A STUDY OF METHODS FOR TAKING SOIL SAMPLES FROM BLUEBERRY PLANTATIONS

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Robert J. Van Klompenberg

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A STUDY OF METHODS FOR TAKING SOIL SAMPLES FROM BLUEBERRY PLANTATIONS

By

Robert J. Van Klompenberg

AN ABSTRACT OF A THESIS

Submitted to
Michigan State University
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ABSTRACT

A STUDY OF METHODS FOR TAKING SOIL SAMPLES FROM BLUEBERRY PLANTATIONS

by Robert J. Van Kompenberg

A study was undertaken to determine how to effectively secure a composite soil sample that would reflect the fertility level of the soil from a blueberry plantation.

To test the sampling methods replicated soil samples were obtained and soil tests were made. Soil tests results from several replications were compared on the basis of the following limits of acceptability:

pH	±	0.2 of a unit
P	±	7.0 pounds per acre
K	±	10.0 pounds per acre
Ca	±	25.0 pounds per acre
Mg	±	30.0 pounds per acre

Soil test results that fell outside these limits were classed as not acceptable.

In order to obtain a close relationship between the replicates, it was necessary to consider the placement of the fertilizer.

Consequently, soil samples were taken within the fertilized area, and most of the soil test from replicated samples within this area fell within the acceptable range. The most reproducable results were obtained from composited soil samples that contained 20 or more subsamples.

A procedure for taking soil samples from a blueberry plantation was developed. It recognized differences in soils, methods of fertilization, and number of subsamples per composite for a given area.

The method was tested at seven locations and under four different methods of fertilizer placement.

The data indicated that only 14 soil tests out of a total of 135 fell outside the range of acceptability. Of these, only five were significantly out of the acceptable range.

This study suggests that reliable soil samples from blueberry plantations can be obtained with the following provisions:

1) samples must be taken to a depth of 8 inches;
2) a composite sample must contain 20 or more subsamples from the area of fertilizer application;
3) the sampling must be restricted to one soil condition of not more than 10 acres in size.

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INTRODUCTION

With more than 6,000 acres of blueberries (Vaccinium corybosum L), having a value in excess of 4 million dollars annually, Michigan ranks second in production in the United States.

Production at the present time is limited to those soils that are not well suited to other field and vegetable crops. The Au Gres, Saugatuck, and Newton soil series are representative of those acid soils now used in Michigan for commercial blueberry production.

Blueberry soils are generally low in natural fertility. Because of this, the plants respond greatly to the use of commercial fertilizer.

Until recently a 1:1:1 ratio fertilizer was conventionally used in Michigan for blueberry production. Recently, growers with mineral soils changed to a 2:1:1 fertilizer ratio containing magnesium oxide. On organic soils, proportionally less nitrogen is used.

Methods of predicting the fertilizer needs for blueberries have been based on the actual or visual response to fertilizer treatments or upon a chemical analysis of the blueberry leaves. The use of soil tests has been generally restricted to pH determinations.

Very little information is available on soil variability and methods of obtaining representative soil samples. Most growers assume that the same methods that are recommended for field crops are valid for blueberry plantations. This may not be the case because blueberry plants are spaced at a greater distance than field crops. In addition, blueberries are perennials.

Furthermore, fertilizer is not generally applied uniformly in a plantation to the entire soil surface. Another difference is that blueberry roots have a different distribution pattern than do field crops. These four factors perhaps explain why so little success has been obtained when researchers attempted to correlate soil test results with growth response and plant tissue analysis.

The purpose of this study was to attempt to determine a suitable procedure for taking soil samples to be used for soil fertility evaluation in blueberry plantations.

REVIEW OF LITERATURE

This literature review briefly outlines the general soil fertility diagnosis problems that developed in Michigan with the growth of the blueberry industry. Because it is difficult, if not impossible, to separate the nutrient requirement of this crop from methods used to evaluate nutrient requirements, little effort was made to attempt this. Therefore, the review of literature, in reality, is a statement and explanation of the problems of taking representative soil samples from blueberry plantations.

A. Origin of cultivated blueberries

Blueberries are becoming an increasingly important cultivated crop in Michigan.

