown rot was bad this year.
* K Doubled.
** K Tripled.

It will be seen from a study of this table that applications of nitrogen have consistently produced larger yields reaching a maxmium average gain over the check in Plot 10, with Carman, of 400 pounds. Where phosphorus or potassium was added alone or in combination the yield fell below that from nitrogen, although in only one instance, Plot 5 with Waddell, did the yield fall below the check. The addition of phosphorus, potassium, or both with nitrogen did not increase the yield over nitrogen alone. It should be pointed out that the addition of one and one-half pounds of nitrate of soda per tree practically doubled the annual yield of both varieties. This small amount of fertilizer has prolonged the productive life of the tree, and

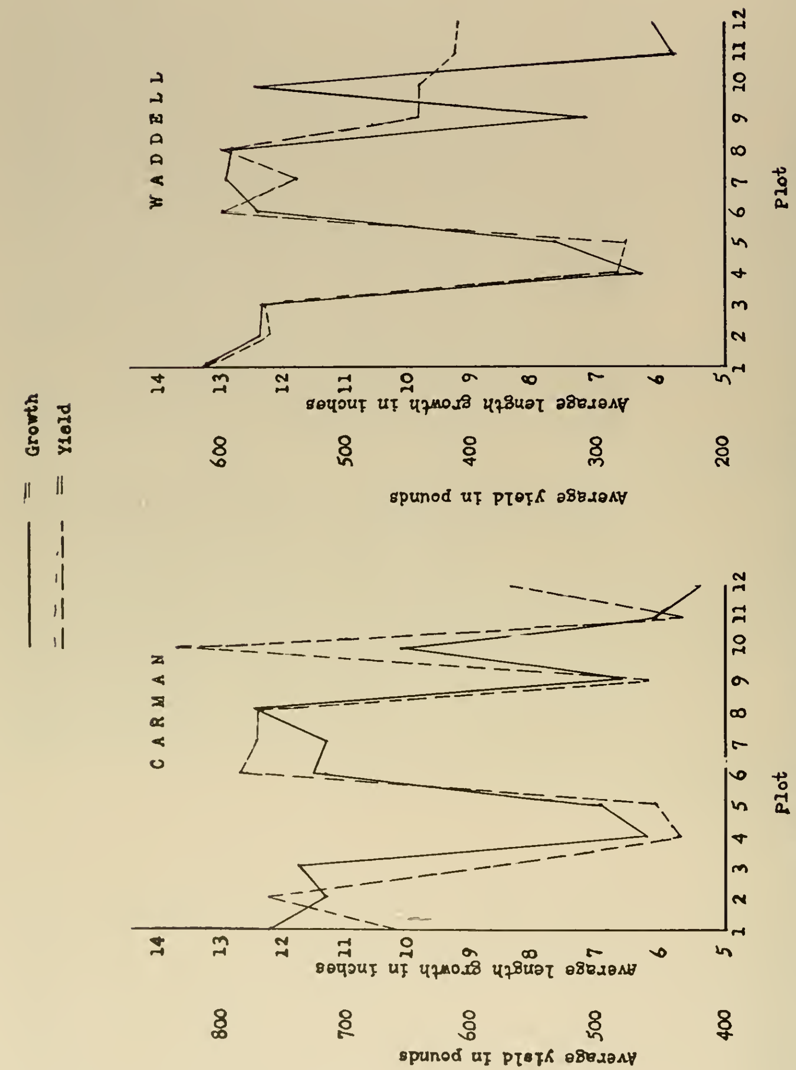

Fig. 17.—Diagram Showing the Yield and Growth of Carman and Waddell, Sleepy Creek Experiment. Observe That Yield is Closely Correlated With Growth.

judging from the data presented in Table XX this difference would have been greater had larger amounts of nitrate of soda been applied as the trees became older.

The results for Waddell, Plots 10, 11 and 12, show marked increases for all the materials applied. The uniformity of the data would suggest at once that factors other than the fertilizer applications were operating. It is true, as previously noted on page 6, that these three plots were on slightly lower ground and received the wash from the other plots which probably accounts for the great similarity in yield. In the limed plots the yield was larger with Waddell than with Carman. It would appear from these data that the chief influence of lime in the peach orchard comes from its influence on cover crop growth.

In the plan of the Sleepy Creek experiment tests were made to determine the influence of nitrogen on trees of low vigor by dividing Plots 4 and 5 into two parts. The results of these tests on the half plots are given in Table XVIII where the yield is entered on the basis of full plots.

TABLE XVIII.—Effect of Nitrate of Soda on Total Yield from Trees of Low Vigor in the Sleepy Creek Orchard.

Plot No.	Treatment	Total Yield in Pounds*			Average Yield in Pounds	Average Gain for Nitrate of Soda	
		1916	1917	1918		3-Yrs.	2-Yrs. 1918-19
Carman:							
4	Check	212.25	369.25	301.00	294.16	.	
4	4 Lbs. N	317.50	650.25	435.00	467.58	173.42	207.50
5	P K	344.50	375.00	430.64	383.38		
5	4 Lbs. N P K	357.00	596.00	476.00	476.33	92.95	133.18
Waddell:							
4	Check	332.00	218.00	195.75	248.58		
4	4 Lbs. N	403.00	376.87	292.50	357.45	108.87	127.80
5	P K	319.81	183.25	323.75	275.60		
5	4 Lbs. N P K	293.50	374.50	417.25	361.75	86.15	142.37

* Total yield for 8 trees per plot.

Nitrate of soda was applied for the first time to Plots 4 and 5 on May 23, 1916. The effect was noticeable the same season in each instance, as the yield was increased as much as 105 pounds. This increase apparently was due to a small drop on the nitrogen fed trees, and by the increased size of the peaches which resulted the first season. This point has considerable bearing on peach orchard fertilization, since growers can expect returns from nitrate of soda application the same season the material is applied on old trees. It should be pointed out that the increased yield of the nitrated plots resulted from the same bearing area and from the same set of fruit buds.

The second year of the experiment the influence of nitrogen on the yield was even more pronounced than the first year. Figures 4 and 5 show the comparative growth and vigor of the nitrogen-treated trees. Table VIII shows that the increased yields follow increased growth. It should be pointed out that the Carman variety yielded considerably more when nitrogen was applied to the trees even though the percent of fruit buds was smaller than that of the non-nitrogen treated plots. This was due to greater bearing area and to the more fruitful conditions as brought about by the nitrogen applications. In these tests then, an increase in both growth and yield resulted from the nitrogen applications.

Alderman (1) presented data which show the picking date of the various plots in this experiment and the effect of fertilizers on the maturity of the fruit. Nitrate of soda delayed ripening of the fruit from two to ten days, depending upon the season. In addition the peaches produced on the plots receiving nitrogen were not so highly colored as were those on plots receiving no nitrogen. This difference in color was largely due to the increased shading from the foliage on the nitrogen treated plots. However, this was not a serious objection, and could be overcome to some extent by proper pruning.

The Cherry Run Experiment.—Yield records were taken in this experiment for four years only. In 1918, unfortunately, some one harvested a part of the crop during the absence of Mr. Fulton, the orchard manager. Consequently, the records had to be omitted for that year.

TABLE XIX.—The Effect of Fertilizers on the Total Yield of Carman in the Cherry Run Orchard.

Plot No.	Treatment	Yield in Pounds				Average Yield in Pounds	Annual Gain in Pounds Over Check
		1914	1915	1916	1917		
1	N P	30.06	417.00	751.93	851.87	512.71	224.43
2	N K	5.75	341.00	496.68	742.87	396.57	108.29
3	N P K	49.37	426.87	685.56	830.06	497.98	208.70
4	P K	0.18	172.00	262.31	355.25	197.43	—90.85
5	Check	3.50	190.12	445.62	513.87	288.28	
6	P		333.62	559.56	531.00	474.73	91.53
7	K		294.00	474.06	622.80	433.62	50.42
8	N		236.03	646.00	778.20	553.41	170.21

The largest yields in this experiment were secured where nitrogen was applied. Where phosphorus or potassium or both were used with nitrogen the yield was not increased over that of nitrate of soda. In Plots 6 and 7 the yield was slightly increased when potassium and phosphorus were applied singly. On the other hand these two in combination (Plot 4) yielded less than the check plot.

The Elberta Experiment.—The effect of fertilizers, especially nitrogen, on the yield of Elberta has not been quite so marked in some instances as in the two experiments above. This may be accounted for in part by greater fertility at the beginning of the experiment. The total yields for six years are given in Table XX.

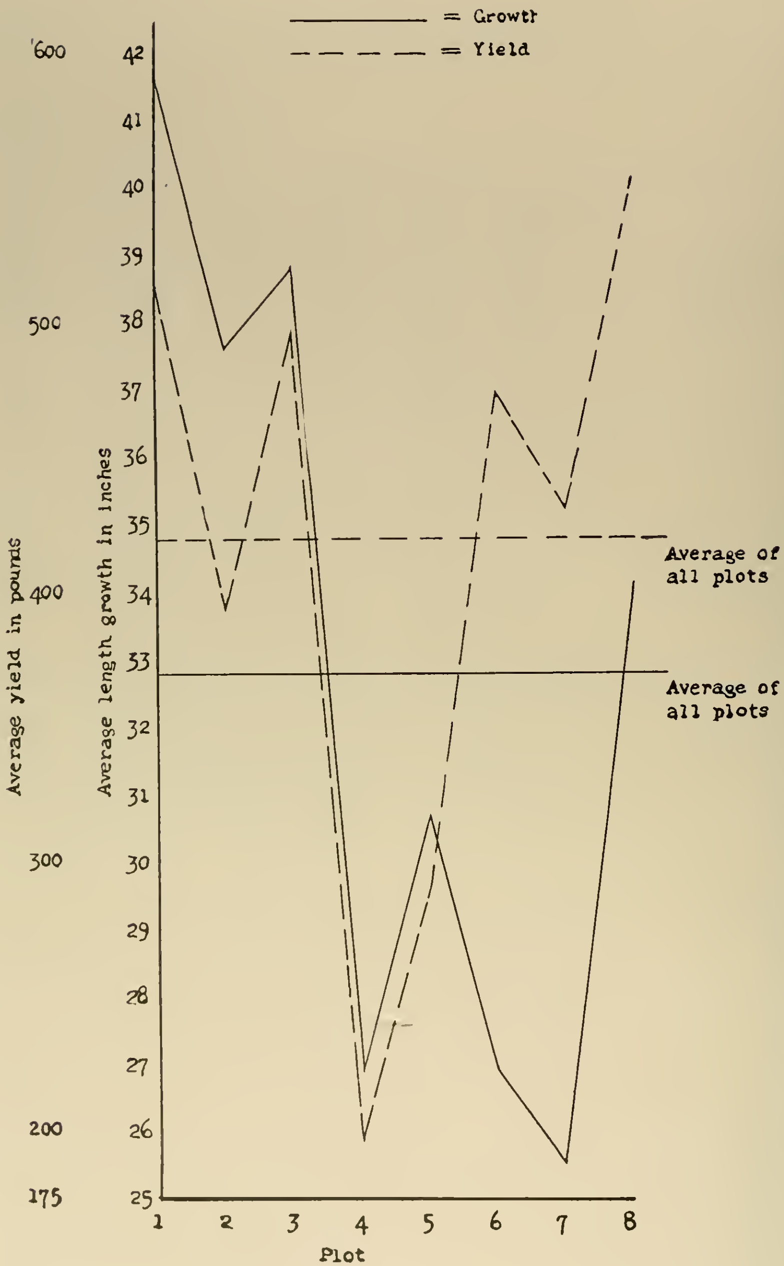

Fig. 18.—Diagram Showing the Influence of Fertilizers on the Yield and Growth of Carman Peaches, Cherry Run Experiment.

