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A TEST OF COMMERCIAL FERTILIZERS FOR GRAPES.

U. P. HEDRICK AND F. E. GLADWIN.

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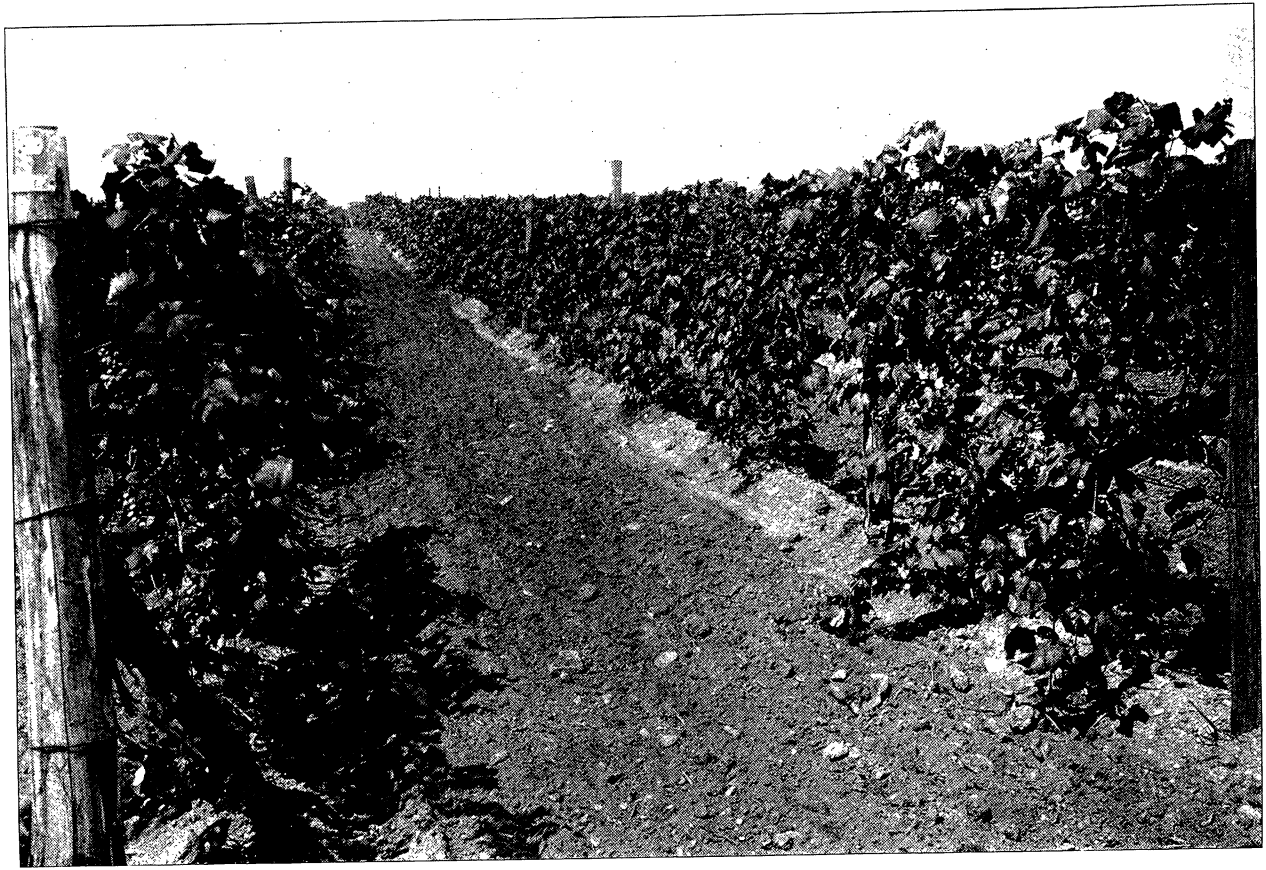

View in Experimental Vineyard at Fredonia.

BULLETIN No. 381.

A TEST OF COMMERCIAL FERTILIZERS FOR GRAPES.

U. P. HEDRICK AND F. E. GLADWIN.

SUMMARY.

1. There has been a decline in yields of grapes in the Chautauqua Grape Belt, the chief grape-growing region of New York. This bulletin is a report of several experiments to determine the value of commercial fertilizers in increasing or restoring former yields.

2. The experiments under discussion were carried on in a leased vineyard near Fredonia, New York, and in six vineyards in various parts of Chautauqua County in which cooperative work was carried on with the owners. The vineyards were selected to obtain fair averages of soils and of health and vigor of the grape plantations of this region.

3. The treatments consisted of annual applications of nitrogen at the rate of from 56 to 72 pounds per acre; phosphorus from 18.3 pounds to 25.3 pounds per acre; potassium from 52.7 pounds to 59.3 pounds per acre; and lime at the rate of 2000 pounds per acre. The nitrogen was applied in nitrate of soda, dried blood and cotton-seed meal, the phosphorus in acid phosphate and the potassium in sulphate of potash.

4. The results of the experiments are gauged by yield of fruit, effects on the fruit, effects on the foliage and effects on the wood. A brief summary of the results in the Fredonia vineyard is:

Nitrogenous fertilizers had a marked beneficial effect upon the yield and quality of fruit and upon leaf and wood growth, making it certain that nitrogen is the limiting factor in this vineyard.

Lime had no appreciable effect in this vineyard and phosphorus and potassium had so small a beneficial effect that their use was not profitable.

5. In the cooperative experiments not only commercial fertilizers but stable manure and green manure crops were used. The results from the use of all are confusing and unsatisfactory, varying greatly in any one vineyard or in the several vineyards compared with one another.

6. From the data obtained in these experiments it is evident that the fertilization of vineyards is so involved with other factors that only long continued work will give reliable results. From the work done, however, several suggestions may be made to grape-growers:

First, fertilizers can not be profitably applied in vineyards poorly drained, suffering from winter freezes or spring frosts, or in which fungi or insects are uncontrolled, or where good care is lacking.

Second, it is probable that most vineyards have a one-sided wear, there being few plantations indeed where more than one or two of the elements of fertility are lacking. Nitrogen is probably most frequently the element needed. Each grape-grower should try to discover which of the food elements his particular soil needs, if any.

Third, maximum profits cannot be obtained in many vineyards of the Chautauqua Belt because of the lack of uniformity in vineyard conditions. Grape-growers should strive by every means possible to secure an equally vigorous and healthy growth over the entire area cropped.

Fourth, the steps to be taken in restoring a failing vineyard are, in the usual order of importance, 1st, give good drainage; 2d, control insects and fungi; 3d, improve the tillage and general care; 4th, apply such fertilizers as may be found lacking.

INTRODUCTION.

THE CHAUTAUQUA GRAPE BELT.

The Chautauqua Grape Belt, the largest and most important area in which native grapes are grown in America, consists of a narrow strip of land along the southern shore of Lake Erie, varying in width from two to five miles, extending from Derby, New York, on the east, to Erie, Pennsylvania, on the west, approximately sixty-five miles. The grape industry in this belt is about thirty-five years old. Starting with small and scattered vineyards a steady increase in acreage has followed until now nearly 40,000 acres are planted to grapes. The U. S. Census Bureau reports 12,930,000 grape vines in Chautauqua and Erie counties in 1899 and 16,924,000 in 1909, a thirty-per-ct. increase.

A DECLINE IN YIELDS.

As the industry grew there should have followed a proportionate increase in tonnage. In other words, if 30,000 acres yielded 96,000 tons in 1900, 40,000 acres should have yielded 128,000 tons or thereabouts in 1913. But with the increased acreage there has followed only a slight gain in tonnage. Table I, from data collected and compiled in the office of "The Grape Belt,"[1] shows the total production in car loads shipped or used locally for the period from 1900 to 1913 inclusive.

TABLE I.—GRAPE PRODUCTION IN CHAUTAUQUA BELT, 1900–1913.