Prior to 1910 there were at least two cultivated plantings of high-bush blueberries. The plantations were composed of high yielding plants which were selected from nearby swamps. Subsequently, Coville selected (27) and bred the wild plants. This work laid the foundation for the new blueberry industry.

B. Soils used for blueberry culture

The ideal blueberry soil is a mixture of peat and coarse sand underlaid by a hardpan at the depth of three to four feet (3, 11, 19, 33, 37). Johnston (38) contended that the degree of acidity is more important in blueberry production than is the clay content of the soil.

The blueberry plant has no root hairs. The entire root system is very fine and fibrous. It forms a dense mat several inches thick at or near the surface of the soil. The ideal soil for adequate root penetration is open and porous in structure (19).

C. Soil pH requirements for blueberries

The ideal pH level for blueberries is considered to be between 4.0 and 5.2 with the optimum range being between 4.5 and 4.8 (18, 33, 34, 39).

Blueberries can be produced at higher pH levels if necessary nutrients are maintained in available form. Hill (34) corrected the chlorsis of blueberry plants on a high pH soil with 100 grams per plant of chelated iron.

D. Soil fertility and balance

Fertilizer recommendations today, as in the past, vary and are often conflicting. Lack of knowledge concerning both soils and the nutrient requirements of blueberry plants undoubtedly account for this unfortunate situation.

Kramer and Schrader (42) suggested that the blueberry bush has a low cation requirement and a high anion requirement. Ballinger (5) reported that poor growth results where percent saturation with calcium exceeds 10 percent. Cain (15) indicated that ammonium nitrogen is superior to nitrate nitrogen when the pH of the soil is near 5.0 or above.

E. Fertilizer recommendations

It is thought that the soils used for blueberry production do not supply adequate quantities of nitrogen for optimum quality and production. At times, potassium, phosphorus, calcium, and magnesium may be limiting plant growth (13). Because of this situation, the following general fertilizer recommendation is frequently made: "Avoid nitrates and chlorides, 16-8-8-4* for mineral soils; 8-16-16-4 for organic soils. On 6 year old and older plants, about 400 pounds per acre (rates depend on age of plants)."

Johnston (37) reported an increase in the yield of blueberries from the use of high rates of superphosphate. He gave no recorded evidence of the nutrient level and balance in the soil. He also observed that a magnesium deficiency could be induced with the use of high rates of commercial fertilizer.

F. Soil testing

Considering such circumstances, if possible, it would be desirable to be able to sample blueberry soils for chemical analysis. With sufficient background, it should be possible with the use of commercial fertilizer to create an optimum fertility level and balance. The first problem that must obviously be faced then pertains to the reproducibility of soil test results. In other words, the sample to be tested must

*Percent Magnesium in the oxide form

represent a given area of soil. Also, the sample quality and soil test results must be reproducible.

G. Soil sampling

The emphasis of past work has been on methods used in the chemical laboratory and not on methods of taking a representative soil sample (22, 35, 58).

Factors affecting quality of soil samples are: natural soil heterogeneity, number of subsamples per composite, and methods of handling the sample after it is collected and before it is received by the testing laboratory (22, 35, 45, 52). Variability due to depth of sampling has also been established (8, 55).

Welch et al (55) found that samples with similar characteristics can be obtained with a tube, spade, or trowel.

Most of the research on soil sampling has been done on soils used for field crop production. Most investigators agree that soil samples should be randomized within the area to be sampled.

In areas used for field crops (35, 45, 51, 52) at least 20 soil probes or subsamples per composite sample from 10 acres has been determined to be sufficient for chemical determinations. Some workers are reluctant to make such recommendations (44).

With fruit crops, it cannot be assumed that soil sampling procedures should be similar to those used for field crops. A procedure frequently followed is to sample under the spread of the tree or bush limbs (59).

Kenworthy (41) working on fruit trees took (1) samples of the surface soil below the tree limbs; (2) surface soil between trees; and (3) subsoil samples to a depth of three feet. Wilcox (59) tentatively adopted a method that involved sampling soils so that there was a 2:1:1 ratio between samples from the following locations: (1) under the limbs; (2) midway between two trees in the row; (3) in the center of the tree square. Larson (44) in a study on grapes used samples taken one foot away from the base of the vine and to a depth of six to eight inches.