TABLE XX.—The Influence of Fertilizers on Total Yield in the Elberta Experiment at Cherry Run.

Plot No.	Treatment	Total Yield in Pounds						Total Yield Six Years	Increase Over Average Checks
		1915	1916	1917	1918	1919	1920		
1	Soybeans				Discarded				
2	Soybeans P K	52.75	574.93	778.06	796.50	858.75	893.00	3953.99	241.67
3	Crimson Clover	35.50	515.25	641.50	782.62	624.50	875.50	3474.87	—237.45
4	Crim. Clover P K	11.25	455.06	992.00	148.40	941.13	432.75	2980.59	—731.73
5	2 Lbs. N	345.65	597.72	703.35	508.50	873.45	946.35	3975.02	262.70
6	Check	88.31	601.37	658.92	686.97	789.39	767.97	3592.93	
7	4 Lbs. N	72.37	759.87	853.31	1002.50	954.00	1569.51	5211.56	1499.24
8	6 Lbs. N	44.93	1007.37	1051.12	989.64	1014.03	1193.76	5300.85	1588.53
9	2 Lbs. N P	204.75	630.75	790.65	494.32	994.05	1365.75	4480.27	767.95
10	4 Lbs. N P	89.75	1054.12	1198.00	704.25	1340.00	1424.00	5810.12	2097.80
11	6 Lbs. N P	48.00	985.31	1218.15	597.06	1003.77	1112.76	4965.05	1252.73
12	Check	15.00	699.00	762.60	536.94	914.94	984.87	3913.35	
13	Check	51.06	731.12	676.70	203.94	758.61	845.64	3267.07	
14	2 Lbs. N P K	45.25	787.06	831.06	452.16	943.02	1042.25	4100.80	388.48
15	4 Lbs. N P K	29.75	891.62	995.62	916.29	1174.50	1678.50	5686.28	1973.96
16	6 Lbs. N P K	101.50	1199.75	1307.79	1210.00	1306.25	2044.00	7169.29	3456.97
17	Manure	54.75	502.50	1017.00	360.72	1216.80	1421.28	4573.05	860.73
18	Manure P	26.50	795.31	1518.75	1012.75	1696.50	1914.75	6964.56	3252.24
19	4 Lbs. N K	16.50	696.81	1208.25	774.54	1055.79	1085.22	4837.11	1125.79
20	4 Lbs. N on 6-15	14.50	655.81	1041.25	678.25	993.25	1099.25	4482.31	769.99
21	P K	13.75	764.37	957.50	63.25	754.50	767.50	3320.87	—391.45
22	Check	13.25	585.62	1060.29	306.63	1106.64	1003.50	4075.93	
23	4 Lbs. N on 3-25	0.75	774.56	999.50	554.25	1127.88	1277.01	4733.95	1021.63
24	4 Lbs. N on 7-15	0.50	553.68	996.00	299.25	510.25	1668.25	4027.93	315.61
	Av. of all checks							3712.32	

One of the most striking features of Table XX and more plainly brought out in Figure 19 is the total yield of the Plots 2, 3, and 4 on which leguminous cover crops were grown. The growth of the soybeans and crimson clover was very light but it was better on the plots to which acid phosphate and muriate of potash were applied. Plot 2, only, yielded more than the adjacent check Plot 6 or the average of the checks, while Plots 3 and 4 yielded less. It was shown in Tables XI and XII that these plots made greater increases in trunk circumferences and longer terminal growths than did the check plots. The cover crops were seeded the last of July or the first part of August, and by the last of August or the first few days of September, which is the normal picking season of Elberta peaches, the cover crops had made considerable growth. For the growth of the cover crops moisture was required which was also needed to mature the crop of peaches already partially matured. The greater growth and leaf area of these trees also required more moisture than the smaller adjacent check trees. Leaves draw moisture from the fruit at the time of an insufficient supply in the soil. Since the soil in this orchard was not retentive of moisture, becoming dry very quickly even after heavy rains, a growing cover crop materially reduced the moisture available for the peach trees. In these experiments the check plots and the other low-yielding plots produced a larger proportion of the larger sized peaches, while the plots which the leguminous cover crops were grown produced a much smaller proportion of peaches of these sizes. This also would indicate that lack of moisture was the cause of the decreased yield of these plots.

The effect of nitrogen on the yield in this experiment is very evident from a study of Table XX. Every plot to which nitrogen was added gave a larger yield than the checks. The increase in yield was slight where two pounds of nitrate of soda were added and was much greater when 4 or 6 pounds per tree were used. The yield of Plot 5 was greater than that of the checks. It was shown in Tables XI and XII that this plot made less terminal growth and that the trunk circumference was less than that of the check plots. The increased yield of Plot 5 shows the effect of nitrogen on the set of fruit. Table XVI shows that Plot 5 had more buds set than the checks. Apparently the nitrogen caused enough more fruits to be set and carried through to maturity to more than make up for the decreased growth of this plot as compared with the checks.

The increase in yield was not in direct proportion to the amount of nitrate of soda applied in two of the three series. The yield of Plot 8, receiving six pounds of nitrate, was only slightly better than that of Plot 7 which received only four pounds per tree. In the case of Plot 11, receiving 6 pounds of nitrate and 4 pounds of acid phosphate per tree, the yield was more than eight hundred pounds less for the six-year period than that of Plot 10 which received 4 pounds of nitrate and the same amount of phosphate. Only in Plots 14, 15, and 16 were the yields in proportion to the amount of nitrogen applied. It will also be noticed that the difference in the yield of these plots was consistent year after year, while there was more fluctuation in the six plots receiving nitrogen. Here it would appear that the trees of the plot used the 6 pounds of nitrate of soda as efficiently as others used 4 or, even 2 pounds.

The total yields of Plots 5, 7, and 8, which received 2, 4, and 6 pounds of nitrate of soda per tree, respectively, were in round numbers 14,500 pounds; the total yield of Plots 9, 10, and 11, which re-

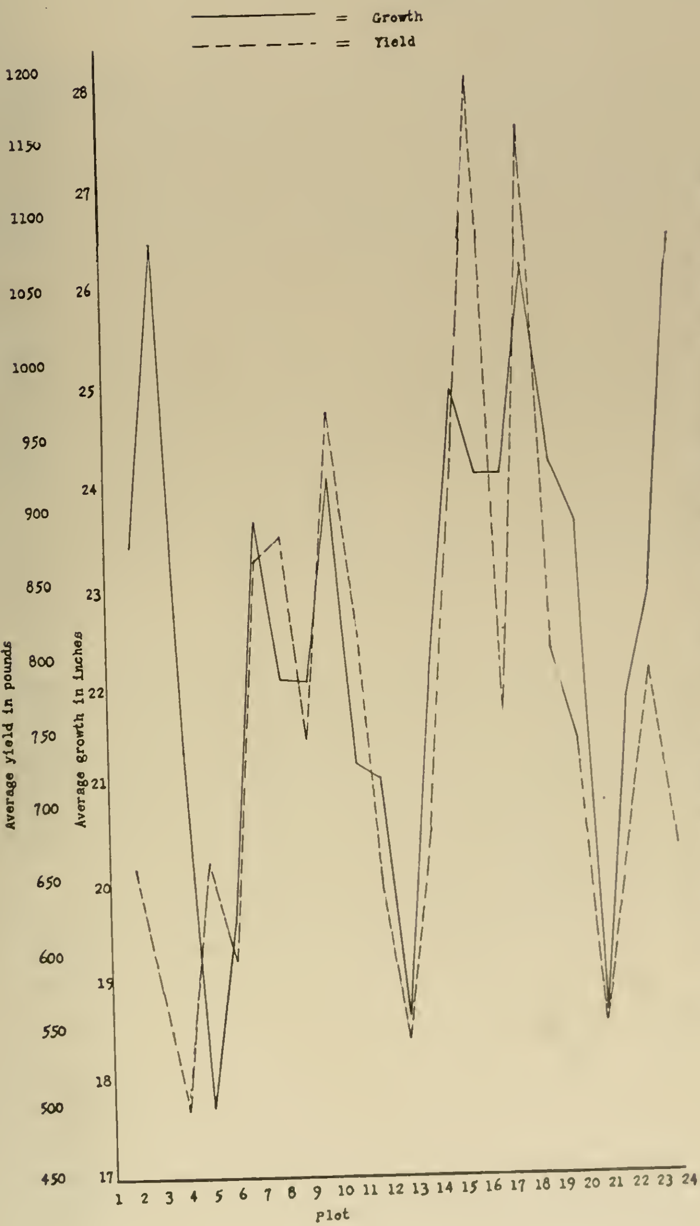

Fig. 19.—Diagram Showing the Influence of Fertilizers on the Growth and Yield of Elberta Peaches, Cherry Run Experiment.

ceived the same amounts of nitrate of soda and in addition 4 pounds of 16 percent acid phosphate per tree was 15,250 pounds or a gain of 750 pounds in the six-year period. The total yield of Plots 14, 15, and 16, where nitrogen was used in combination with phosphorus and potassium, was 17,000 pounds or a gain of 2500 pounds over Plots 5, 7, and 8 where nitrogen was used alone, or 1750 pounds more than Plots 9, 10, and 11, where nitrate of soda was used with acid phosphate, which could be attributed to the potassium applied during the years 1915, 1916, and 1920. The data obtained in the two former experiments do not warrant any such conclusion. Even in this experiment when potassium was applied in combination with nitrogen, Plot 19, the yield was not increased over that of the plots (7) receiving the same amount of nitrogen applied at the same time. It would seem that the differences in the yields between the series of plots under question were due to soil conditions, to the more vigorous conditions of the trees, and to the variation between plots rather than to the addition of phosphorus or potassium in combination with the nitrogen. This conclusion would seem justified when the difference between the size of the trees at the beginning of the experiment is considered, Table XI.