1900 (estimated)	8000 cars	1907	5186 cars
1901	6669 cars	1908	4323 cars
1902	5062 cars	1909	7561 cars
1903	2952 cars	1910 (estimated)	5700 cars
1904	7479 cars	1911	8100 cars
1905	5362 cars	1912	7528 cars
1906	5364 cars	1913	3957 cars
	40888 cars		42355 cars

A study of Table I discloses the fact that notwithstanding a greatly increased acreage, during the period beginning with 1900, the yields have been considerably less in many years and in only one, 1911, has it been larger. The total yield for the last half of the period is thus only 3½ per ct. greater than that of the first half.

WHY HAVE YIELDS DECREASED?

Undoubtedly the chief reason for the failure of the yield to keep pace with the acreage has been the planting of vineyards on soils unfitted for the grape because of thinness, infertility and poor drainage. Vineyards planted under any of these conditions were doomed to failure from the beginning. But there are also many old and young vineyards on good soils that are not producing profitable annual crops, indicating that something beside the soil is amiss. On these good soils two or three fair crops are often harvested and yields then diminish. Many plantings that a few years ago promised well, today are but average vineyards, or must even be classed as poor.

[1] A semi-weekly paper published at Dunkirk, N. Y.

Further examination of Table I shows that yearly yields are exceedingly variable. A year of large yield is usually followed by short crops for two or three years; these in turn are succeeded by another yield considerably above the average. These variations are attributed to many causes, among which are severe winters, late spring frosts, summer drouths, cold, wet weather during the growing season, insect depredations and lack of fertility. Undoubtedly any of the causes ascribed could materially affect the yield but it is certain that decreasing yields in all vineyards are not due to the same causes. Furthermore, vineyards that are in a weakened condition because of some obscure trouble are less able to stand low temperatures, drouths, and insect invasions, some one of which are of almost annual occurrence. Again, some vineyards produce very fair annual crops even though subjected to several unfavorable conditions, while others, seemingly under the same influences, are unprofitable.

AN EFFORT TO STOP THE DECREASE.

This Bulletin presents part of the results of five years of work by this Station in an effort to find out how the decreasing yields can be checked. Experiments in the control of insect and fungus pests and with commercial fertilizers, stable manure, green manures and lime have been made. The present report is an account of the experiments with commercial fertilizers.

A VINEYARD SURVEY.

In order to obtain at first hand the experiences of vineyardists with commercial fertilizers and stable manures, the junior author made a farm-to-farm survey in 1909. Growers of grapes to the number of 482 were interviewed and in most instances their vineyards were examined. The following statements sum up the information obtained pertinent to the subject under discussion.

The use of commercial fertilizers has been and is an extremely irregular practice, irregular not only as to frequency of application, but also as to the carriers and the elements used. Of the 482 growers interviewed, only 46 had used commercial fertilizers in 1904, 49 in in 1905, 102 in 1906, 107 in 1907 and 178 in 1908; or in all 252 used commercial fertilizers one or more years during the five for which

data were collected. It will be seen also that there has been an increase in the number using fertilizers during the five-year period and it is very probable that the increase has been proportionately greater during the past four years. Of the 252 reporting as having used some form of commercial fertilizer only 89 applied a complete one. Seventy used kainit alone, 45 ammoniated bone, 28 tankage, 20 raw ground bone, 17 potash and acid phosphate, 10 bone and kainit and 10 bone and muriate of potash. Quickly available forms of nitrogen have been used in but few instances. The amounts applied, viewed in the light of our tests, have generally been much too small to be very useful. It was interesting to note that many believed they had obtained decided results from the use of commercial fertilizers, while others secured no favorable effects.

Usually immediate returns were expected and failure to get them resulted in a change of materials or a discontinuance of the use of fertilizers. Some growers seem to have gone on the theory that fertilization is a substitute for tillage. The data seemed to show, considered broadly, that growers who had used commercial fertilizers regularly, other conditions being the same, had secured less variable crops from year to year, than those who had made irregular and scant applications or none at all.

The survey disclosed similar irregularities in the use of stable manure but indicated that more confidence is placed in its use by vineyardists than in commercial fertilizers. But little stock is kept in this region, however, and not nearly enough manure is produced to enrich vineyards, while the cost of importing is almost prohibitive. The usual plan in manuring is to go over a portion of the vineyard one year, another the next, and so on until all has been fertilized. This practice often requires a long period to cover a vineyard. Usually two or three forkfuls are thrown around the base of the vine, to be spread by the plow or cultivator. These amounts are not sufficient nor the mode of application such that the vine can utilize the manure at maximum efficiency.

The vineyard survey made at the beginning of the work in Chautauqua county clearly showed two things: First, that lack of fertility is a contributing cause in the decline of vineyards. Second, that fertilizing practices were very diverse and the results uncertain.

STATION WORK IN GRAPE BELT.

IN THE EXPERIMENTAL VINEYARD.

In the spring of 1909 this Station leased the 30-acre farm of H. B. Benjamin, Fredonia, New York. The soil on the Benjamin farm is of three types: Dunkirk gravelly loam, Dunkirk silt loam and Dunkirk clay loam. The fertilizer experiment was located on the gravelly loam, described as follows:

The Dunkirk gravelly loam is a deep, open soil quite inclined to leaching. It is formed of alternating layers of varying degrees of fineness. In the Benjamin vineyard it extends to a depth of approximately 20 feet. This type of soil is generally preferred by vineyardists in the Chautauqua Belt, not by reason of superiority in its plant food content nor because grapes are grown better on it but rather because it is naturally well drained and more easily worked. It consequently commands a higher price per acre. In 1909 about one-third of the entire acreage of the Chautauqua District was located on Dunkirk gravel and Dunkirk gravelly loam. Since then, however, the plantings have been largely on other soil types as practically all land of this type had previously been planted to grapes or other fruits.

Chemical analyses of this type of soil, collected from the check plats of the experiment, are given in Table II.

TABLE II.— SUMMARIZED CHEMICAL ANALYSES OF DUNKIRK GRAVELLY LOAM SOIL ON UNFERTILIZED PLATS, BENJAMIN FARM, FREDONIA, N. Y.

Calculated to pounds per acre

Section.	Depth of sampling.	K_2O.	K.	P_2O_5	P.	CaO.	Ca.	MgO.	Mg.	N.
	Ins.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
4.....	0– 7	44,600	36,800	3,940	1,720	12,800	9,000	16,200	9,600	3,200
4.....	7–14	47,400	39,200	2,860	1,240	14,400	10,200	18,400	11,000	1,700
5.....	0– 7	41,400	34,200	2,640	1,140	13,600	9,600	15,800	9,600	2,520
5.....	7–14	45,400	37,600	2,380	1,040	13,000	9,200	15,800	9,600	1,480

THE FERTILIZER SECTION.

A section of approximately three acres was selected for the test of commercial fertilizers. This area is very uniform and has a gentle slope to the south. A slight depression extends across the

entire section from west to east. The plats extend at right angles to this depression so that the topography is uniform. The soil on the north side is possibly a little lighter than elsewhere in the section but the same extent of each plat overruns this variation. The rows, 46 in number, run north and south and contain 37 vines per row. A few scattering vines have died and not all are yet replaced. The vines in this section were approximately 18 years old when this experiment was begun in 1909. At this time it was a representative vineyard for this type of soil, except that the west portion, including about 20 rows, was in poor condition. Plats 1, 2 and 3 fell in this poorer part.

As far as could be learned no commercial fertilizer nor stable manure had been applied to the vineyard for at least 10 years before the beginning of this experiment. The tillage had been that ordinarily given; namely, spring plowing, horse-hoeing, hand-hoeing and cultivation with the spring-tooth and disc harrow. Spraying had been done intermittently.