Some workers failed to mention the location of the soil samples taken and the number of cores that were included in the composite sample. Bear (8) stated that one is often led to question the conclusion drawn by investigators from their analytical results when the method of choosing the samples was not indicated or when given, showed the lack of appreciation of the necessity of accuracy in their selection.

When working with chemical soil tests as related to blueberry production Cain (17), Bally (3), Beckwith (11), Johnston (37), and others all failed to mention method or methods used in selecting soil samples. Ballinger (5), in his thesis, stated that soil samples were taken to the side of the plants. As stated by Bear, "one is left in complete amazement when incomplete data are recorded."

PROCEDURE

A. Consideration in soil sampling in blueberry plantations

Sites for soil sample studies were selected on the basis of types of soil, methods of fertilizer application, and age of plants. In this study, the three most productive soil series for blueberry culture in Ottawa County were used: the AuGres, the Newton, and the Saugatuck.

Four methods of using fertilizer were considered: (1) band; (2) broadcast in blueberry rows; (3) broadcast between blueberry rows; (4) broadcast over entire area. The age of the plants ranged from 6 to 24 years.

B. Methods of sampling soils

Several methods of selecting composite soil samples were investigated. The number of subsamples per composite ranged between 1 and 40. The samples were taken to a depth of 8 inches with a conventional sampling tube measuring one inch in diameter and 18 inches long. At one location, samples were also taken at a depth of 12 to 20 inches. Replications of soil sample treatments ranged from 2 to 4. Subsequent to sampling the soils material was air dried and then well mixed by hand.

C. Chemical tests on soil samples

The following chemical tests were made by Michigan State University Soil Testing Laboratory. Available phosphorus (P), and exchangeable potassium (K), calcium (Ca), and magnesium (Mg). The tests were made by standard procedures. (See Appendix)

D. Estimations of soil variability

A relatively uniform area of Au Gres sand (Site A), 1.5 acres in size, was used for estimating the variability of the soil test results. Samples were taken at random within the area disregarding proximity to blueberry bushes and previous method of fertilizer application. Duplicate composite samples composed of 1, 5, 10, 20, and 40 subsamples were collected to a depth of 8 inches and treated as previously described.

Because the ranges in soil test results were greater than desired, the area was resampled on the basis of small plots in an attempt to measure the kind of variation that might occur in a plantation. Three plots in the same area were established each consisting of 9 bushes (11 x 54 feet). The same sampling and testing procedures previously described were used on each of the three plots, except that only 10, 20, and 40 soil probes per composite soil samples were taken at two depths, 0 to 8 inches and 12 to 20 inches.

E. <u>Estimation of effect of fertilizer on soil test results</u>

Soil test results on the small plots were still variable and apparently reflected the use of commercial fertilizer. Therefore, in an effort to locate the area where the fertilizer had been applied, samples were taken only of the surface soil. One bush was selected from each plot to represent the area. The soil samples, composed of 12 subsamples and taken to a depth of 8 inches, were taken in a line perpendicular to the row at distances of 36, 30, 24, 18, 12, 9, 6, and 3 inches from the base of the plant. The samples were handled as previously described.

F. <u>Development of acceptable soil sampling procedures</u>

With the location of the fertilized area known, as reflected by soil test results, the plots were resampled in the fertilized area to determine if the sampling and soil test results could be duplicated. Composite soil samples were taken to a depth of 8 inches with 1, 5, 10, 20, and 40 subsamples per sample and treated as previously described.

This sampling procedure was tested the following year on the previously established plots. Plots were divided into subplots of 3 plants each (4 x 18 inches). Composite soil samples were taken 3 weeks after fertilizer was applied. The sampling and testing procedures previously described were used for each of the 9 subplots.

From these data, a proposed method for sampling soil in a blueberry plantation was developed. The method was tested on four sites.