Stable manure was as effective in increasing the yield of peaches as was nitrate of soda. Plot 18, which received phosphorus in addition to the manure, outyielded the plot (17) to which manure alone was applied. The soil of Plot 18 was slightly more fertile and better supplied with moisture than was Plot 17, owing to a slight dip in the land. This was further evidenced by the ranker growth of cover crops and by the greater amount of moisture in the soil during cultivation. The difference in yield therefore may have been due in part to these factors. This experiment shows that manure is undoubtedly the best fertilizer to apply to peaches, because it not only adds nitrogen, phosphorus, and potassium to the soil but increases the organic matter as well.

Early applications of nitrogen have been recommended to induce a better set of apples. In this connection it is interesting to observe that an application of 4 pounds of nitrate of soda about March 25 on Plot 23 had no effect in this respect. There is an indication that some of the nitrate of soda was lost to the trees in this plot, as these trees made less growth, Table XII, than those of other plots receiving the same amount of nitrate applied sometime in May. It will also be noticed, Table XX, that the yield of Plot 23 was considerably less than that of Plots 7, 10, and 15 and slightly less than that of Plot 19.

Applications of nitrate of soda made later than May increased the length of the terminal growth and reduced the yield as compared with applications made at this time. From Table XX it will be seen that the yield of Plots 20 and 24 was less than that of Plot 23 receiving the early applications. It will also be observed that these two plots yielded considerably less than similar plots receiving the same amount of nitrate of soda but applied some time in May, Plots 7, 10, 15, and 19.

From these data it would seem that nitrate of soda should be applied just before, at, or soon after blossoming period to secure the maximum returns in yields under West Virginia conditions. There is not the problem of securing a commercial set of fruit on the peach as in the case of apples, due to the self-fertility of the former, and as there is some chance of losing some of the nitrogen when applications are made as early as March, it would seem wise to delay the time of applying the fertilizer until May. Late applications cause the trees to grow later in the season, thus making them more susceptible to winter injury.

The yield of Plots 21 receiving phosphorus and potassium was less than the average of the checks, and less than the nearest check. It will be remembered that the yields of similar plots in the Cherry Run experiment, Table XIX, and that of the Sleepy Creek experiments, Table XVII, either failed to show an increase or yielded less than the check plots. Under such conditions these materials should not be applied in combination to peach trees, at least not on soils similar to those in these experiments. Phosphorus may be applied to the cover crop with very beneficial results.

The Effect of Fertilizers on Size of Fruit

So far attention has been centered upon the effect of fertilizers upon (a) growth, (b) the set of fruit buds, and (c) yield. Consideration will now be given to the size of fruit produced under the different treatments.

In studying the effect of fertilizers on the sizes of peaches in these experiments the crops of each tree were sized on a mechanical sizer. The sizes used were: culls (up to 2 inches in diameter); choice (2 to 2 1-4 inches); fancy (2 1-4 to 2 1-2 inches); extra fancy (2 1-2 inches up). These sizes are the ones used in packing the various packs in the six-basket Georgia carriers. The total weights of the peaches of each grade produced on each plot and the percentage of the various grades are entered in the following tables.

The Effect of Fertilizers upon Size in the Sleepy Creek Experiment.—None of the fertilizers applied had a marked effect on size. The data presented in Table XXI show that the plots producing the largest percentage of culls did not receive nitrogen.

TABLE XXI.—Effect of Fertilizers on the Size of Peaches in the Sleepy Creek Experiment[1].

Plot No.	Treatment	Weight in Pounds					Percent of the Different Grades			
		Culls 0—2"	Choice 2"—2¼"	Fancy 2¼"—2½"	Extra Fancy 2½"—up	Total	Culls 0—2"	Choice 2"—2¼"	Fancy 2¼"—2½"	Extra Fancy 2½"—up
Carman:										
1	N P	343.12	2168.15	1162.53	339.59	4013.39	8.55	54.02	28.96	8.47
2	N K	256.10	2736.35	1280.43	331.93	4604.81	5.57	59.42	27.80	7.21
3	N P K	227.50	1885.61	1211.43	307.18	3631.72	6.27	51.92	33.35	8.46
4	Check	661.82	1080.52	612.51	257.47	2612.32	25.33	41.36	23.46	9.85
5	P K	543.80	1234.80	729.90	336.07	2844.57	19.12	43.41	25.65	11.82
6	N P K	246.93	2825.78	1212.44	433.40	4718.55	5.24	59.89	25.68	9.19
7	N P K*	232.43	2429.53	1472.23	515.68	4649.87	5.00	52.25	31.67	11.08
8	N P K**	705.01	2565.06	1241.84	626.25	5138.16	13.73	49.92	24.16	12.19
9	Lime	370.45	1224.90	863.37	317.54	2776.26	13.32	44.13	31.10	11.44
10	N	249.28	2431.86	1888.06	400.34	4969.54	5.01	48.94	38.00	8.05
11	P	699.06	1043.52	595.94	209.18	2547.70	27.44	40.95	23.39	8.22
12	K	545.65	1462.29	1084.38	334.84	3427.16	15.92	42.66	31.64	9.78
Waddell:										
1	N P	948.34	2304.00	410.00	28.32	3690.66	25.70	62.42	11.10	.77
2	N K	656.93	2154.18	539.99	44.26	3395.36	19.35	63.44	15.90	1.31
3	N P K	586.26	2175.25	556.11	42.56	3360.18	17.45	64.74	16.54	1.27
4	Check	715.73	766.27	229.09	8.25	1719.34	41.63	44.57	13.32	.48
5	P K	629.54	666.63	333.20	58.18	1687.55	37.31	39.50	19.74	3.45
6	N P K	624.10	2321.30	582.75	71.35	3599.50	17.34	64.49	16.18	1.99
7	N P K*	621.93	1996.72	598.39	30.05	3247.09	19.16	61.49	18.42	.93
8	N P K**	448.48	2307.74	858.08	141.04	3755.34	11.94	61.45	22.85	3.76
9	Lime	789.63	1403.10	417.33	41.99	2652.05	29.78	52.90	15.73	1.59
10	N	451.73	1625.57	520.13	47.98	2645.41	17.08	61.44	19.66	1.82
11	P	601.14	1431.37	736.81	85.15	2854.47	21.06	50.14	25.82	2.98
12	K	724.96	1246.86	433.24	75.09	2480.15	29.24	50.27	17.47	3.02

[1] This table includes the total weight of all grades for the years 1913-18, inclusive.

* K Doubled.

** K Tripled.

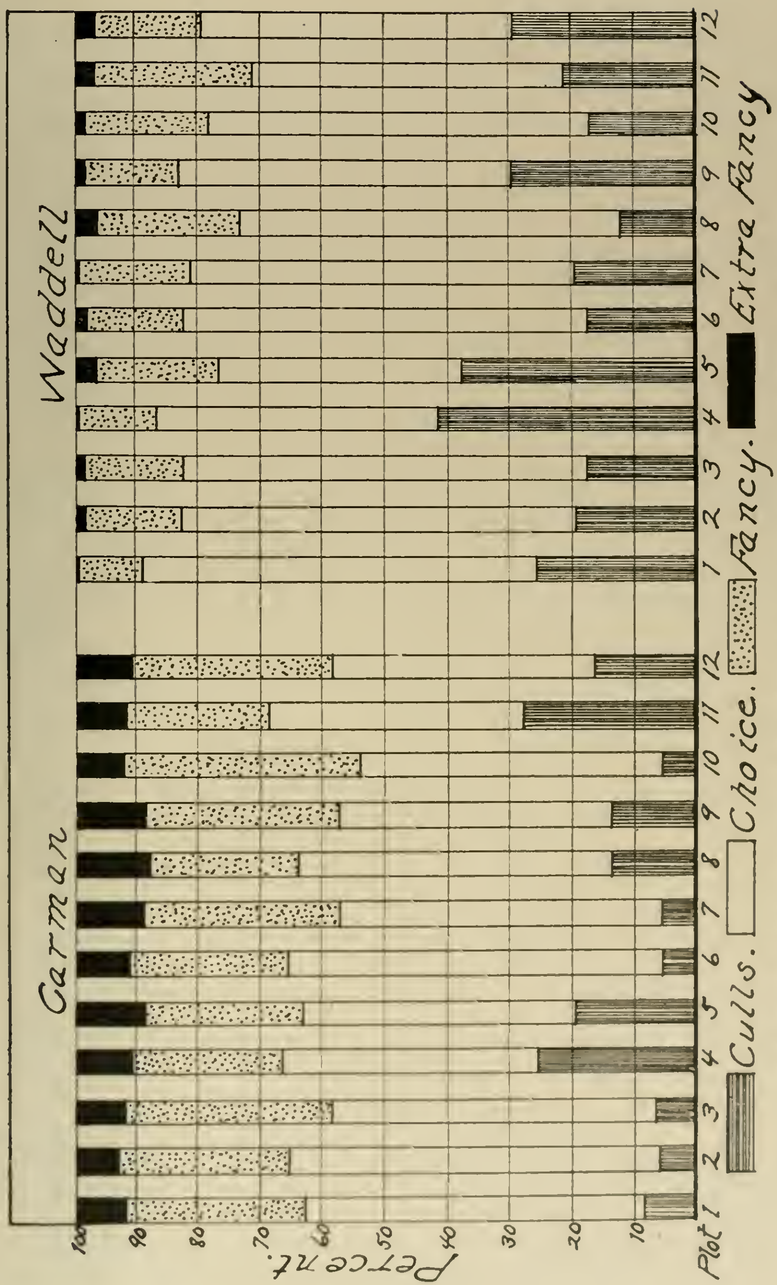

Fig. 20.—Diagram Showing the Influence of Fertilizers on the Size of Carman and Waddell Peaches, Sleepy Creek Experiment.

The Carman check plot produced 25 percent culls, while the culls in the nitrogen-treated plots ranged from 5 to 13 percent. Likewise in Waddell the highest percentage of culls occurred in the check, while the next highest was in the plot receiving acid phosphate and muriate of potash. The total production of culls was greater in Waddell, the smaller variety. The plots receiving phosphorus, potassium, and lime produced approximately the same quantity of culls as did the check plots, even though the total production of the latter was considerably less. In Carman the nitrogen-treated plots produced the largest quantity of extra fancy peaches but this tendency was not so pronounced with Waddell. Taken as a whole, however, there was no significant difference between the different fertilizer treatments as to the quantity of extra fancy peaches produced, although with Carman the four plots producing the greatest yield of this size were nitrogen-treated.