This section was divided into 11 plats consisting of 3 rows each, with an "outside" row at each end of the section and a "buffer" or "discard" row between successive plats. The plats were numbered from 1 to 11 in order from west to east. The vines are 8 feet apart each way, making 680 to the acre. Each plat contains 111 vines, about one-sixth acre. In computing the results the producing vines only are counted. Outside of a few scattering vines of Clinton and Catawba the vines are all Concord.

TREATMENT OF PLATS.

Fertilizers were to be applied annually as follows:

Plats 1 and 7.

Nitrate of soda at the rate of 100 pounds per acre.
Cottonseed meal at the rate of 800 pounds per acre.
Acid phosphate at the rate of 300 pounds per acre.
Sulphate of potash at the rate of 200 pounds per acre.
Lime (air slaked) at the rate of 2000 pounds per acre.

Plats 2 and 8.

These plats had the same applications as 1 and 7 excepting that no lime was used.

Plats 3 and 9.

Nitrate of soda at the rate of 100 pounds per acre.

Cottonseed meal at the rate of 800 pounds per acre.
Acid phosphate at the rate of 300 pounds per acre.

Plats 4 and 10.

Nitrate of soda at the rate of 100 pounds per acre.
Cottonseed meal at the rate of 800 pounds per acre.
Sulphate of potash at the rate of 200 pounds per acre.

Plats 5 and 11.

Sulphate of potash at the rate of 200 pounds per acre.
Acid phosphate at the rate of 300 pounds per acre.

Plat 6.

Unfertilized.

After the first year dried blood was substituted for the cottonseed meal owing to the difficulty in obtaining the meal. The amount of dried blood used in 1910 was at the rate of 560 pounds per acre; but in the last three years this was reduced to 400 pounds per acre. The difference was made necessary because of the variability of the nitrogen content of the blood in 1910 and the three years following.

The lime applications have been made at three-year intervals. Thus far two applications have been made, one of air-slaked lime and the other an equivalent amount of ground limestone.

The fertilizers were purchased in the open market at prevailing prices and were "home mixed." Table III gives the prices paid for the materials.

TABLE III.— PRICE PER TON OF COMMERICAL FERTILIZERS USED IN GRAPE FERTILIZER EXPERIMENTS.

Commercial fertilizers.	1909.	1910.	1911.	1912.	1913.
Nitrate of soda	$54.00	$49.25	$49.00	$50.00	$56.00
Dried blood	39.50	40.00	55.00	55.00	40.00
Cottonseed meal	24.75	.....	.....	.....	.....
Acid phosphate	13.00	13.00	13.00	13.00	11.00
Sulphate of potash	47.00	45.00	48.00	48.50	45.00

The lime was broadcasted and harrowed in after spring plowing. In 1909 the cottonseed meal and nitrate of soda were mixed with the other materials, broadcasted and plowed under; but in the

following years the dried blood and nitrate of soda were withheld from the mixtures and two applications of them made, one shortly after growth started and the second two or three weeks later. In both, the fertilizer was broadcasted and lightly harrowed in. The acid phosphate and sulphate of potash were applied early and plowed under.

Using these materials at the rates just given, in 1909 we applied 72 pounds of nitrogen, 25.3 pounds of phosphorus (58 pounds of phosphoric acid), and 59.3 pounds of potassium (108 pounds of potash) per acre. In 1910, 1911, 1912 and 1913 we applied 56 pounds of nitrogen, 18.3 pounds of phosphorus (42 pounds of phosphoric acid), and 52.7 pounds of potassium (96 pounds of potash).

COVER CROPS.

Table IV shows the cover crops that have been used in this experiment, the rates of seeding, the dates of seeding and the time they were turned under.

TABLE IV.— COVER CROPS USED IN GRAPE FERTILIZER EXPERIMENTS.

Year.	Crop.	Amount of seed per acre.	Date sown.	Date plowed under.
1909	Rye	1 bu	Aug. 4	April 19
1910	Barley and cowhorn turnips.	1 bu barley, 12 oz. turnip	July 28	April 26
1911	Cowhorn turnips	1½ lbs.	July 24	May 15
1912	Winter wheat	1 bu	July 31	April 29
1913	Cowhorn turnips	2 lbs.	July 28	.....

The time of sowing depended largely upon the amount of moisture in the soil. The cover crops were turned under at the time the soil was fit for working, though if the growth was not large the plowing was delayed a little. Ordinarily the three-gang plow was used in turning the crop under but if the work could not be thoroughly so done, a two-horse plow with a chain was employed.

CULTIVATION.

The first detail of cultivation each year was the turning under of cover crops. The plowing was up to the vines one year and the

next away from them. After plowing, a spring-tooth harrow was used, though if the cover crop were heavy the plow was followed by a disc harrow. In 1913 the wheat was disced before and after plowing with good results. Horse-hoeing followed harrowing and was done considerably earlier than is the usual practice. After horse-hoeing the section was thoroughly hand-hoed. From this time on until time for sowing the cover crop the vineyard was harrowed about every ten days, depending upon the frequency of heavy rains. The aim was to keep a dust mulch throughout the growing season. Just before the last cultivation, a ridge was thrown up to the vines by the horse-hoe with the blade reversed.

PRUNING AND TRAINING.

The Chautauqua System of training, common to the Chautauqua Belt, was used throughout this experiment. The method is described in Circular No. 16 from this Station. The same man has done the pruning during the five seasons. He was instructed to disregard differences in plat treatment and to prune solely according to the vigor of each vine. If a vine had made a good growth of well ripened wood, it was pruned to four canes; if but fair growth, it was pruned to two or three canes; but if the growth was poor all fruiting wood for the succeeding crop was cut away. In certain years, as every grape-grower knows, the wood is "short-jointed" and in others "long-jointed" or medium. In the years of "short-jointed" wood fewer canes per vine have been reserved for fruiting. If the internodes were long, the number of canes was increased. Pruning was done as soon as the leaves were off and the weight of the wood from each plat was taken as the work progressed.

SPRAYING.

The number of times the vineyard was sprayed was determined by the prevalence of insects and fungi. All plats were sprayed alike. The principal insects combated were the grape root-worm and the grape leaf-hopper. Powdery mildew was the only fungus requiring treatment. Bordeaux mixture and arsenate of lead were the materials used for the root-worm and the powdery mildew, while "Black Leaf" tobacco extract was used for the grape leaf-hopper.

WEATHER CONDITIONS DURING THE FIVE YEARS.

Table I shows that the 1911 crop was the largest since 1900, with the 1909 crop but slightly less. A part of the increase can be accounted for through increased acreages, but the average tonnage per acre in the old vineyards was generally considerably greater than that for several years previous. Vineyardists were of the opinion, after the large crop of 1909, that the era of low yields and poor wood growth was past. However, when pruning time came, it was seen that while wood growth was ample, it was not, as a rule, well ripened. That this was the case was further shown at the time growth started in the spring of 1910 when it was found that approximately 50 per ct. of the buds that were to bear the crop of that year were dead. The opinion prevailed that late spring frosts had killed them. In the opinion of the authors, however, the injury came indirectly from the heavy crop of 1909, which delayed bud maturity, making the buds tender, and as a result they were killed by cold. In this connection the weather conditions of the winter of 1909–10 are worth noting.

The latter half of December, 1909, was an unbroken period of cold weather, with a minimum temperature of 5 degrees below on December 29th. Once during the month of January, 1910, the temperature dropped to 2 degrees and again to 10 degrees below in February. The last freezing temperature of 1910 was on May 12 and while the buds had started slightly, they were uninjured in a young vineyard nearby that had borne but a small crop in 1909 and in which the wood and buds were well ripened. Whether bud injury was due to severe temperatures or late spring frosts is immaterial but it should be emphasized that well ripened wood and buds were able to withstand both conditions.

The fall and winter temperatures following the large crop of 1911 were characterized by frequent and decided changes. January, 1912, was the coldest on record, —15 degrees and —19 degrees being recorded. The cold weather continued until the middle of February and after that another severe cold period occurred in March. The soil froze to unusual depths. The grape crop in 1912 in the old vineyards fell considerably below that of 1911. The wood growth for the season was very scanty and examination disclosed many injured buds. The crop of 1913 was the lightest since 1903.