The soil samples were taken at random at each site within the fertilized area. A total of 20 subsamples per composite were taken to a depth of 8 inches. Each site was sampled four times. The samples were prepared by conventional methods and tested in the State Laboratory.

In order to test the validity of the proposed methods which were developed for sampling soils in a blueberry plantation, three other locations were sampled by another person. These soil samples were prepared and tested as has been described.

RESULTS AND DISCUSSION

This study was undertaken to develop a procedure for obtaining good, representative soil samples from blueberry plantations for soil testing purposes. Preliminary studies indicated that soil test results from a given soil sample could easily be duplicated in the laboratory. Therefore, any great difference in soil test results from replicated samples reflects upon differences in soil samples and not upon the soil test procedure.

A. Acceptable ranges for results of repeat soil tests

Suspecting that great differences in soil test results from soil samples collected within one area of soil might occur, limits of acceptability were arbitrarily established. If soil tests fell within the limits of acceptability, it would be assumed that the method of sampling was acceptable for further use in soil testing and in making fertilizer recommendations. However, if the soil test results between replications were greater than the specified standards, the sampling methods would be classified as unsatisfactory.

The limits of acceptability that were considered acceptable are as follows:

pH ± 0.2 of a unit
P ± 7.0 pounds per acre
K ± 10.0 pounds per acre
Ca ± 25.0 pounds per acre
Mg ± 30.0 pounds per acre

B. Soil fertility variation in a blueberry plantation

In order to determine the range in soil test results that might normally be expected in samples taken from a young blueberry plantation, a relatively small area within a large plantation was selected. This area is referred to as Site A. Plate 1 shows this site.

The soil within this area was classified by Dr. E. P. Whiteside of the Soil Science Department of Michigan State University as an Au Gres sand which is one of the typical soils used extensively for blueberry production. This soil is acid in nature, imperfectly drained, and sandy. The surface soil is dark gray to pinkish gray underlaid with a dark reddish brown to dark brown sand, containing some iron concretions. A detailed soil description can be found in the Appendix.

The blueberry plantation was established in 1958 with three year old plants. In 1959 the plants were fertilized

Plate 1

View of Site A

A seven year old plantation in Au Gres Soil with 12-12-12 at the rate of 3 ounches per plant. The fertilizer was placed in a 10 inch ring around each plant. In 1960 the same procedure was followed only the rate was increased to 4 ounces. In 1961, 1962, and 1963, ammonium sulfate was applied at the rate of 5 ounces per bush in a band 24 inches long and 2 inches wide approximately 18 inches from the plant. Only 1 ounce was used in 1964.

Samples of surface soil were taken within the 1.5 acre area of Au Gres soil. They were taken at random without regard to bush location or the use of fertilizer. The soil test results are shown on Table 1. The range in soil test results for pH, K, and Ca were greater than desirable and those described by the "limits of acceptability." There seems to be a close relationship between soil test variability and the number of subsamples in the composite sample that was tested.

If it can be assumed that the sample which contained the 40 subsamples is the most representative of the entire area, the need for using a composite soil sample is illustrated by the data in Table 1. There was only a slight difference in soil test results from those samples containing 20 subsamples.

Table 1. Soil test results from a 1.5 acre area of Au Gres soil. Site A.

Number of subsamples per composite in duplicate	pH	P	K	Ca	Mg
		pounds per acre			
1	5.5	32	144	296	120
	5.2	32	32	153	32
5	5.7	30	35	184	99
	5.3	32	32	128	80
10	5.6	32	35	136	80
	5.6	32	40	200	80
20	5.1	36	35	160	64
	5.5	34	35	153	64
40	5.1	40	35	153	80
	5.0	35	35	184	80

Within an area larger than 1.5 acres, it seems logical to assume that natural soil variations would be greater than those within the 1.5 acre area. Therefore, within a larger area, soil test variation may be greater than those shown by these data.

C. Determining the best number of subsamples per composite

The soil at Site A was sampled twice in an effort to attempt to duplicate the soil test results reported in Table 1. The same sample procedures were followed. The data in Table 2 show the average of the soil test results from the two samplings as well as the range in soil test results.