It will be recalled from the discussion on growth that in this experiment Plots 4 and 5 were each divided into two parts so that one-half of each variety was left as the original experiment was planned, and to each tree in the other half four pounds of nitrate of soda were applied. The data on effect of nitrate of soda on size in this test are included in Table XXII.

TABLE XXII.—Effect of Nitrate of Soda on Size of Peaches on Trees of Low Vigor in Plots 4 and 5 of the Sleepy Creek Experiment (Seasons of 1917 and 1918).

Plot No.	Treatment	Size of Peaches—Weight in Pounds						Percent				
		0—1¾"	1¾"—2"	2"—2¼"	2¼"—2½"	2½"—up	Total	0—1¾"	1¾"—2"	2"—2¼"	2¼"—2½"	2½"—up
Carman:												
4	Check	17.00	95.50	235.75	218.00	104.00	670.25	2.53	14.25	35.17	32.53	15.52
4	4 lb N	43.50	264.50	341.00	270.90	164.25	1084.15	4.01	24.40	31.46	24.98	15.15
5	P K	17.00	99.06	262.06	272.50	136.32	786.94	2.16	12.59	33.30	34.63	17.32
5	4 lb N P K	65.00	251.50	289.25	236.50	228.75	1071.00	6.07	23.48	27.01	22.08	21.36
Waddell:												
4	Check	59.74	125.00	132.52	88.24	8.24	413.74	14.44	30.21	32.03	21.33	1.99
4	4 lb N	120.74	212.24	222.24	109.86	4.24	669.32	18.04	31.71	33.21	16.41	.63
5	P K	41.50	98.75	154.50	161.25	54.50	510.50	8.13	19.34	30.27	31.59	10.67
5	4 lb N P K	45.75	180.75	253.50	221.75	56.50	758.25	6.03	23.84	33.43	29.25	7.45

These data show that although there was a much larger yield of peaches on the nitrogen-treated plots, the percent falling in any one size was about the same as from the plots receiving no nitrogen. Nitrogen did not increase the size of the fruit, and the additional fruit borne on the nitrogen-treated trees did not reduce the average size.

Effect of Fertilizers on Size in the Cherry Run Experiment.—As shown in Table XXIII none of the fertilizers applied alone or in combination had any appreciable effect in increasing the size of the peaches in this experiment. Nitrogen increased the percent of extra fancy peaches by a very small margin over the trees not so

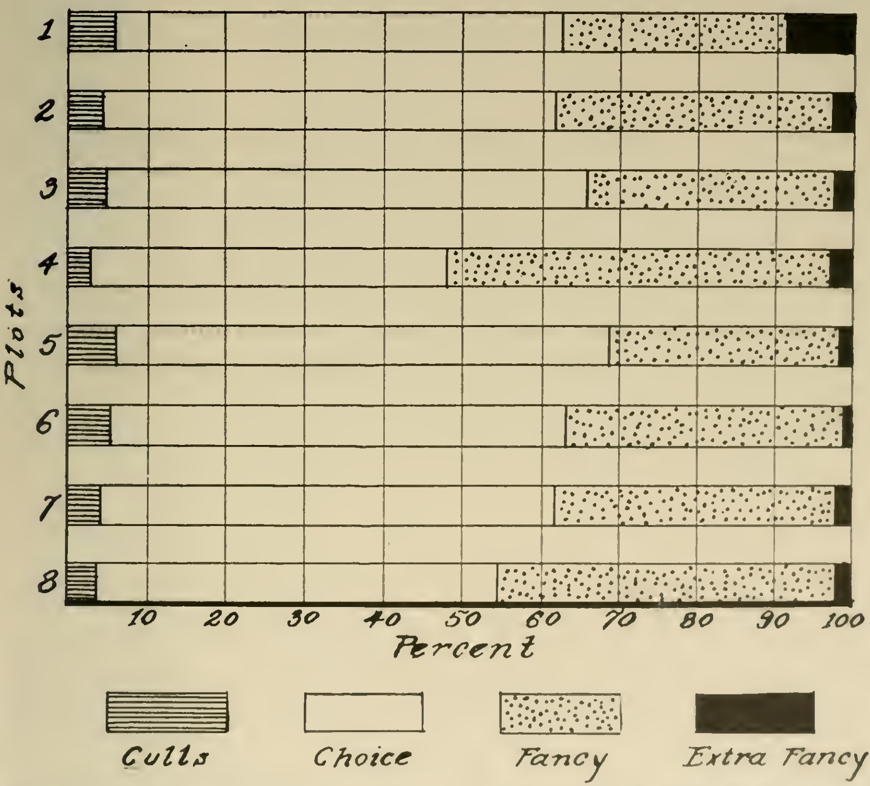

Fig. 21.—Diagram Showing the Influence of Fertilizers on the Size of Carman Peaches, Cherry Run Experiment.

TABLE XXIII.—Effect of Fertilizers on the Size of Carman in the Cherry Run Experiment (1914 to 1917).

Plot No.	Treatment	Percent of Each Grade			
		Culls 0—2″	Choice 2″—2¼″	Fancy 2¼″—2½″	Extra Fancy 2½″—up
1	N P	6.13	56.53	28.65	8.67
2	N K	4.47	56.75	35.60	3.17
3	N P K	4.98	61.16	31.51	2.34
4	P K	3.05	45.72	48.26	2.94
5	Check	5.91	62.90	29.65	1.51
6	P	5.27	58.66	34.96	1.04
7	K	3.98	57.53	36.24	2.23
8	N	3.38	50.88	43.68	2.05

treated but lowered the percent of fancy peaches somewhat. Those fertilizing materials which increased the yield also produced about the same amount of each of the four sizes as did the check. It will be seen, therefore, that none of the treatments was outstanding in increasing the yield of the larger sizes.

Effect of Fertilizers on Size of Fruit in the Elberta Experiment.—It has generally been held that nitrogen-carrying fertilizers increase the size of peaches. Whitten and Wiggans (11) state that during dry seasons in Missouri peaches produced on trees fertilized with nitrate of soda were smaller than those produced on unfertilized trees. The suggestion was made that this was due to the nitrogen producing a larger area of foliage which withdrew moisture from the fruit or at least used the moisture which would have otherwise gone to the fruit. It will be recalled that none of the fertilizer treatments increased the size of the peaches to any marked extent in the Cherry Run or in the Sleepy Creek experiments.

TABLE XXIV.—Effect of Fertilizers on Size of Fruit in the Elberta Experiment (1915-1920 Inclusive).

Plot No.	Treatment	Size in Pounds: Culls 0—2"	Choice 2"—2¼"	Fancy 2¼"—2½"	Ex. Fancy 2½" Up	Total	Size % Total: Culls 0—2"	Choice 2"—2¼"	Fancy 2¼"—2½"	Ex. Fancy 2½" Up
1	Soybeans			Discarded						
2	Soybeans P K	47.62	809.75	2229.06	722.12	3808.55	1.0	22.0	58.0	19.0
3	Crimson Clover	57.00	756.25	2020.75	666.00	3500.00	2.0	22.0	57.0	19.0
4	Crimson Clover P K	17.40	498.55	1367.86	1094.70	2978.51	0.6	16.7	45.9	36.8
5	2 Lbs. N	66.61	1054.52	2088.60	770.25	3979.98	1.7	26.5	52.5	19.3
6	Check	32.62	704.30	2003.25	813.25	3553.42	0.9	19.8	56.4	22.9
7	4 Lbs. N	113.12	1459.12	2727.99	909.43	5209.66	2.1	28.1	52.4	17.4
8	6 Lbs. N	122.51	1457.19	2636.98	1086.86	5303.54	2.3	27.5	49.7	20.5
9	2 Lbs. N P	47.25	980.18	2406.00	1012.26	4445.69	1.0	22.0	54.1	22.9
10	4 Lbs. N P	75.00	1024.81	3303.79	1399.87	5803.47	1.3	17.7	56.9	24.1
11	6 Lbs. N P	55.69	926.85	2553.76	1363.17	4899.47	1.1	18.9	52.2	27.8
12	Check	29.98	621.37	2366.25	902.25	3919.85	0.8	15.8	60.4	23.0
13	Check	26.13	270.88	1542.01	1445.50	3284.52	0.8	8.2	46.9	44.1
14	2 Lbs. N P K	28.37	528.93	2228.42	1355.40	4141.12	0.7	12.8	53.8	32.7
15	4 Lbs. N P K	51.94	1246.40	2788.78	1536.13	5623.25	0.9	22.2	49.6	27.3
16	6 Lbs. N P K	68.56	1698.34	3445.49	1655.38	6867.77	1.0	24.7	50.2	24.1
17	Manure	17.50	257.50	2164.57	2288.67	4728.24	0.4	5.4	45.8	48.4
18	Manure P	32.19	625.40	3801.55	2521.53	6980.67	0.5	8.9	54.5	36.1
19	4 Lbs. N K	65.90	1258.16	2621.68	893.16	4838.90	1.3	26.0	54.3	18.4
20	4 Lbs. N on 6-15	58.50	1003.58	2458.93	920.18	4441.19	1.3	22.6	55.4	20.7
21	P K	88.57	356.51	1596.41	1270.26	3311.75	2.7	10.8	48.2	38.3
22	Check	32.37	756.68	2404.07	877.38	4070.50	0.8	18.6	59.1	21.5
23	4 Lbs. N on 3-25	96.32	1230.94	2530.57	831.64	4689.47	2.1	26.2	54.0	17.7
24	4 Lbs. on 7-15	38.00	940.12	2154.82	917.50	4050.44	0.9	23.2	53.2	22.7

Difference between total weights given in this Table and Table XX is due to variation in weighing; also when the peaches were graded, those badly damaged by brown rot or scab were thrown out and not weighed.