Thus, winter temperatures, coupled with immature wood and buds, have influenced the yields to a large degree in two of the five years that this experiment has been running.

GAUGING RESULTS.

During the first two years, 1909 and 1910, records were made of the fruit yields from the different plats and of the vigor of the vines as indicated by the wood growth and the amount and color of the foliage. For the past three years, weight of pruned wood, leaf weight (green and dry), amount of bearing wood, size of fruit clusters, size of berries, compactness of bunch, and time of maturity of fruit were also recorded for each plat.

YIELD OF FRUIT.

In Table V are given the amounts of fruit borne the past five years, beginning in 1909. Records of individual vines were not kept. The total production of each plat was recorded and from these the average yield per vine was obtained. The yields per acre are computed in tons and are net. The table shows that in 1909 the unfertilized check yielded less than any plat in the experiment, ranging from three-hundredths of a ton less in one instance to one and seventy-nine-hundredths tons less in another. On either side of the check plat the yields, with one exception, are considerably greater than in it. The exception is in the plat to which no nitrogen was applied. Differences in wood growth or in the color of the foliage in any of the plats were not discernible in 1909.

TABLE V.— YIELD OF GRAPES (TONS PER ACRE) IN FERTILIZER EXPERIMENTS.

Plat No.		1909.	1910.	1911.	1912.	1913.	5-yr. av.
		Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
1	Complete fertilizer; lime....	4.48	2.10	5.37	3.46	2.14	3.51
2	Complete fertilizer.....	4.76	2.21	5.71	4.30	2.83	3.96
3	Nitrogen and phosphorus...	5.17	2.14	5.61	4.00	2.25	3.83
4	Nitrogen and potash.....	4.25	2.55	5.64	4.10	2.85	3.87
5	Phosphorus and potash....	3.41	2.00	5.44	4.35	1.78	3.39
6	Check.....	3.38	2.10	5.32	3.60	1.24	3.12
7	Complete fertilizer; lime....	4.69	2.38	5.62	4.80	3.04	4.10
8	Complete fertilizer.....	4.66	2.07	5.71	4.98	2.72	4.02
9	Nitrogen and phosphorus...	4.99	2.04	5.35	4.89	2.61	3.97
10	Nitrogen and potash.....	4.79	2.26	5.91	4.89	3.07	4.18
11	Phosphorus and potash....	4.99	1.87	5.03	4.21	1.97	3.61

During the winter of 1909–1910 approximately 50 per ct. of the buds, as we have seen, were killed. Counts made of injured buds in the different plats showed that the damage was uniform throughout the vineyard and that the fertilizers had not affected hardiness of bud. This condition was reflected, as Table V shows, in the uniformity of yields in the several plats in 1910. Not only were the yields about equal over the entire section for the year 1910 but the small crop, by not taxing the vines, probably served also to equalize the 1911 crop which was as uniformly high as the crop of 1910 was low. Thus the season of 1910 may be considered a rest period. Differences in yield between the check and fertilized plats in both 1910 and 1911 were so slight that they are within the range of accidental variation.

The yield records for 1912, however, show marked differences in the several plats. From them it will be seen that only one fertilized plat, No. 1, to which was applied complete fertilizer and lime, fell below the check. The vines on the part of the section that includes this plat, with the adjacent plats, it will be remembered, were lacking in vigor at the beginning of the experiment. It is probable that their poor condition is reflected in the yields of 1912.

The differences in yield this year between the check and the fertilized plats range from four-tenths of a ton to one and thirty-eight-hundredths tons per acre. The yields over the entire section were above the average for that of the five years.

In 1913, the check plat is, without exception, the lowest producer. The differences between it and the fertilized plats range from fifty-four-hundredths of a ton in the case of Plat 5, phosphorus and potassium, to one and eighty-three-hundredths tons with Plat 10, nitrogen and potash. In this year both of the phosphorus and potassium plats, which up to 1913 produced crops comparable with any of the others, gave lower yields than any other fertilized plats. This seems to indicate that the lack of nitrogen in these plats is beginning to be felt.

The five-year averages for the plats indicate that all have produced more than ordinary crops for the period and while the showing for the check is good, the fact that it dropped behind in 1912 and 1913 probably means that the fertilizers are beginning to tell in the fertilized plats. We shall see that the fertilized vines show improvement as well.

EFFECTS ON THE FRUIT.

No differences were to be detected in the fruit from the various plats in 1909, 1910 and 1911. The grapes in all respects compared very favorably with those in the average well-cared-for vineyard on the same soil type — no better, no worse. Nor were any differences noted in time of maturing. In 1912, however, it began to appear that the fruit from the plats on which nitrogen had been used was superior in compactness of cluster, size of cluster and size of berry. The crop also matured earlier than in the check plats. The grapes in the phosphorus and potassium plats, while superior to those in the checks in these respects, were not equal in quality of fruit to those from the plats which had had nitrogen. The clusters from the check were poorly filled out and both clusters and berries were small. In 1913 these differences, with the exception of earlier maturity, were even more marked. The favorable ripening season and the smaller crop probably tended to equalize the time of maturity between the fertilized and the unfertilized plats. In 1912 ripeness was an important consideration and no doubt the fertilizers played an important part in hastening maturity.

EFFECTS ON THE VINES: THE FOLIAGE

In the growing seasons of 1909, 1910 and 1911 there were no indications of differences in the amount or color of the foliage on the vines on the different plats. In 1912, though, the plats fertilized with nitrogen showed more abundant foliage, which was of better color than that on the other plats, the check showing the poorest foliage of all. During 1913 these differences became more apparent; even the casual observer could easily note them. The check was so inferior to any other plat that one not knowing the experiment would have suspected the presence of disease as the cause of the poor condition. The nitrogen plats were distinctly superior to the phosphorus and potassium plats in amount and color of foliage — more so than in 1912. The years 1912 and 1913, in which these differences in leaf characteristics were first observable, it is remembered, are the years in which marked differences were prominent in fruit characteristics.

TABLE VI.— COMPARATIVE WEIGHTS OF GRAPE LEAVES IN FERTILIZER EXPERIMENTS.

Plat No.	Treatment.	1911.		1912.		1913	
		Green.	Dry.	Green.	Dry.	Green.	Dry.
		Grams.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
1	Complete fertilizer; lime....	1,551	660	735	285	995	421.6
2	Complete fertilizer.....	1,515	642	745	275	1,010	416.4
3	Nitrogen and phosphorus...	1,632	699	690	265	970	416.0
4	Nitrogen and potassium....	1,677	723	720	265	1,065	413.1
5	Phosphorus and potassium.	1,509	636	640	245	960	410.4
6	Check.....	1,359	585	565	245	865	396.0
7	Complete fertilizer; lime....	.....	.....	760	280	1,135	446.1
8	Complete fertilizer.....	.....	.....	765	280	1,115	432.7
9	Nitrogen and phosphorus...	.....	.....	800	320	1,145	463.1
10	Nitrogen and potassium....	.....	.....	835	305	1,050	421.2
11	Phosphorus and potassium..	.....	.....	720	280	990	402.6

Note.— 300 leaves are considered in each determination, 5 being taken from each of 60 vines. The first leaf beyond the last cluster is taken.

It seems reasonable to suppose that differences in foliage existed before they were discernible to the eye and an examination of Table VI indicates that such was the case. This table gives leaf weights, green and dry, of 300 leaves from each plat. These were taken from 60 vines. The first leaf beyond the last cluster was selected from each of five canes, which were located at about the same level for all vines. Owing to other demands at the time only one-half of the plats were calculated in 1911 but the records are complete for 1912 and 1913. Shortly after the leaves were gathered they were weighed. They were then air-dried and reweighed. From this data, it would appear that nitrogen is increasing the size of the leaf.