The average soil test levels tend to be slightly lower than those results reported in Table 1. The range between test values where the sample contained only one probe of soil was greater than the limits of acceptability for the tests for K, Ca, and Mg. Where five subsamples were included only the test for Ca exceeded the limits of acceptability. This was also the situation for the samples that contained 10 subsamples. The ranges in tests were all within the limits of acceptability where the composite samples contained either 20 or 40 subsamples. Therefore, it seems that disregarding previous management and fertilizer practices within the 1.5 acre area a composite sample should be composed of a minimum

Table 2. Range in soil test results between duplicate samples of each composite sample taken from a 1.5 acre area of Au Gres soil. Site A.

Number of subsamples per composite	pH	P	K	Ca	Mg
		pounds per acre			
1	0.3	0	112	143	88
5	0.4	2	3	56	18
10	0.0	0	5	64	0
20	0.4	2	0	7	0
40	0.1	5	0	31	0

of 20 subsamples. The implications for what might be needed from a 10 or 20 acre plantation are great and perhaps beyond the realm of practicability.

To further test this method of soil sampling which disregards fertilizer placement, three small plots, each containing 9 plants (10 x 54 feet) were selected within the 1.5 acre area. (Site A).

Composite samples were taken at random throughout the plot area at two depths; 0-8 inches and 12-20 inches. Ten, twenty, and forty subsamples were composited and tested. The results of the chemical tests are recorded in Table 3.

The soil test results at the 0-8 inch depth are considerably different than those reported in Table 1. This again illustrates the need for the use of a composite soil sample. The variation in soil test results was greater between plots than within plots; however, the variation was reduced when 40 subsamples were taken to make a composite sample (Table 1).

Disregarding plots, the pH ranged between 3.7 and 4.5. The test for available phosphorus varied between 27 to 50 pounds per acre. Similarly the values for potassium were 16 to 32; for calcium, 112 to 128; and for magnesium 32 to 64.

Table 3. Soil test results from composite samples taken at random and to a depth of eight inches in three small plots, each containing 9 plants growing on an Au Gres soil. Site A

Soil probes per sample	Soil Test Results pH	pounds per acre P	K	Ca	Mg
<u>Plot 1</u>					
10	4.0	44	24	112	64
20	4.3	50	24	112	64
40	4.1	40	24	120	51
<u>Plot 2</u>					
10	3.9	29	24	112	40
20	3.7	29	16	112	40
40	3.9	40	24	120	32
<u>Plot 3</u>					
10	3.9	45	32	112	61
20	4.5	27	24	120	51
40	4.0	32	24	128	61

Such wide differences reflect soil variations caused by the use of commercial fertilizer and by various tillage. The variations in the test results are probably related to the number of subsamples that were taken from the areas to which fertilizer had been added within the plots.

The soil test results taken at 12 - 20 inches showed the same trend as 0 - 8 inch depth with a wider variation between plots than within plots (Table 4).

In taking these samples, it was noted that the soil contained very few roots. Many probes of soil contained no roots. If they were present they were restricted to the surface few inches of soil. This situation leads one to believe that on the average, soil test results from samples have little practical value.

D. The effect of fertilizer placement on soil test results

To further investigate the wide variation in soil test results, it was decided what effect the method of fertilization had on soil test results.

Because band placement of fertilizer had been used on these plots, soil samples were taken near 3 bushes, one from each plot. The samples consisted of 12 soil probes per composite sample which were taken perpendicular to the row to a depth

Table 4. Soil test results from composite samples taken at random and at a depth of 12 to 20 inches in three small plots, each containing 9 plants growing on an Au Gres soil. Site A.

Soil Test Results

Soil probes per sample		pounds per acre			
	pH	P	K	Ca	Mg
Plot 1					
10	4.3	13	16	80	27
20	4.3	24	16	96	40
40	4.4	14	16	88	51
Plot 2					
10	4.4	27	16	112	40
20	4.0	30	24	128	40
40	4.4	32	24	96	40
Plot 3					
10	4.6	23	24	176	46
20	4.4	27	24	120	27
40	4.6	34	16	104	40

of 8 inches and at intervals of 36, 30, 24, 18, 12, 9, 6, and 3 inches from the base of the plant. Twelve probes represented the maximum number of subsamples that could logically be obtained within limits described in this phase of research. The soil test results are recorded in Table 5.