A study of Table XXIV and Figure 22 shows that the majority of plots receiving nitrate of soda produced a smaller percent of fancy and extra fancy peaches than did the checks. Plot 21, receiving muriate of potash and acid phosphate, also produced a somewhat higher percent of the larger sized peaches. The data show that the plots which produced the greatest total yield of peaches had the smallest percent of the larger sizes, with the exception of Plots 17 and 18 which received manure at the rate of 150 pounds per tree. In these plots the bulk of the crop, 92.4 percent, was fancy and extra fancy, even though the yield was large. In the check and non-nitrogen-treated plots the yield was less, and since there were fewer fruits, the size was larger. The

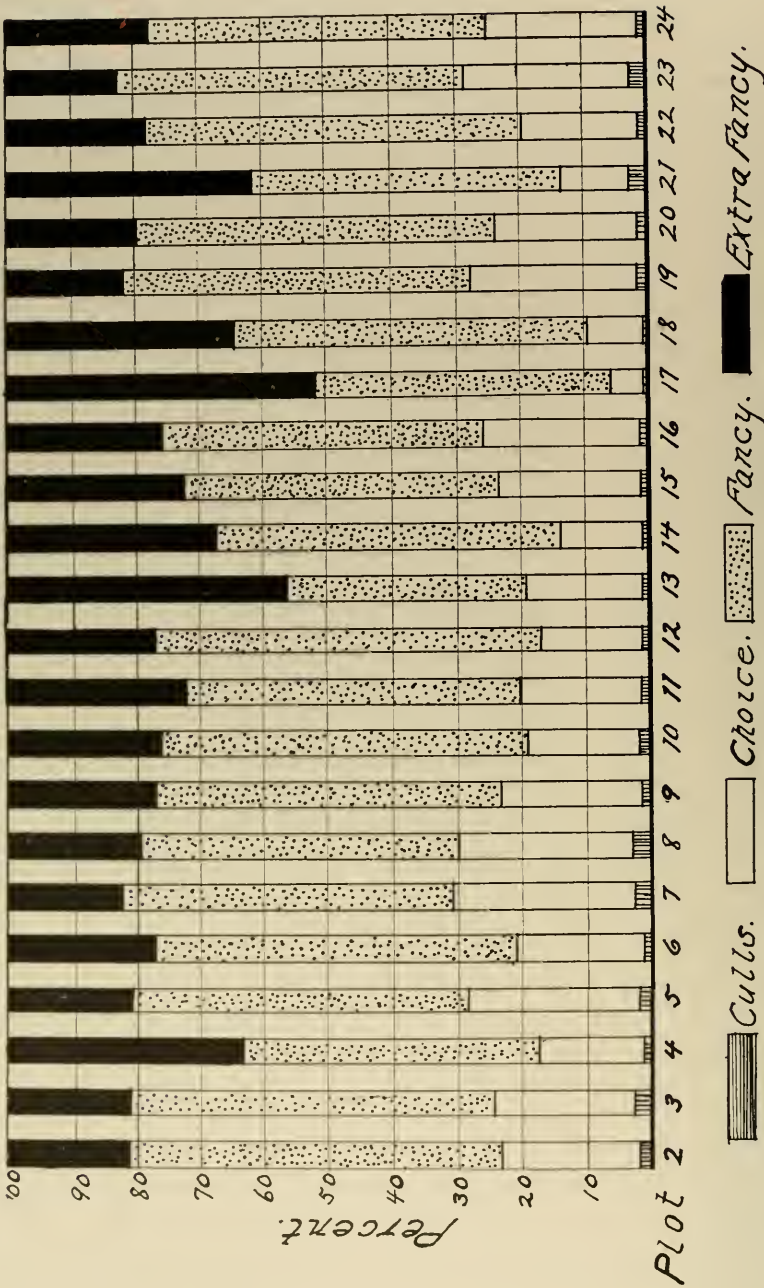

Fig. 22.—Diagram Showing the Influence of Fertilizers on the Size of Elberta Peaches, Cherry Run Experiment.

probable reason for this influence of the manure was through the mulch effect before plowing and the better retention of moisture as a result of the increased organic matter content afterward. Moisture determinations were not made, but that there was a greater amount in the manured plots was quite evident during the growing season. The influence of the manure was more pronounced on this soil because of its low organic content. The applications of nitrate of soda produced a greater growth, a larger leaf area, and a heavier set of fruit, all of which increased the demands on the soil for moisture. Under these conditions when the soil moisture became low during dry periods the size of the fruit was first affected.

The percent of fancy and extra fancy peaches produced in Plots 14, 15, and 16 showed that the size of the peaches was reduced in direct proportion to the amount of nitrate of soda applied. This was not the case, however, in the other plots where nitrate of soda was applied.

These experiments indicate that soil moisture plays an important part in determining the size of peaches. The shale soil on which the above experiments were conducted is not retentive of moisture, and consequently the effect of a slight drouth was readily noticed. On soils better supplied with or more retentive of moisture, size of fruit might be increased by nitrogen applications. If the best results are to be secured from the application of fertilizers to peaches the soil must be well supplied with organic matter, and cultural methods must be used which are efficient in conserving soil moisture.

Influence of Fertilizers on the Time of Maturity

The effect of fertilizers, particularly those containing nitrogen, upon the time of maturity of peaches is an important consideration to the grower. This phase of the subject has been given careful attention in these experiments because of the direct bearing upon the time of marketing and hence upon prices. It should be kept in mind, however, that in some years, depending upon the time of highest prices during the season, late maturity may be an advantage and in other years a disadvantage.

The Time of Picking in the Cherry Run Experiment.—In this experiment nitrogen delayed the time of picking the bulk of the crop from two to ten days. The results for the different seasons are included in Table XXV.

TABLE XXV.—Influence of Fertilizers on Time of Picking in the Cherry Run Experiment.

Carman:

Date of Picking	Percent of Crop Harvested at Each Picking							
	1	2	3	4	5	6	7	8
	N P	N K	N P K	P K	Check	P	K	N
1915: Aug. 2	.0	.0	.0	19.8	20.2	14.0	21.3	.0
Aug. 4	.0	.0	2.4	35.1	33.9	30.7	34.4	.0
Aug. 7	7.8	16.4	16.4	45.1	45.9	55.3	44.3	40.1
Aug. 9	34.8	30.4	12.4	.0	.0	.0	.0	23.8
Aug. 13	57.4	53.2	68.8	.0	.0	.0	.0	36.1
1916: Aug. 1	1.3	2.3	.1	25.5	44.2	31.0	51.5	14.6
Aug. 3	7.8	5.6	4.9	29.7	19.1	27.3	40.1	29.9
Aug. 5	65.8	66.8	69.7	41.5	31.3	35.1	7.3	44.5
Aug. 7	25.1	25.3	25.3	3.3	5.4	6.6	1.1	11.0
1917: Aug. 6	18.9	19.8	15.8	47.9	63.6	57.9	71.5	36.4
Aug. 8	81.1	80.2	84.1	52.1	36.4	42.1	28.5	63.6

In contrast to the influence of nitrogen it will be seen that the plots which received potash and acid phosphate either singly or in combination ripened the crop at approximately the same time as did the check. The dates given in the table, however, do not quite show the real difference between the nitrogen-treated and non-nitrogen-treated plots for the reason that the early maturing peaches were allowed to hang on the trees in some cases until they became overripe and those on the nitrogen-treated plots were picked as early as possible in order to lessen the number of shipments. The peaches on the nitrogen-treated plots were greener in color than were those on the non-nitrogen-treated plots but this difference should not be ascribed directly to nitrogen in view of the reduced sunlight which reaches the peaches as a result of the denser foliage.

Time of Picking in the Elberta Experiment.—The general trend of the influence of nitrogen in this experiment is similar to that in the Cherry Run experiment. The percent of the crop ripe on the different picking dates is given for each plot. A study of Table XXVI will show that the time of ripening on the different treatments varies considerably.

The number of pickings varied from 8 in 1916 to 3 in 1920. As in the previous experiment, except in 1916, the tendency was to pick the first of the crop late and the last of the crop early. The data show that the delay in maturity was generally in direct proportion to the amount of nitrogen applied: the plots receiving 6 pounds of nitrate of soda per tree and the manured plots being the last to ripen. In this experiment as well as in the one at Cherry Run the treatments which increased the yield delayed the time of ripening. This is an important point to keep in mind in view of the relationship between growth and yield.

TABLE XXVI.—Influence of Fertilizers Upon the Time of Picking in the Elberta Experiment as shown by The Percentage of the Crop Harvested at Each Picking.

Date of Picking	Plot Numbers*																						
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	Soybeans P K	Crimson Clover	Crimson Clover P K	2 Lbs. N	Check	4 Lbs. N	6 Lbs. N	2 Lbs. N P	4 Lbs. N P	6 Lbs. N P	Check	Check	2 Lbs. N P K	4 Lbs. N P K	6 Lbs. N P K	150 Lbs. Manure	150 Lbs. Manure P	4 Lbs. N K	4 Lbs. N 6-15	P K	Check	4 Lbs. N 3-25	4 Lbs. N 7-15
1915																							
Aug. 24	0.	0.	0.	.4	27.7	6.9	0.	2.9	0.	8.3	0.	0.	0.	0.	7.8	0.	0.	0.	0.	0.	13.2	0.	0.
Aug. 26	39.3	30.0	41.5	36.6	55.1	58.8	8.9	17.0	10.0	17.7	40.0	22.6	12.1	0.	3.9	24.7	3.8	0.	0.	23.6	20.8	0.	0.
Aug. 30	59.8	69.3	58.5	54.6	17.0	25.2	90.0	47.3	55.4	51.0	35.0	70.2	71.8	28.6	10.5	70.7	63.2	77.3	24.1	31.0	58.5	100.0	100.0
Sept. 2	.9	.7	0.	8.4	.2	9.1	1.1	32.8	34.6	23.0	25.0	7.2	16.1	71.4	77.8	4.6	33.0	22.7	75.9	45.4	7.5	0.	0.
1916																							
Aug. 21	0.	0.	0.	9.4	6.8	0.	0.	0.	.5	.5	1.5	2.1	0.	0.	.5	0.	0.	0.	0.	0.	0.	0.	0.
Aug. 23	0.	0.	0.	0.	3.7	0.	0.	0.	.5	0.	0.	11.8	.2	0.	0.	0.	0.	0.	0.	0.	1.2	1.7	0.
Aug. 26	0.	0.	0.	0.	0.	0.	1.5	.2	5.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
Aug. 28	1.9	3.5	5.1	21.0	8.0	0.	7.2	12.5	0.	2.6	11.6	21.0	5.4	5.3	5.0	0.2	0.	8.4	4.6	29.0	5.8	20.4	0.
Aug. 31	31.9	25.8	37.4	49.0	53.5	23.2	28.4	0.	0.	0.	29.0	0.	0.	7.7	24.5	0.	0.	15.0	23.0	0.	0.	29.6	37.2
Sept. 1	23.3	9.0	5.2	6.0	14.5	6.6	9.9	30.5	21.0	16.7	0.	49.8	42.0	11.8	0.	29.1	16.6	0.	0.	51.1	51.1	0.	0.
Sept. 4	34.8	40.7	41.4	8.6	13.5	41.0	39.5	47.8	51.3	65.4	45.6	15.3	45.2	56.7	42.1	67.5	54.7	65.2	45.0	19.9	34.9	45.7	52.8
Sept. 7	8.1	21.0	10.9	6.0	0.	29.2	13.5	9.0	21.7	14.8	12.3	0.	7.2	18.5	27.9	3.2	28.7	11.4	27.4	0.	7.0	2.6	10.0
1917																							
Aug. 28	4.0	2.0	7.0	12.4	0.	4.4	1.8	8.4	8.3	4.6	5.4	14.5	9.8	12.8	0.	4.4	0.	0.	0.	25.4	10.4	14.8	0.
Aug. 31	18.0	5.8	13.4	40.2	78.7	9.6	20.7	13.4	13.0	5.7	21.6	23.6	13.0	6.7	.9	8.8	1.2	2.1	10.2	43.1	39.2	15.3	1.3
Sept. 3	38.8	28.8	59.6	34.4	17.6	33.6	46.5	31.5	26.3	38.0	59.8	58.1	65.8	29.8	24.2	40.9	29.0	69.0	60.9	23.4	35.2	61.4	12.7
Sept. 5	39.1	63.4	20.0	13.0	3.7	52.4	31.0	46.7	52.4	51.7	13.2	3.8	11.4	50.7	74.9	45.9	69.8	28.9	28.9	8.1	15.2	8.5	26.0