ANNUAL WOOD GROWTH.

There were no indications either, in 1909, 1910 or 1911, that fertilizers were producing any increases, apparent to the eye at least, in wood growth. In the fall of 1911, as fast as the plats were pruned, the wood was stripped from the wires, taken to the end of the rows and weighed. The weights included the weights of the canes put up for the year previous in each instance. Owing to unfavorable weather but six plats were weighed at this time.

The remaining five were weighed early in the spring of 1912. These are starred in Table VII which gives the results. It is quite probable that the wood from those that were not weighed lost weight during the interim between pruning and weighing, as the weights taken for the years 1912 and 1913 do not show the differences in weight between the halves of the section shown in 1911. Table VII should be studied with Table VIII which gives the average number of canes per acre put up on each plat for 1911, 1912, 1913 and 1914.

TABLE VII.— COMPARATIVE WEIGHTS OF PRUNED WOOD PER ACRE FROM GRAPE VINES IN FERTILIZER EXPERIMENTS.

Plat No.	Treatment	1911.	1912.	1913.	3-year average.
		Lbs.	*Lbs.*	*Lbs.*	*Lbs.*
1	Complete fertilizer; lime	*1,244	1,020	1,088	1,117
2	Complete fertilizer	*1,387	1,196	1,292	1,291
3	Nitrogen and phosphorus	*1,360	1,156	1,088	1,201
4	Nitrogen and potassium	*1,360	1,258	1,360	1,326
5	Phosphorus and potassium	*1,224	1,033	816	1,024
6	Check	1,305	707	734	915
7	Complete fertilizer; lime	1,734	1,162	1,496	1,464
8	Complete fertilizer	1,747	1,183	1,400	1,443
9	Nitrogen and phosphorus	1,679	1,162	1,190	1,343
10	Nitrogen and potassium	1,720	1,203	1,407	1,476
11	Phosphorus and potassium	1,489	1,003	952	1,149

* Weights taken in spring of 1912. All others in the fall of their respective years.

TABLE VIII.— TOTAL NUMBER OF FRUITING CANES PER ACRE LEFT ON GRAPE VINES IN FERTILIZER EXPERIMENT PLATS.

Plat No.	Treatment.	1912.	1913.	1914.	3-year average.
1	Complete fertilizer; lime	2,815.2	1,985.6	2,332.4	2,377.7
2	Complete fertilizer	3,033.6	2,373.2	2,366.4	2,591.0
3	Nitrogen and phosphorus	3,094.0	2,373.2	2,142.0	2,536.4
4	Nitrogen and potassium	3,039.6	2,407.2	2,454.8	2,633.8
5	Phosphorus and potassium	3,019.2	2,121.6	2,033.2	2,391.3
6	Check	2,856.0	2,087.6	1,387.2	2,110.2
7	Complete fertilizer; lime	2,856.0	2,400.4	2,386.8	2,547.7
8	Complete fertilizer	3,066.8	2,407.2	2,407.2	2,627.0
9	Nitrogen and phosphorus	3,289.6	2,366.4	2,244.0	2,633.3
10	Nitrogen and potassium	3,107.6	2,434.4	2,434.4	2,658.8
11	Phosphorus and potassium	2,862.8	1,897.2	2,019.9	2,259.9

The amounts of wood pruned further emphasize the fact, stated before, that the west part of the vineyard, in which are located plats 1, 2 and 3, is somewhat weaker than the remainder of the section. Coming to the several plats we find that those on which the complete fertilizer and lime were used have pruned 375 pounds more wood per acre, during the three-year period, 1911, 1912 and 1913, than the check, while 352 more canes per acre were put up than in the check. From the complete fertilizer plats were pruned 452 pounds more wood per acre than in the check, yet 499 more canes were left. From the nitrogen and phosphorus plats were pruned 357 pounds more wood and 474 more canes were left. From the nitrogen and potassium plats were pruned 486 pounds more than the check and 535 canes more were put up, while from the phosphorus and potassium plats were pruned 121 pounds more wood per acre and 121 canes more than in the check were put up.

These data seem to signify that the fertilized plats are producing a larger annual wood growth than the unfertilized check, as well as bearing more fruit. Table IX gives the averages for 1911, 1912 and 1913 of the amounts of wood pruned per acre from each plat and the number of canes per acre put up during 1912, 1913 and 1914.

TABLE IX.— COMPARATIVE WOOD GROWTH OF GRAPE VINES IN FERTILIZER EXPERIMENTS.

Plat No.	Treatment.	Average amount of wood pruned per acre, 1911, 1912 and 1913.	Average number of canes put up per acre, 1912, 1913 and 1914.
		Lbs.	
1	Complete fertilizer; lime	1,117	2,377.7
2	Complete fertilizer	1,291	2,591.0
3	Nitrogen and phosphorus	1,201	2,536.4
4	Nitrogen and potassium	1,326	2,633.8
5	Phosphorus and potassium	1,024	2,391.3
6	Check	915	2,110.2
7	Complete fertilizer; lime	1,464	2,547.7
8	Complete fertilizer	1,443	2,627.0
9	Nitrogen and phosphorus	1,343	2,633.3
10	Nitrogen and potassium	1,476	2,658.8
11	Phosphorus and potassium	1,149	2,259.9

TABLE X.— FINANCIAL GAIN OR LOSS PER ACRE FROM USE OF FERTILIZERS ON GRAPES.

	Plat No.	1909.	1910.	1911.	1912.	1913.	Total.
Complete fertilizer; lime.	1	+$8 92	—$18 91	—$18 08	—$27 21	+$26 05	—$29 23
	7	+14 70	—6 17	—11 88	+19 69	+71 05	+87 39
Complete fertilizer.	2	+18 63	—11 91	—7 75	+4 17	+62 55	+65 69
	8	+15 88	—18 27	—9 98	+27 99	+57 05	+72 67
Nitrogen and phosphorus.	3	+34 65	—10 59	—5 99	—1 41	+38 05	+54 71
	9	+29 70	—15 14	—14 49	+29 70	+56 05	+85 82
Nitrogen and potassium.	4	+6 55	+5 51	—7 93	—0 86	+65 20	+68 47
	10	+21 40	—7 68	+0 27	+26 79	+76 20	+116 98
Phosphorus and potassium.	5	—7 52	—11 00	—2 50	+19 44	+20 85	+19 29
	11	+37 57	—16 91	—14 95	+14 54	+30 35	+50 60

Table X gives the net gain or loss in dollars and cents per acre for each fertilized plat as compared with the money return from the unfertilized check plat. The cost of the fertilizers that were applied to each plat has varied from year to year, as has the price obtained for the fruit. The amount deducted for the materials each year was based on the market values for that year. The returns from the sale of the fruit represent actual sales made.

CO-OPERATIVE EXPERIMENTS.

In 1910, vineyards were selected in several parts of the Chautauqua Belt for co-operative commercial fertilizer, stable manure and green manure tests. The vineyards selected represent distinct variations in soil types and differences in altitude. The owners and locations of the vineyards are as follows:

S. S. Grandin, Westfield, 5 acres, Dunkirk gravelly loam grading into clay loam.

Hon. C. M. Hamilton, State Line, 2 acres, Dunkirk clay loam.

James Lee, Brocton, $2\frac{1}{4}$ acres, Dunkirk shale loam.

H. G. Miner, Dunkirk, $2\frac{1}{2}$ acres, Dunkirk clay loam.

Miss Frances Jennings, Silver Creek, $4\frac{2}{3}$ acres, Dunkirk shale loam to clay loam.

J. T. Barnes, Prospect Sta., 5 acres, Dunkirk shale loam.

In 1911, the Jennings vineyard had to be given up. This is to be regretted as owing to uniformity of soil and evenness of the

stand of vines it promised much. All were vineyards of Concords. The previous fertilization, with but one or two exceptions, was rather infrequent applications of stable manure in moderate amounts. In the exceptions some commercial fertilizers had been used.