Results of the soil test show a decrease in pH between the plant rows at about 18 inches from the plant on plot 1 and between 9 and 12 inches on plots 2 and 3. This suggests the acidifying effect from the fertilizer band and partially explains some of the variation in test results. (Tables 1, 2, 3, and 4)

The tests for phosphorus varied greatly, but generally were highest near the base of the plant at the 3-inch distance. This could be due to the accumulation of grasses about the base of the plant.

Plot 2 generally tested higher in phosphorus than Plot 1 and 3. This may be considered to be due to natural soil variation since the bushes had received no fertilizer containing phosphorus since 1961. The tests for phosphorus, on an average, were higher within the 12 inch area. This is considered to be the effect of the phosphorus which was used prior to 1961.

Table 5. Soil test results from composite samples of 12 soil probes each taken in a band at different intervals from the base of one bush in each of 3 plots taken to a depth of 8 inches perpendicular to the row. Site A.

Distance from Blueberry Bush	36"	30"	24"	18"	12"	9"	6"	3"
Soil test <u>pH</u>								
Plot No. 1	5.2	5.3	5.1	4.7	4.9	5.0	5.0	5.1
Plot No. 2	4.7	4.8	4.8	4.6	4.4	4.4	4.5	4.0
Plot No. 3	5.0	5.9	5.7	4.7	4.4	4.4	4.8	5.0
Soil test - <u>Pounds per acre of P</u>								
Plot No. 1	24	22	35	35	51	28	36	59
Plot No. 2	36	39	47	39	68	59	50	85
Plot No. 3	27	40	32	30	45	43	39	42
Soil test - <u>Pounds per acre of K</u>								
Plot No. 1	32	40	40	32	32	40	48	40
Plot No. 2	24	24	32	24	24	24	32	24
Plot No. 3	32	48	35	32	24	32	40	32
Soil test - <u>Pounds per acre of Ca</u>								
Plot No. 1	120	120	120	104	88	88	88	96
Plot No. 2	120	104	104	88	112	120	120	96
Plot No. 3	184	184	128	104	112	153	153	136
Soil test - <u>Pounds per acre of Mg</u>								
Plot No. 1	53	45	80	45	64	72	64	80
Plot No. 2	45	32	53	64	64	64	45	32
Plot No. 3	80	136	53	53	32	64	99	80

The tests for potassium showed between plot variation as well as within plot variation. The use of fertilizer containing potassium prior to 1961 was not reflected in soil test results. The tests for potassium tended to be lower in the areas of maximum acidity. This is logical in that the hydrogen ions from ammonium sulfate fertilizers probably exchanged with the potassium ions thus decreasing the test values for potassium. The tests for calcium and magnesium varied as much as 100 per cent. Such variation is not easily explained.

After collecting so many soil samples and analyzing the soil test results, it became evident from the variability of the test results that in order to obtain a representative sample, several factors would have to be considered. While soils that are used for blueberry production are naturally acid and test low in phosphorus, potassium, calcium, and magnesium, there apparently is considerable natural soil variation. The variation in soil test results appears to increase with the use of commercial fertilizer, especially when it is banded. The location of the blueberry roots undoubtedly has a profound effect upon soil test levels.

In young plantations it was observed less than a third of the surface soil contain roots. This undoubtedly affects soil fertility levels and soil test results. Vegetation between plants, especially down the row varies greatly as to number and species. This also influences soil test results -- at least from a theoretical point of view. The last consideration is the number of subsamples that should be composited and tested to represent the average condition within a given area -- the area occupied by the roots of the plants.

In order to measure average fertility conditions by the use of soil tests, it would seem that soil samples should be collected near the plant where the roots are actively growing and in the area where fertilizer had been used. Because it is not possible, in most instances, to see fertilizer particles it therefore becomes necessary to take several subsamples and composite them.

With this in mind three small plots each containing 9 plants were selected on Site A on the Au Gres soil. Samples composed of varying number of subsamples were collected within or near the location of the fertilizer band as shown in Table 6.