1918																							
Aug. 20	6.2	9.8	20.5	21.0	30.6	15.8	12.4	4.8	4.1	5.8	21.9	18.5	7.3	2.0	1.8	0.	0.	16.1	5.3	32.4	13.8	8.2	1.5
Aug. 22	41.1	35.7	64.3	21.0	27.2	15.9	15.5	6.3	2.0	3.6	7.0	9.0	5.0	6.0	1.8	3.6	.9	16.2	24.6	45.1	29.1	39.8	16.8
Aug. 24	25.2	26.4	13.2	47.0	36.0	45.3	45.7	43.5	41.4	57.6	63.7	57.9	65.7	65.8	44.4	34.6	16.4	58.2	44.7	22.5	36.6	42.5	42.9
Aug. 26	27.5	28.1	2.0	11.0	6.2	23.0	26.4	45.4	52.5	33.0	7.4	14.6	22.0	26.2	46.5	32.6	43.4	9.5	25.4	0.	20.5	9.5	38.8
Aug. 27	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	5.5	29.2	39.3	0.	0.	0.	0.	0.	0.
1919																							
Aug. 21	12.6	7.4	27.6	22.4	54.5	15.3	17.3	12.9	8.1	9.0	33.2	0.	18.9	8.4	0.	0.	0.	0.	0.	0.	0.	0.	0.
Aug. 22	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	54.8	0.	0.	0.	4.5	12.5	29.7	22.1	49.9	45.3	28.2	10.4
Aug. 25	58.7	33.2	43.0	56.5	38.7	34.0	48.8	25.0	12.0	14.2	37.6	30.8	32.1	20.4	16.5	36.8	28.3	31.2	39.6	40.2	22.6	34.0	33.2
Aug. 27	26.0	55.2	28.7	20.1	5.4	48.7	39.4	61.0	77.6	68.0	27.3	14.4	49.0	63.9	80.6	55.8	57.1	38.9	37.3	9.3	30.6	33.4	48.9
Aug. 28	2.7	4.2	.7	1.0	1.4	2.0	.5	1.1	2.3	8.8	1.9	0.	0.	7.3	2.9	2.9	2.1	.2	1.0	.6	1.5	4.4	7.5
1920																							
Aug. 31	11.3	0.	38.5	9.4	80.2	.5	10.9	0.	0.	0.	31.1	37.1	5.3	.3	.8	0.	0.	18.7	25.7	50.4	49.8	41.6	11.0
Sept. 2	67.9	72.8	56.2	82.1	18.4	58.5	71.0	48.9	26.9	23.8	65.8	59.3	50.4	11.1	26.4	35.0	46.6	78.3	71.0	49.4	46.4	57.4	53.0
Sept. 4	20.8	27.2	5.3	8.5	1.4	41.0	18.1	51.1	73.1	76.2	3.1	3.6	44.3	88.6	72.8	65.0	53.4	3.0	3.3	.2	3.8	1.0	36.0

* Plot 1 discarded.

Effect of Lime on Growth.—The various analyses which have been made of the wood and fruit of the peach show that it uses large amounts of calcium. The limed plot in the Sleepy Creek experiment gave some indication of stimulated growth and bearing. In view of this, it was thought best to make additional tests of the effects of lime on growth and yield. Accordingly in the Elberta Experiment a single application of lime was made to three record trees of each plot in the spring of 1915. Ground limestone was drilled between the rows at the rate of two and a half tons per acre, this amount being in excess of the lime requirement of this soil.

It will be seen from the data in Table XXVII that the application of lime did not effect the length of the terminal shoot growth. The seven-year average length of ten terminal shoots per tree was 20.2 feet on the limed trees, and 20.3 feet on the unlimed trees, or one-tenth of a foot in favor of no lime. The effect of lime on the check plots was insignificant: Plot 6 shows a loss, 12 and 13 a slight gain, and 22 a somewhat larger gain. In plots receiving nitrate of soda, acid phosphate, or muriate of potash, either alone or in combination, lime did not increase the growth.

TABLE XXVII.—Influence of Lime and Fertilizers on Shoot Growth in the Elberta Experiment Based on the Seven Year Average Length of Ten Terminal Shoots per Tree.

Plot	Treatment	1915		1916		1917		1918		1919		1920		1921						
		Lime	No Lime	Lime	No Lime	Lime	No Lime	Lime	No Lime	Lime	No Lime	Lime	No Lime	Lime	No Lime	Total Lime	Average Lime	Total No Lime	Average No Lime	Gain for Lime
1	Soybeans							Discarded												
2	Soybeans P K	39.5	39.2	29.8	27.3	29.2	24.5	11.0	8.4	20.1	18.9	11.6	11.3	10.6	12.6	151.8	21.6	142.2	20.3	1.3
3	Crimson Clover	35.0	38.9	38.3	38.2	29.7	28.3	10.4	12.1	20.7	21.1	11.5	13.6	17.2	16.8	162.8	23.2	169.0	24.1	—0.9
4	Crimson Clover P K	37.6	36.6	34.1	31.4	15.1	13.6	7.8	9.1	20.3	17.5	10.5	10.0	12.2	9.8	137.6	19.6	128.0	18.3	1.3
5	2 Lbs. N	30.3	36.4	20.4	26.8	11.3	10.6	8.2	6.9	12.2	14.9	6.5	7.3	11.2	12.1	100.1	14.3	115.0	16.4	—2.1
6	Check	23.9	38.6	22.9	35.4	18.3	17.3	4.9	8.0	....	....	....	....	....	....	70.0	17.5	99.3	24.8	—7.3
7	4 Lbs. N	38.9	42.7	38.9	38.9	15.8	19.5	6.7	8.9	13.4	17.2	9.3	12.2	12.6	18.7	135.6	19.3	158.1	22.6	—3.3
8	6 Lbs. N	34.4	43.7	33.3	31.3	19.2	15.2	7.3	8.8	14.3	14.9	9.7	10.4	16.1	16.9	134.3	19.2	141.2	20.2	—1.0
9	2 Lbs. N P	25.3	43.9	25.6	31.9	7.6	16.4	10.5	10.7	18.4	18.5	8.3	10.9	15.7	13.5	111.4	15.9	145.8	20.8	—4.9
10	4 Lbs. N P	44.2	45.9	39.3	35.8	16.2	11.7	9.9	9.3	13.9	16.9	13.2	11.1	24.0	17.8	160.7	22.9	148.5	21.2	1.7
11	6 Lbs. N P	30.7	43.7	26.6	33.7	18.6	16.4	8.6	9.4	12.6	15.9	13.1	12.4	24.5	24.5	134.7	19.2	156.0	22.3	—3.1
12	Check	36.7	37.5	35.6	38.4	10.3	12.5	9.7	8.6	20.3	16.6	10.2	8.9	12.1	9.1	134.9	19.2	131.6	18.8	0.4
13	Check	42.1	40.4	29.3	29.3	10.3	5.9	9.0	7.3	10.7	14.2	5.5	6.5	9.0	6.2	115.9	16.5	109.8	15.7	0.8
14	2 Lbs. N P K	40.1	40.8	44.1	27.0	11.2	10.3	10.7	9.9	19.6	18.3	12.1	10.2	12.1	6.9	149.9	21.4	123.4	17.6	3.8
15	4 Lbs. N P K	46.4	45.8	34.5	37.2	21.5	13.9	8.4	9.8	22.4	18.3	11.0	11.8	13.7	14.5	157.9	22.5	151.3	21.6	0.9
16	6 Lbs. N P K	34.9	44.8	31.5	31.2	14.3	18.5	10.6	10.8	16.3	23.1	12.6	12.0	14.2	23.8	134.4	19.2	164.2	23.4	—4.2
17	Manure	51.0	39.9	39.8	34.1	13.8	11.2	11.1	12.4	20.3	17.8	12.8	10.1	21.2	12.7	170.0	24.3	138.2	19.7	4.6
18	Manure P	47.6	46.1	42.1	42.2	21.8	17.3	9.1	11.4	20.9	17.1	9.3	9.7	19.2	13.8	170.0	24.3	157.6	22.5	1.8
19	4 Lbs. N K	44.2	44.6	42.6	40.0	14.3	15.5	9.3	9.9	15.9	14.7	7.7	10.7	11.2	14.1	145.2	20.7	149.5	21.3	—0.6
20	4 Lbs. N 6-15	42.8	44.3	46.6	34.8	13.8	14.6	10.4	9.9	15.6	16.3	8.3	9.2	13.0	14.2	150.5	21.5	143.3	20.4	1.1
21	P K	47.0	40.5	36.0	28.5	9.3	7.0	6.8	6.4	11.2	10.0	9.7	5.0	7.3	6.3	127.3	18.2	103.7	14.8	3.4
22	Check	43.9	41.4	44.6	35.2	12.5	12.6	9.5	8.5	16.3	12.6	9.6	8.3	8.5	5.6	144.9	20.7	124.2	17.7	3.0
23	4 Lbs. N	44.6	44.6	38.1	35.4	13.4	12.8	9.1	8.7	15.1	16.8	9.9	9.4	10.2	14.2	140.4	20.0	141.9	20.2	—0.2
24	4 Lbs. N 7-15	39.6	46.0	42.1	42.4	17.7	17.1	11.3	12.9	20.7	21.4	11.1	9.5	21.4	19.4	163.9	23.4	168.7	24.1	—0.7
	Total	900.7	966.3	816.1	786.4	365.2	342.7	210.3	218.1	371.2	373.0	223.5	220.5	317.2	303.5	3204.2	464.6	3210.5	468.8	
	Av. of all Plots																20.2		20.3	

The outstanding influence from lime came through its effect upon cover crops. The growth of soybeans and crimson clover was larger and thicker in the rows which had received lime. As shown above, however, the limed trees, in Plots 2, and 4 made increased growth in favor of lime, while Plot 3 showed a loss.