CARE OF THE VINEYARDS.

The cultivation before and during the period of the experiments was that ordinarily practiced; namely, spring plowing, harrowing, grape-hoeing and more or less frequent harrowings or cultivations with the spring-tooth and disc harrows and diamond-tooth cultivator until about August 1 and then plowing back to the vines. Only in two vineyards has spraying been consistently done. The vineyards, with but two exceptions, were considered old. These two are the Jennings and the Hamilton plantations which were, respectively, 5 and 7 years set at the beginning of the experiments.

Each vineyard has been pruned and trained according to the Chautauqua System, the work being done usually by a man engaged particularly for the task and not by the owner. There are two exceptions to this practice in the six vineyards.

AMOUNTS AND METHODS OF APPLICATION OF FERTILIZERS.

The same carriers and amounts of nitrogen, phosphorus and potassium have been used in each case that were used and discussed under the Station experiment, namely nitrate of soda, dried blood, acid phosphate and sulphate of potash. The only difference in the methods of application was that the materials were all applied in a single treatment and were plowed under. The time of application was generally a little later than for those made at Fredonia. The same forms of lime and like amounts were used in these experiments as in the Station vineyards. The stable manure was applied in the spring at the rate of 5 tons per acre and plowed under. The rate and time of seeding the green crops was approximately the same as in the other experiments.

GAUGING THE RESULTS.

In measuring the relative values of the different treatments in the cooperative vineyards, only fruit yields have been used. The range of time over which vineyards are pruned and lack of facilities

for weighing wood made impossible the taking of data on wood production. So, too, the interval that would elapse between the gathering of leaves and weighing was so great that such data would be valueless. All yields have been figured on the acre basis and as the greater number of the vineyards were set 8 x 8 feet, or 680 vines per acre, all have been computed for this number of plants for sake of uniformity. Only the actual number of vines in a plat have been considered in computing the average per vine. Thus, if a row originally contained 66 vines but 24 were missing, 42 vines alone have produced the fruit for that plat and the average was made from the 42.

JENNINGS VINEYARD.

The Jennings vineyard is located on a level piece of Dunkirk shale loam varying to Dunkirk clay loam. The part on the shale loam is fairly well drained naturally while the portion on the clay loam is decidedly wet. There is no artificial underdrainage. The vineyard is a young and promising one for this type of soil. The rows, if no vines were missing, would contain 66 vines. The actual number varies from 42 to 66. Each plat consists of a single row separated from the others by discard rows. The plats are duplicated. The rows extend in a general north and south direction. The fruit from the discard rows was not weighed. This vineyard was sprayed once each year during 1910 and 1911 for the control of grape root-worm and powdery mildew.

Table XI gives the treatment of the plats and their relative order in the vineyard together with the yields in tons per acre for the years that the experiment ran, and the two-year average.

Careful study of the data does not show striking consistent differences between the treated plats nor between those treated and untreated. A comparison of Plats 2, 3, 4 and 5 would seem to indicate that there was a slight gain from the use of nitrogen, but in no case is it sufficient to pay for the fertilizer. Again comparing Plats 12, 13 and 14 it would seem that there has been some gain from the use of stable manure, but even here the increase is not enough to buy the manure and apply it.

TABLE XI.— YIELD OF GRAPES ON PLATS DIFFERENTLY FERTILIZED IN JENNINGS VINEYARD.

Calculated to tons per acre.

Plat No.	Treatment.	1910.	1911.	Average.
		Tons.	*Tons.*	*Tons.*
1	Complete fertilizer; lime	2.38	2.82	2.60
2	Complete fertilizer	2.72	3.87	3.29
3	Check	2.44	3.29	2.86
4	Nitrogen and phosphorus	2.51	3.67	3.09
5	Nitrogen and potassium	2.48	3.91	3.19
6	Phosphorus and potassium	1.76	3.63	2.69
7	Complete fertilizer; lime	1.80	3.12	2.46
8	Complete fertilizer	1.63	3.43	2.53
9	Nitrogen and phosphorus	1.97	3.40	2.68
10	Nitrogen and potassium	1.56	3.67	2.61
11	Phosphorus and potassium	2.38	2.92	2.65
12	Check	2.10	3.46	2.78
13	Stable manure	2.38	3.77	3.07
14	Stable manure; lime	2.44	4.35	3.39
15	Mammoth clover	2.38	3.26	2.82
16	Check	2.07	4.14	3.10
17	Mammoth clover; lime	2.21	3.60	2.90
18	Barley and cowhorn turnips	2.34	3.43	2.88
19	Barley and cowhorn turnips; lime	2.27	2.44	2.35
20	Stable manure	2.17	3.84	3.00
21	Stable manure; lime	3.23	3.36	3.29
22	Mammoth clover	2.00	3.36	2.68
23	Check	2.44	3.06	2.75
24	Mammoth clover; lime	1.42	2.72	2.07
25	Barley and cowhorn turnips	2.78	3.23	3.00
26	Barley and cowhorn turnips; lime	1.97	3.19	2.58

A study of the average yields from Plats 15, 16, 17 and 18 leads to the conclusion that no benefit thus far had occurred from the use of green manures. Comparing Plats 20, 21, 22, 23, and 24 we again note slight gains from the stable manures but still insufficient to pay for the applications, while the green manures show yields less than the check. Applications of lime with stable manure present consistent gains in each set of plats and sufficient to pay for the treatment, while the applications made on the green manure plats do not indicate any gain. The low production of 1910 and its contributory causes have been discussed earlier in this bulletin. The fact stands out with this vineyard as with the Station vineyard

that the yields for this year were very uniform over all the plats including the checks and that this tended to equalize the yields of 1911.

MINER VINEYARD.

The Miner vineyard is situated on a level piece of low-lying land of the Dunkirk clay type, which is as a rule much improved by underdrainage. The rows run in a general north and south direction and vary in length from 40 to 59 vines. Each plat consists of a single row separated from the others by discard rows. During the period over which this experiment has run, the vineyard has not been sprayed. Severe infestations of the grape root-worm and the grape leaf-hopper occurred in 1911 and 1912 respectively. Just how much these insects have lessened the yields cannot be determined, but judging from the appearance of the vines it was considerable. Table XII gives the order in which the plats occur in the vineyard, the annual yields per acre for each plat and the four-year average.

TABLE XII.— YIELD OF GRAPES ON PLATS DIFFERENTLY FERTILIZED IN MINER VINEYARD.

Calculated to tons per acre.

Plat No.	Treatment.	1910.	1911.	1912.	1913.	4-year average.
		Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*
1	Complete fertilizer; lime	0.81	3.63	2.23	0.91	1.89
2	Complete fertilizer	0.68	2.73	2.26	1.12	1.69
3	Check	0.74	2.65	2.89	0.98	1.81
4	Nitrogen and phosphorus	1.02	3.11	2.34	1.12	1.89
5	Nitrogen and potassium	1.15	3.63	2.44	1.02	2.06
6	Check	0.74	2.64	2.38	0.81	1.64
7	Phosphorus and potassium	0.85	2.84	2.34	0.95	1.74
8	Stable manure	0.68	2.98	2.82	1.56	2.01
9	Check	0.85	2.76	1.87	1.08	1.64
10	Stable manure; lime	0.78	2.97	2.51	1.63	1.97
11	Mammoth clover	0.78	2.69	2.41	1.12	1.75
12	Mammoth clover; lime	1.19	2.19	2.44	1.05	1.71
13	Check	1.02	2.34	2.00	0.74	1.52
14	Wheat and cowhorn turnips	0.81	2.30	1.80	0.64	1.38
15	Wheat and cowhorn turnips; lime	1.02	3.57	1.93	0.57	1.77

These data in no way indicate superiority of one treatment over another nor of that of any application over the checks. They only

serve to emphasize the influence of a previous crop upon succeeding ones, a point that has been mentioned before. This is shown by comparing the yields of 1911 with those of 1912 and 1913. The extreme high-yielding plats of that year fell off more proportionally in the years 1912 and 1913 than those that yielded moderately the previous year, while with two plats there was a gain in 1912.