In interpreting the data in Table 6, consider the test results from the composite sample which contained 40 subsamples as the standard. Deviation from these values should fall within

Table 6. Soil test results from composite samples taken within or near the fertilizer band at a depth of 8 inches in three small plots, each containing 9 plants growing in an Au Gres Soil. Site A.

Soil probes per sample	pH	P	K	Ca	Mg
		pounds per acre			
Plot 1.					
1	4.8	61	37	128	160
5	5.0	56	37	112	160
10	5.1	63	43	112	160
20	5.0	53	27	112	160
40	4.9	51	27	112	136
Plot 2.					
1	4.7	56	37	120	128
5	4.9	46	37	136	128
10	4.8	50	37	128	128
20	4.9	42	37	120	128
40	4.9	51	27	112	128
Plot 3.					
1	5.0	53	37	176	173
5	4.8	39	37	136	160
10	5.1	53	43	160	136
20	5.3	48	43	153	181
40	5.0	45	43	153	210

the limits of acceptability if they are to be considered useable for evaluating soil fertility levels and balance. Since the pH values did not deviate more than those established as the standard, all of the pH values reported in this table are considered to be acceptable.

The phosphorus, potassium, calcium, and magnesium varied more than the pH, however, the variation was less than that in the previous sampling studies (Table 1, 2, 3, 4). Under the condition that existed, more than 10 subsamples per plot were required to satisfy the standards that were established.

E. Reproducibility of soil test results from samples taken in blueberry plantation

Considering the soil test results that were obtained near individual plants, and on small plots, it seemed logical to evaluate the heterogeneity of soil tests obtained from samples taken from commercial blueberry plantations. The specifications for the sampling methods employed were as follows:

(1) the soil should be taken from the fertilizer zone;

(2) the soil should be representative of one soil series;

(3) the soil should consist of 20 subsamples;

(4) the samples should be taken to a depth of 8 inches.

Four composite soil samples from each site were collected taking these factors into consideration. Samples were taken from four fields labeled as Sites B, C, D, and E.

The soil test results were averaged to obtain an estimate of the fertility levels within any one plantation. Deviations from the mean were evaluated on the basis of the previously described limits of acceptability.

The soil test results from Site B, are shown in Table 7. This site is on Au Gres soil and the plantation was four years old (Plate 2). The tests for pH were within acceptable limits, as were the individual tests for phosphorus, calcium, and magnesium. Two of the tests for potassium were outside of the acceptable range by approximately 15 per cent.

The soil test results from Site C are shown in Table 8. This site is characterized by a 24 year old plantation on a Newton sand (Plate 3).

The tests for pH and magnesium were all within the limits of acceptability. This is especially important because these two are more likely to be limiting factors than are phosphorus, potassium, and magnesium. Two of the tests for phosphorus and potassium and one of the tests of calcium were just barely outside of the range of acceptability.

Soil test results for Site D, are shown in Table 9. This site is characterized by a three-year-old plantation growing on a Saugatuck sand (Plate 4).

Table 7. Soil test results from four composite samples taken in a four year old blueberry plantation growing on an Au Gres sand. Site B.

	pH	pounds per acre			
		P	K	Ca	Mg
Sample 1	4.3	69	104	208	50
Sample 2	4.5	73	136*	224	61
Sample 3	4.5	66	83*	248	78
Sample 4	4.4	75	112	224	50
Mean	4.4	71	109	226	57

Table 8. Soil test results from four composite soil samples taken in a 25 year old blueberry plantation on a Newton sand. Site C.

	pH	pounds per acre			
		P	K	Ca	Mg
Sample 1	5.1	162*	166	409	50
Sample 2	5.2	174	152	488	78
Sample 3	5.1	168	180*	512*	67
Sample 4	5.2	192*	144*	480	19
Mean	5.2	174	161	472	54

*Outside the limits of acceptability

PLATE 2

View of Site B

A four year old plantation in Au Gres Soil

PLATE 3

View of Site C

A twenty-five year old plantation on Newton soil

PLATE 4

View of Site D

A three year old plantation in Saugatuck soil

When the soil tests were compared with the limits of acceptability, only the potassium and calcium tests exceeded the standards. The potassium test exceeded the limits by only 2 and 9 pounds per acre and the calcium by 7 pounds. These are considered to be not greatly outside the limits. For all practical purposes in making fertilizer recommendations, they are satisfactory.