The Effect of Lime on Yield.—The data on yield for the six years, 1915 to 1920, inclusive are given in Table XXVIII.

Fig. 23.—Plot 8 in the Foreground and Plot 4 in the Background. Very Poor Stand and Growth of Soybeans on Plot 8 Which Received Nitrogen Alone. Much Better Growth and Stand in Plot 4 Which Received Phosphorus and Potassium. Picture Taken August, 1921.

Fig. 24.—Plot 8 in the Foreground and Plot 4 in the Background. This Row Received the Same Treatment as the One Shown in Figure 23 Except That in the Spring of 1915 When Ground Limestone at the Rate of 2 1-2 Tons per Acre was Applied. Lime is Very Essential for Soybean Growth in Peach Orchards. Picture Taken Same Day as in Figure 23.

TABLE XXVIII.—Influence of Lime and Fertilizer on Total Yield in the Elberta Experiment.

Plot	Treatment	YIELDS IN POUNDS PER TREE 1915 Lime	1915 No Lime	1916 Lime	1916 No Lime	1917 Lime	1917 No Lime	1918 Lime	1918 No Lime	1919 Lime	1919 No Lime	1920 Lime	1920 No Lime	Total Lime	Average Lime	Total No Lime	Average No Lime	Total Gain for Lime
1	Soybeans									Discarded								
2	Soybeans P K	4.2	6.7	69.8	60.9	92.0	83.6	100.6	82.4	105.2	90.5	117.5	90.1	489.3	81.5	414.2	69.0	75.1
3	Crimson Clover	5.7	3.4	52.6	59.6	74.6	69.6	89.0	85.9	80.2	64.0	101.7	95.1	403.8	67.3	377.6	62.9	26.2
4	Crim. Clover P K	2.1	.9	24.1	63.7	55.5	123.0	8.8	22.5	94.2	89.9	50.0	43.0	234.7	39.1	343.0	57.2	—108.3
5	2 Lbs. N	45.8	30.9	78.4	59.2	74.1	84.2	71.5	52.7	139.7	86.4	113.5	103.1	523.0	87.1	416.5	69.4	106.5
6	Check	5.6	12.3	18.8	107.6	57.5	90.6	53.0	80.2	14.0	120.0	....	80.9	148.9	29.9	491.6	81.9	—312.9
7	4 Lbs. N	21.2	1.5	111.3	70.9	131.0	76.7	114.9	109.6	84.6	112.8	194.0	166.5	657.0	109.5	538.0	89.7	119.0
8	6 Lbs. N	8.8	3.1	107.0	114.0	105.3	125.3	111.3	108.9	95.5	125.5	130.2	136.0	558.1	93.0	612.8	102.1	—54.7
9	2 Lbs. N P	39.2	17.2	37.7	86.2	56.5	100.4	40.0	58.6	57.7	136.8	121.7	167.0	352.8	58.8	566.2	94.4	—213.4
10	4 Lbs. N P	16.5	6.7	119.1	116.1	148.2	125.6	95.8	69.4	184.2	131.2	179.2	164.4	743.0	123.8	613.4	102.2	129.6
11	6 Lbs. N P	5.2	5.4	148.4	89.9	194.7	111.6	122.5	81.8	65.7	129.8	134.5	119.3	671.0	111.8	537.8	89.6	133.2
12	Check	1.5	1.7	66.9	81.9	75.1	96.3	52.6	72.2	97.7	130.2	122.7	104.1	416.5	69.4	486.4	81.0	—69.9
13	Check	6.5	5.2	53.6	93.6	39.5	96.0	39.6	15.9	97.4	79.0	131.5	86.4	368.1	61.3	376.1	62.8	—8.6
14	2 Lbs. N P K	0.2	7.4	86.9	87.7	98.5	90.3	36.1	54.9	89.6	109.8	104.7	133.7	416.0	69.3	483.8	80.6	—67.8
15	4 Lbs. N P K	4.0	2.9	121.8	87.7	113.4	110.9	151.7	85.1	143.6	126.1	245.7	166.6	780.2	130.0	579.3	96.5	200.9
16	6 Lbs. N P K	14.0	15.6	99.0	150.4	111.5	156.5	141.6	132.0	129.7	150.3	186.0	224.3	681.8	113.6	829.1	138.2	—147.3
17	Manure	0.5	8.8	109.0	29.2	152.3	83.6	28.8	45.7	90.7	164.8	145.7	205.0	527.0	87.8	537.1	89.5	—10.1
18	Manure P	6.1	1.3	126.6	69.2	166.8	169.9	85.3	126.5	200.3	181.4	239.7	196.6	824.8	137.4	744.9	124.1	79.9
19	4 Lbs. N K	0.6	2.4	68.3	79.0	155.0	127.3	84.4	87.0	104.7	124.6	102.2	131.5	515.2	85.8	551.8	91.9	36.6
20	6 Lbs. N 6-15	2.2	1.3	53.6	82.4	95.4	125.8	94.6	65.7	128.9	101.1	146.2	110.1	520.9	86.8	486.4	81.0	34.5
21	P K	1.2	1.6	99.5	74.6	117.6	100.8	17.4	1.8	97.1	73.9	111.3	65.7	444.1	74.0	318.4	53.0	125.7
22	Check	0.6	1.8	38.0	78.6	114.5	118.9	34.7	33.8	152.0	111.3	149.5	116.1	489.3	81.5	460.5	76.7	28.8
23	4 Lbs. N 3-15	0.0	0.1	88.8	84.7	106.6	113.3	70.8	57.2	109.2	131.7	164.2	133.6	539.6	89.9	520.6	86.7	19.0
24	4 Lbs. N 7-15	0.2	0.0	44.3	70.3	96.0	118.0	47.7	26.0	51.9	59.1	168.3	193.8	408.4	68.0	467.2	77.8	—58.8
	Total	191.9	138.2	1823.5	1897.4	2431.6	2498.2	1692.7	1555.8	2431.8	2632.2	3160.0	3032.9	11713.5	1956.6	11752.7	1958.2	
	Average of Plots														85.0		85.1	

This table shows that, as in the case of growth, lime had no appreciable effect on yield. In the six-year period the average yield per tree on the limed plots was 85 pounds and on the unlimed plots 85.1 pounds. It will be recalled (Tables VI, VII, XIV and XVII) that a very slight increase in growth, fruit bud formation, and yield was secured from lime in the Sleepy Creek experiment. The results in that experiment, however, are not so clear as in the Elberta experiment since the soil and the trees were much more uniform in the latter.

Clean culture has been found to be the most successful method of producing peaches. With clean culture, however, must go some system of cover cropping which will hold the soil during the winter and aid in maintaining the organic matter. Lime has greatly increased the growth of the cover crop. These results indicate that lime should be used only where needed by the cover crops and should be applied uniformly over the orchard.

The difference in growth of soybeans due to the application of lime in the Elberta experiment is shown in Figures 23 and 24, The lime was applied in the spring of 1915 and the pictures were taken in August, 1921. It was interesting to note the increased growth of soybeans resulting from a lime application made six years previously.

ADDITIONAL PHASES OF THE FERTILIZER PROBLEM

Residual Effect of Fertilizers

The late spring freezes of 1921 killed all of the fruit buds in the Elberta experiment and as a result there was no crop. Since no fertilizers had been applied after the spring application of 1920, an opportunity was afforded of making a study of the residual effect of fertilizers. In the fall of 1921 marked differences were evident in the color of the foliage and length of the terminal growths in the different plots. The length of the terminal growth made seemed to bear a direct relationship to the amount of nitrogen applied. In order to determine what residual effect, if any, there was from nitrogen ten terminal shoots were measured from each of the record trees of different plots. The results of these measurements are given in Table XXIX.

TABLE XXIX.—Residual Effect of Fertilizer as Measured by Terminal Shoot Growth in the Elberta Experiment.

Plot No.	Treatment	Av. Length in Ft. of Ten Shoots	Gain Over Average of Checks
1	Soybeans — Plot Discarded		
2	Soybeans P K	11.97	4.44
3	Crimson Clover	16.98	9.45
4	Crimson Clover P K	10.72	3.19
5	2 Lbs. N	11.87	4.34
6	Check	6.58	
7	4 Lbs. N	16.47	8.94
8	6 Lbs. N	16.57	9.04
9	2 Lbs. N P	14.25	6.72
10	4 Lbs. N P	20.16	12.63
11	6 Lbs. N P	24.55	17.02
12	Check	10.12	
13	Check	6.80	
14	2 Lbs. N P K	8.25	.72
15	4 Lbs. N P K	14.31	6.78
16	6 Lbs. N P K	21.47	13.94
17	Manure	16.15	8.62
18	Manure P	15.87	8.34
19	4 Lbs. N K	13.08	5.55
20	4 Lbs. N 6-15	13.88	6.35
21	P K	6.95	—.58
22	Check	6.62	
23	4 Lbs. N 3-20	13.07	5.54
24	4 Lbs. N 7-15	20.13	12.60
	Average of checks	7.53	

The plots to which nitrogen had been applied made from two to three times the growth made by the check plots. Plots 2, 3, and 4, on which leguminous cover crops had been grown, made from 3 to 9.5 inches more growth than did the average of the check plots and still more when compared with the nearest check. This fact indicates that there was as much residual effect on growth from the cover crops as there was from applications of 2 to 4 pounds of nitrate of soda. The combination of acid phosphate or muriate of potash or both with nitrogen had little effect on shoot growth. The acid phosphate and muriate of potash combination (Plot 21) resulted in a growth .58 of a foot less than the average of all the checks, or the growth on this plot was .33 of a foot greater than that of the adjacent check plot (Plot 22). At the time the measurements were made the foliage on the check plots and on the plots receiving acid phosphate and muriate of potash had turned yellow and many leaves had dropped, while the leaves on those which had received nitrogen were still dark green. The data set forth in Table XXIX therefore indicate that there was, in general, a tree response proportionate to the rate of nitrogen application during the previous year.

This was also observed in the season of 1922, two years after the last nitrogen application was made.

Effect of Fertilizers on Winter Killing in the Elberta Experiment

A study was made in 1918 on the effect of fertilizers on the winter killing of fruit buds. The results are shown in Table XXX. The plots which received nitrate of soda had from 10 to 45 percent more injury to the fruit buds than did the check plots. The mortality of the fruit buds was greatest where the applications of nitrate of soda were heaviest or when made late in the season.

TABLE XXX.—Effect of Fertilizer on Winter Killing of Fruit Buds, Winter 1917-18.