LEE VINEYARD.

The Lee vineyard is a typical upland vineyard situated on the hillside south and east of Brocton. The soil is of the Dunkirk shale loam type and quite stony. The natural drainage is better than in many vineyards, owing in part to the slope, yet rock pockets keep parts of the land wet. However, lack of drainage is not so important here as in hundreds of other cases. The rows extend in a general east and west direction at right angles to the slope, varying in length from 40 to 52 vines. The plats consist of single rows separated by discards. The vineyard has had no serious insect infestations during the life of the experiment and consequently has not been sprayed. Table XIII represents the order of the plats in the experiment with their yields in tons per acre for each year and the four-year average.

TABLE XIII.— YIELD OF GRAPES ON PLATS DIFFERENTLY FERTILIZED IN LEE VINEYARD.
Calculated to tons per acre.

Plat No.	Treatment.	1910.	1911.	1912.	1913.	4-year average.
		Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*
1	Wheat and cowhorn turnips; lime	1.25	2.04	2.93	0.74	1.74
2	Check	1.25	2.09	2.48	0.63	1.61
3	Wheat and cowhorn turnips	1.05	2.00	2.25	0.85	1.53
4	Mammoth clover; lime	1.42	1.79	2.52	0.81	1.63
5	Mammoth clover	1.17	1.83	1.99	0.74	1.43
6	Stable manure; lime	1.36	2.14	3.40	0.98	1.97
7	Stable manure	1.56	2.17	2.84	1.08	1.91
8	Check	1.29	2.24	2.20	0.61	1.58
9	Phosphorus and potassium	1.39	2.09	2.43	0.68	1.64
10	Nitrogen and potassium	1.22	1.87	2.46	0.61	1.54
11	Nitrogen and phosphorus	1.46	2.19	2.57	0.68	1.72
12	Complete fertilizer	0.98	1.73	2.50	0.61	1.45
13	Complete fertilizer; lime	1.12	1.66	2.04	0.88	1.42

There appears from a consideration of the four-year average a slight gain from the use of stable manure but this is not great enough to pay for the manure applied. Plats 12 and 13 have always been inferior rows according to information furnished by the owner. Our subsequent observations and these data seem to confirm it.

BARNES VINEYARD.

The Barnes vineyard at Prospect Station is another upland vineyard situated on Dunkirk shale loam. It differs from the Lee vineyard in that it lies very level below a high ridge from which much seepage water gains access to it. It would be benefited by underdrainage. The rows extend in a general east and west direction and consist of 31 vines each. The plats comprise from four to six rows. Infestations of the grape root-worm shortly before the beginning of this experiment, coupled with the wetness of the soil, have tended to keep this vineyard at low production. Table XIV gives the yields in tons per acre for each plat for the four years and the average. The order in which the plats are placed is different from that in the foregoing vineyards for the reason that the experiment was planned originally for a renovation experiment by the use of fertilizers and spraying. This accounts for the checks being located in pairs.

Analyses of the returns indicate that previous to 1912 none of the treatments returned sufficiently increased yields over the checks to make the application profitable. The stable manure Plats 1, 2, 13 and 14 returned a profit over the checks in 1912 and 1913, while the stable manure Plats 7 and 8 did not. In 1912 the complete fertilizer applications in no instance returned a profit, nor did the phosphorus-potassium-lime-cover-crop plats. The complete fertilizer Plats 3 and 16 yielded enough above the checks in 1913 to pay small returns while Plat 9 failed to do so. Phosphorus-potassium-cover-crop and lime Plat 4 gave net gains over check. Plat 5 and Plat 10 likewise gave small returns over Plat 11 but did not over Plat 12, both checks. Plat 17 returned a net gain over one check plat, 15, but failed to give a sufficient increase to return a profit over the other check plat, 18. These variations can only be accounted for on the ground of non-uniform fertilization in previous years coupled with soil differences which have not become apparent.

TABLE XIV — YIELD OF GRAPES ON PLATS DIFFERENTLY FERTILIZED IN BARNES VINEYARD
Calculated to tons per acre.

Plat No.	Treatment.	1910.	1911.	1912.	1913.	4-year average.
		Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*
1	Stable manure	1.12	2.14	2.55	1.15	1.74
2	Stable manure; lime	1.12	2.38	2.72	1.08	1.82
3	Complete fertilizer	1.02	2.38	1.97	1.25	1.65
4	Phosphorus and potassium; lime	0.91	1.87	2.38	1.05	1.55
5	Check	1.29	1.93	1.80	0.81	1.45
6	Check	0.98	2.00	1.42	0.35	1.18
7	Stable manure	0.88	2.10	1.94	0.71	1.43
8	Stable manure; lime	1.19	2.17	1.90	0.70	1.49
9	Complete fertilizer	0.71	2.51	1.66	0.78	1.41
10	Phosphorus and potassium; lime	0.78	2.14	1.53	0.78	1.30
11	Check	1.08	2.17	1.59	0.47	1.32
12	Check	0.44	2.07	2.07	0.95	1.38
13	Stable manure	0.61	2.14	2.82	1.22	1.72
14	Stable manure; lime	0.74	2.14	2.75	1.63	1.81
15	Check	0.57	2.12	2.10	0.64	1.35
16	Complete fertilizer	0.74	2.38	2.78	1.25	1.78
17	Phosphorus and potassium; lime	1.05	2.17	2.65	1.22	1.77
18	Check	1.36	2.24	2.44	0.91	1.73

GRANDIN VINEYARD.

The Grandin vineyard at Westfield, located in part on Dunkirk gravelly loam and the remainder on Dunkirk clay loam, presents a well drained area succeeded by a wet one. While each plat extends on each type of soil, the plats are not equally situated over the two. Approximately two-thirds of the length of the rows is on the Dunkirk clay loam while but one-third is on the gravelly loam. On the west side of the vineyard a still greater proportion of the row is on clay loam. The length of the plats varies from 129 vines on the west side of the section to 99 vines on the east, equal in area to about one-fifth of an acre. The rows run in a north and south direction. Spraying in this vineyard has been consistent and thorough. Commercial fertilizers and stable manures had been used previous to the beginning of the experiment by the owner in an experimental way but no records of the behavior of the vines under different treatments were available. Each plat row is separated from the others by discard rows.

TABLE XV.— YIELD OF GRAPES ON PLATS DIFFERENTLY FERTILIZED IN GRANDIN VINEYARD.
Calculated to tons per acre.

Plat No.	Treatment.	1910.	1911.	1912.	1913.	4-year average.
		Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*
1	Phosphorus and potassium	2.44	−2.95	2.34	1.25	2.24
2	Nitrogen and potassium	2.27	2.82	2.18	1.03	2.07
3	Nitrogen and phosphorus	2.41	2.82	2.32	1.02	2.12
4	Check	2.41	2.65	2.23	1.02	2.07
5	Complete fertilizer	2.44	2.58	2.42	1.19	2.15
6	Complete fertilizer; lime	2.61	2.93	2.75	1.19	2.37
7	Wheat and cowhorn turnips; lime	2.10	2.48	2.66	1.22	2.11
8	Wheat and cowhorn turnips	2.75	2.75	3.06	0.98	2.38
9	Mammoth clover; lime	2.75	2.92	2.75	1.42	2.46
10	Check	−2.99	2.44	−2.92	0.85	2.30
11	Mammoth clover	1.15	2.44	−2.86	1.19	1.91
12	Stable manure; lime	2.34	2.78	−3.53	−1.83	2.62
13	Stable manure	2.07	2.44	−3.58	−1.63	2.43

Table XV gives the yields in tons per acre for each plat during the four years that the test has run, with the four-year average. A study of the table shows that for the years 1910 and 1911 none of the treatments have brought about yields greater than the unfertilized check. In 1912, however, the increased returns from the stable manure plats, 12 and 13, returned a profit over the check plat, 10. Further than this no consistent increase can be noted. No gains are apparent from the use of commercial fertilizers in 1913. There is evidently a gain from the use of clover as a green manure and again the use of stable manure has proved profitable. Lime used in conjunction with the clover and the stable manure has contributed profitably to greater yields. The apparent gain from its use in Plat 7 as compared with Plat 8 is offset when we compare the yields of the two in 1912 and note how the 1913 yield has been influenced by each. Plat 8 which produced .40 of a ton more than Plat 7 in 1912 yielded .34 of a ton less in 1913.