Plot No.	Treatment	Percent Fruit Buds Set, 1918	Percent of Live Buds	Percent of Buds Killed
13	Check	57	54	46
14	2 Lbs. N P K	54	44	56
15	4 Lbs. N P K	48	44	56
16	6 Lbs. N P K	43	31	69
20	4 Lbs. N on 6-15	46	23	77
21	P K	71	50	50
22	Check	64	46	55
23	4 Lbs. N on 3-25	41	33	67
24	4 Lbs. on 7-15	61	11	89

The time of the application of nitrogen also had an important bearing on the amount of injury. Plot 23 which received 4 pounds of nitrate of soda on March 15 had 67 percent of the flower buds killed, Plot 20 which received 4 pounds on June 15 had 77 percent killed, and Plot 24 which received 4 pounds on July 15 had 89 percent of the flower buds killed.

In the spring of 1922, following a winter of practically no injury to peach fruit buds, observations were made to determine the number of fruit buds that had died or been killed during the winter. Ten shoots per tree were taken at random for all the trees in each of the nine plots and the average of the records are given in Table XXXI.

TABLE XXXI.—Effects of Fertilizer on Winter Killing of Fruit Buds, Winter 1921-22.

Plot No.	Treatment	Average Length of Shoots in Inches	No. Buds Set Per Node	No. of Dead Buds Per Node	No. of Nodes Per Shoot	No. of Buds Per Shoot	Percent of Buds Killed
8	6 Lbs. N	7.18	.754	.166	13.86	2.30	22.02
13	Check	4.96	.759	.113	11.12	1.26	14.89
14	2 Lbs. N P K	6.90	.900	.220	13.27	2.92	24.45
15	4 Lbs. N P K	8.12	.930	.179	14.07	2.52	19.24
16	6 Lbs. N P K	13.21	1.122	.280	20.48	5.74	24.96
20	4 Lbs. N 6-15	6.43	.775	.180	12.27	2.21	23.22
21	P K	6.23	.851	.153	12.66	1.94	17.97
22	Check	6.00	.763	.151	11.63	1.75	19.79
23	4 Lbs. N 3-25	6.57	.712	.136	14.01	1.90	19.10

From this table it will be seen that applications of nitrate of soda increased the length of the shoots and the length of the internodes, with one exception, Plot 23. In half the cases where nitrate of soda was applied the set of fruit buds was increased, while in the other plots no increase was evident. All the plots receiving nitrate of soda were found to have more dead buds per node than had the non-nitrated plots, with one exception, Plot 23 which received the application early, and as previously pointed out, some of the nitrate may have leached from the soil before active root absorption took place, thus accounting for this irregularity. Notwithstanding the poorer set of fruit buds on some of the nitrated trees and the much greater injury to all of the nitrogen-fed trees, those receiving nitrate of soda still produced more flowers per shoot than did the non-nitrated trees.

Records of a similar kind in other investigations show that treatments which induce a tree to grow late in the summer or early in the fall also make the fruit buds more susceptible to injury.

Roberts in Wisconsin (8) working with the sour cherry showed that the fruit buds which were the most advanced in development were most easily killed. His results were based upon microscopic studies of these buds as well as upon field observations. Late maturity of the trees was not considered a factor in the bud killing, because with the cherry the trees growing the latest were the least injured.

In contrast to this the studies of Farr (2) with the peach showed that the "young, vigorous shoots almost without exception were found to bear buds in a considerably later stage of development than did the short, stubby spurs .....If the cessation of dormancy is a criterion of the susceptibility to winter injury by severe weather it would seem that the buds on the short, stubby spurs would be the more resistant and those on the young, vigorous shoots would be the more susceptible." The findings of Farr are in accord with studies made in this connection which showed that under West Virginia conditions the fruit buds borne on the short, stubby growths were much hardier that the buds found on the longer, more vigorous shoots. The precaution should be taken, therefore, in this state not to adopt cultural methods or to make fertilizer applications which would induce the trees to grow too late in the season.

Effect of Fertilizers on Color of Peaches

In each of the three experiments reported here the fruit produced on trees receiving nitrogen was not so highly colored as that from the check plots or from the plots receiving acid phosphate or muriate of potash. This is an important result of the application of fertilizers from the grower's standpoint and the recommendations for counteracting it should be carefully considered. As has been pointed out the nitrogen-treated trees in general made more growth and the foliage was much heavier on these plots than on the others. This heavy dense foliage excluded a large amount of light, while on the check plots and the plots receiving acid phosphate and muriate of potash the foliage was less dense thus permitting a larger amount of sunlight to strike the fruit. The differences in color of fruit, therefore, in the different treatments seems to be due to the amount of sunlight that the fruit received rather than to the fertilizer treatments.

The most effective means of overcoming the shading of the fruit in the vigorous growing nitrogen-treated trees is by proper pruning. The entire tree should be kept thinned out by removing the small lateral branches here and there throughout the top. Trees heavily fertilized with nitrogen will require heavier pruning than unfertilized trees but the tops must be kept open so that small branches will develop on the larger limbs. If this is not done each year the branches in the center of the trees will die and the fruiting area of the tree will not only be reduced but it will rise higher with each season and in time very little fruit will be borne in the central part of the treé where it can be best supported.

RECOMMENDATIONS ON FERTILIZING PEACH TREES

Shall the Peach Grower Use Fertilizers?

The results of the West Virginia experiments show that the greatest yields are secured from trees fertilized with nitrogen or with stable manure. Experiments in Deleware (3), Ohio (10), Oregon (7), Virginia (6), and Missouri (11 and 13) also show that nitrogen is in most locations the limiting factor in peach production. On soils similar to the ones included in these experiments the peach grower cannot afford to produce peaches without the use of some quickly available form of nitrogen such as nitrate of soda.

Along with the use of nitrogen should go a system of cultivation which will conserve the soil moisture so that it may be available at the time the trees most need it. The use of cover crops sown at the proper time for each variety, in early summer or late fall, will help to maintain or to supply organic matter needed. Care should always be taken, in view of the relationship existing between growth and yield, not to have an excessive growth of any cover crop early in the season which will take up moisture at the time it is needed by the trees. The cover crop will be benefited by the liberal use of acid phosphate applied broadcast at the time of seeding the cover.

How Much Fertilizer Shall He Apply?

Bearing peach trees will respond profitably to comparatively large amounts of nitrogen. The experimental results indicate that on most soils in West Virginia the rate of application should be approximately as follows: Trees one to two years old 1-2 to 1 pound per tree; trees three to four years old, 2 pounds per tree; trees five to seven years of age, 4 pounds per tree; and trees eight years or older, 5 to 6 pounds. Nitrate of soda should be applied evenly in a circle under and beyond the drip of the branches, just before, at, or soon after bloom. If nitrogen is applied earlier than this some leaching from the soil may take place, or if much later, late growth with the consequent danger from winter injury may occur.

SUMMARY OF THE EXPERIMENTS

The West Virginia experimental work on the fertilization of peach orchards includes three experiments containing 952 trees of three varieties, Carman, Waddell and Elberta. Two of the experiments were started in the spring of 1911, and the other in the spring of 1915. The first two experiments were completed in 1918 and the last one in 1921. These experiments were located on two of the most common peach soils in West Virginia: the Upshur gravelly silt loam, and the DeKalb shale loam, both being known as poor soils and containing small amounts of nitrogen, phosphorus, and organic matter, but relatively large amounts of potassium.

The soil in each experiment was plowed or disked in the spring of each year. Frequent harrowings were made to maintain a dust mulch until late summer, when the cover crops were sown. Unfortunately the growth of the cover crops was, in many instances, not sufficient to increase the low organic matter content of the soil. The fertilizers were applied by hand in a circle under and beyond the limits of the branches. The date of application varied from the middle of May to the first of June.

The influence of the different treatments on the trees was determined by measuring the terminal twig growth, the trunk circumference, the set of fruit buds, the total yield, and the size and the time of maturity of the fruit.

A cover crop of soybeans or crimson clover, although the growth was slight during some seasons, increased the growth of Elberta as much as did four pounds of nitrate of soda. Two of the plots with cover crops, however, yielded less than the checks while the third yielded only slightly more. It is possible that the light yield was due to the moisture taken up by the soybeans and crimson clover at the time the fruit was maturing.

The limed plot on the Sleepy Creek experiment gave some indication of increased growth and yield, but in the Elberta experiment negative results were obtained. The growth of cover crops, however, on the limed areas was approximately twice as great as on the unlimed plots.

The use of muriate of potash and acid phosphate is not recommended for peaches. Where these two fertilizers were applied together there was no increase in growth or yield. Acid phosphate may be used with good results on cover crops.

Nitrogen was the only fertilizer that has increased the vegetative growth and yield of fruit sufficiently to be of any economic importance. Acid phosphate and muriate of potash applied singly, or in combination with nitrogen, did not increase the growth or yield over that of nitrogen alone. Application of nitrogen in the form of nitrate of soda or in stable manure delayed the maturity of fruit from two to ten days or more depending on the season and the amounts applied.

Fertilizers had no marked effect in increasing the size of the peaches. Plots on which the yield was small produced the highest percentage of culls and also the highest percentage of extra fancy peaches. Nitrate of soda and manure increased the yield by increasing the number of peaches produced because of a large bearing area, but the percent of fancy or extra fancy fruit was not increased.

None of the fertilizers had a marked effect on the percent of fruit buds formed. The increased yield from nitrogen was due primarily to the larger bearing area as a result of greater growth, and possibly to a better set and smaller drop. An early application of nitrate of soda did not increase the growth or yield over applications made about the time of bloom. Some seasons late applications of nitrogen produced a late growth which was followed by heavier mortality of the fruit buds during winter. Nitrated trees produced larger leaves and denser foliage than the non-nitrated trees but the fruit was poorer in color when compared with the non-nitrated, largely as a result of shading. Color can be increased on nitrated trees by adopting a system of pruning which will keep the top thinned out.

One hundred and fifty pounds of stable manure per tree had the same effect on growth and yield as 4 to 6 pounds of nitrate of soda. The addition of phosphorus to manure was not of any direct value to the trees, but it increased the growth of the cover crops and also of the weeds. Six pounds of nitrate of soda each for mature bearing trees was not excessive. When the trees were young very long growths and heavy foliage were produced which necessitated heavy pruning to keep the trees open and within bounds. The results from these experiments indicate that the rate of application of nitrate of soda should be approximately as follows: trees one and two years old, 1-2 to 1 pound per tree; trees three to four years old, 2 pounds per tree; trees five to seven years old, 4 pounds per tree; and trees eight years or over, 5 to 6 pounds. The residual effect of nitrate of soda was shown on trees fertilized in the spring of 1920 which made a terminal growth the following season in direct proportion to the amount of nitrate of soda applied. Those engaged in growing peaches on the Upshur gravelly silt loam or the DeKalb shale loam soils should use some quickly soluble and available form of nitrogen such as nitrate of soda.

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