HAMILTON VINEYARD.

The Hamilton vineyard, located at State Line and consisting of two acres, is situated on Dunkirk clay loam. This vineyard is

wet. Much seepage water from the hills above rises to the surface over it. The west part is worse in this respect than the east portion. The vines, while they have been planted 7 or 8 years, have the appearance of vines set only 3 or 4. During an extremely dry season fair wood growth is made but in a wet one it is very limited, with a correspondingly short crop. This vineyard has not been sprayed during the time the experiment has run. The plats consist of two rows, each of which runs in a north and south direction. Each row contains 44 vines. Thus each plat comprises about .14 of an acre. The stable manure and lime, clover and lime and the barley-turnips and lime plats were limed a year previous to the beginning of the test. No commercial fertilizers nor stable manure had been applied for two or three years previous to 1910. Table XVI gives the order in which the plats occur in the vineyard with the yields in tons per acre for each year and the four-year average.

TABLE XVI.— YIELD OF GRAPES ON PLATS DIFFERENTLY FERTILIZED IN HAMILTON VINEYARD

Calculated to tons per acre.

Plat No.	Treatment.	1910.	1911.	1912.	1913.	4-year average.
		Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*
1	Check	1.19	2.07	2.09	1.02	1.59
2	Phosphorus and potassium	0.95	2.72	2.83	1.93	2.10
3	Nitrogen and potassium	0.78	3.60	2.15	0.98	1.87
4	Check	1.66	2.40	1.75	0.61	1.60
5	Nitrogen and phosphorus	0.88	2.27	2.01	0.71	1.46
6	Complete fertilizer	1.12	2.55	2.24	1.15	1.76
7	Complete fertilizer; lime	0.85	2.44	1.76	0.85	1.47
8	Stable manure	0.68	2.31	2.02	0.71	1.43
9	Wheat and cowhorn turnips	1.29	2.14	2.42	0.44	1.57
10	Mammoth clover	0.71	1.93	1.30	0.30	1.06
11	Check	0.81	2.07	1.55	0.51	1.23
12	Wheat and cowhorn turnips; lime	0.78	1.97	1.66	0.40	1.20
13	Mammoth clover; lime	0.85	2.39	1.43	0.37	1.26
14	Stable manure; lime	0.54	2.38	1.91	1.08	1.47

Consideration of the data discloses nothing that would indicate any material gain for the season of 1910. In 1911, however, two plats, one the nitrogen-potassium and the other the phosphorus-

potassium, returned crops that gave a net profit over the checks. This gain may be due to the larger yield of the check plats the year before rather than a direct effect of the fertilizers. That the phosphorus-potassium plat was at the beginning superior to the others is further shown by a reference to the yields of 1912 and 1913. The stable manure plat and the wheat and cowhorn turnip plat each yielded crops at a profit over the check in 1912. Again we must conclude, in case of the wheat-turnip plat at least, that the treatment was not the determining factor, but rather some unknown influence, as for example soil variation, previous fertilization or the pruning. In 1913, only the stable manure-lime plat yielded a net profit above the check plat, 11. The superiority of the phosphorus-potassium plat has already been explained. The four-year averages do not present any data that would warrant definite conclusions as to the superiority of any one treatment over another.

SUMMARY OF RESULTS.

In the experiments at Fredonia, nitrogenous fertilizers have had a marked effect upon wood growth and yield and quality of fruit. The first season, 1909, the fertilizers containing nitrogen apparently increased the crop of that year, although plat variations might account for the greater yield of the fertilized over the unfertilized vines.

Bud injury during the winter of 1909 and 1910 reduced the crop the second year 50 per ct. The fertilized and unfertilized plats were affected in like degree. The crop of 1910 was fairly uniform on all the plats. The general light crop, no doubt, tended to equalize the yields for the succeeding year, 1911.

No differences in the amount or the color of the foliage were apparent until the summer of 1912 in which season the foliage in the nitrogen-fertilized plats clearly showed superiority over that from the plats on which no nitrogen had been applied. The foliage from the phosphorus-potassium plats was somewhat superior to that from the check plat.

Nitrogen and potassium have in some degree increased the size of the leaves as shown in Table VI. They have also materially increased the amount of wood growth. Table VII, a comparison of the plats, indicates that nitrogen was the more important of the two elements in bringing about these increases in wood growth.

The plats receiving the nitrogenous application produced fruit in the years 1912 and 1913 somewhat superior, in size of cluster, size of berry and compactness, to that from the plats to which phosphorus and potassium had been applied and considerably superior to that from the check. The phosphorus-potassium plats yielded fruit better than the check in these respects and probably more mature at the time the observations were made. The nitrogen has probably indirectly affected fruit characters through its action in producing more vigorous wood and foliage.

It appears that nitrogen is the limiting factor in this vineyard. Appreciable results were not obtained, however, until after several applications of the fertilizer had been made.

Lime seems not to have influenced the vines in the least while phosphorus and potassium, as applied in the fertilizers used, have not greatly influenced the vines for the better — have not proved profitable fertilizers.

The data in the cooperative work with commercial fertilizers, stable manure and green manures are confusing and unsatisfactory. Unsatisfactory because of the great variability of the results from the treatments in any one vineyard or in the several vineyards compared with one another. Taken as a whole they do not corroborate the work in the Station vineyard at Fredonia.

SUGGESTIONS FROM THE RESULTS.

The results of the several tests of which this bulletin is an account throw comparatively little light on the value of fertilizers for grapes. It is evident that the fertilization of vineyards, as well as of orchards, fields and gardens, is so involved with other factors that only carefully planned and long continued work will give reliable results. Indeed, field experiments even in carefully selected vineyards, as the cooperative experiments show, may be so contradictory and misleading as to be worse than useless if deductions are made from the results of a few seasons. The work that has been done is not without value, however, for it has brought forth information about fertilizing vineyards that ought to be most helpful to grape-growers. Thus the results suggest:

First, and most important, that it is usually waste, pure and simple, to make applications of fertilizers in poorly-drained vineyards, in such as suffer frequently from winter cold or spring frosts,

where insect pests are epidemic and uncontrolled, or where good care is lacking. The experiments furnish several examples of inertness, ineffectiveness, or failure to produce profit where the fertilizers were applied under any of the conditions named.

Second, it is certain in some of the experiments and strongly indicated in others that the soil is having a one-sided wear — that only one or a very few of the elements of fertility are lacking. The element most frequently lacking is nitrogen. The grape-grower should try to discover which of the fertilizing elements his soil lacks and not waste by using elements not needed.

Third, the marked unevenness of the soil in all of the seven vineyards in which these experiments were carried on, as indicated by the crops and the effects of the fertilizers, furnishes food for thought to grape-growers. Maximum profits cannot be approached in vineyards in which the soil is as uneven as in these, which were in every case selected because there was an appearance of uniformity. A problem before the grape-growers of Chautauqua County is to make more uniform all conditions in their vineyards.

Fourth, a grape-grower may assume that his vines do not need fertilizers if they are vigorous and making a fair annual growth. When the vineyard is found to be failing in vigor, the first step to be taken is to make sure that the drainage is good; the second step, to control insect and fungus pests; the third, to give tillage and good care; and the fourth step is to apply fertilizers if they be found necessary.