The soil test results for Site E are shown in Table 10. This site is characterized by a 15 year-old plantation growing on a Newton sand (Plate 5).

The test results from the three soil samples taken from this field were within the limits of acceptability with one exception. The test for potassium exceeded the limit by only 5 pounds in one instance. This is not considered to be greatly significant from the standpoint of reproducibility of soil test results or in the area of making fertilizer recommendations.

When comparing the data obtained from these four sites with the range established for this study, the results showed that all 15 soil tests were within the guide lines for pH and magnesium. Thirteen of the phosphorus, 12 of the calcium, and 9 of the potassium soil tests also fell within the guide

Table 9. Soil test results from four composite samples taken from a three year old blueberry plantation growing on Saugatuck sand. Site D.

	pH	pounds per acre			
		P	K	Ca	Mg
Sample 1	4.4	82	69*	144	16
Sample 2	4.6	82	92	200*	19
Sample 3	4.5	82	84	144	16
Sample 4	4.6	77	98*	184	35
Mean	4.5	81	86	168	22

Table 10. Soil test results from three composite samples taken from a fifteen year old blueberry plantation growing on Newton sand. Site E.

	pH	pounds per acre			
		P	K	Ca	Mg
Sample 1	4.8	174	166*	200	31
Sample 2	4.8	168	144	168	19
Sample 3	4.9	174	144	184	19
Mean	4.8	172	151	184	23

*Outside the limits of acceptability

PLATE 5

View of Site E

A fifteen year old plantation in Newton soil lines. Of the 75 separate test results, only 11 fell outside of the range established. However, five of these 11 were only 2 to 9 pounds per acre outside of the established ranges. Looking backward, all conceivably could have been within the limits of acceptability if the limits had not been so narrowly defined.

A summary of deviation from the established guide lines and a summary of a comparison of the actual soil tests with the satisfactory limits for each of these sites is found in the Appendix (Tables 14 & 15). Also a brief description of each soil type and the soil management treatments are summarized.

F. <u>Final testing of the proposed sampling method</u>

Because the soil test results fell within or very close to the proposed limits of acceptability, the soil sampling procedure was evaluated by outlining the sample methods to a fellow worker and then having him take samples by this method from three different blueberry plantations. Four separate composite soil samples were taken at random from each site.

The first plantation was labeled Site F and the soil was an Au Gres sand. The soil test results from this 10 year old plantation are shown in Table 11. All of the soil test values fell within the limits of acceptability.

PLATE 6

Area of root growth of a blueberry bush. Note the high percentage of roots in the first seven inches.

The second plantation was labeled Site G. The soil at this site was also an Au Gres sand. The soil test results from this 12 year old plantation are shown in Table 12.

Of the 20 soil test results for this site, 18 fell within the guide line range. Of the two values outside the range, one phosphorus test fell outside by 7 pounds per acre and one calcium test by 5 pounds per acre.

A third plantation was labeled Site H. The soil at this site was mapped as Saugatuck sand. The soil test results from this 3 year old plantation are shown in Table 13.

Of the 20 soil test results on this site, 19 fell within the required range. One test for potassium fell outside the accepted range by two pounds per acre.

A summary of the characteristics of each soil type and the important management practices at each site are shown in the Appendix.

The experimental results obtained at Sites F, G, and H, on which separate test results were made, show that 57 of these tests fell within the established range. The three values falling outside the accepted range occurred at Sites H and G where 2 pounds per acre of potassium and 5 and 7 pounds per acre of calcium and phosphorus occurred respectively.

Table 11. Soil test results from four composite samples taken from a two year old blueberry plantation growing on Au Gres soil. Site F.

	pH	pounds per acre			
		P	K	Ca	Mg
Sample 1	4.3	150	104	280	16
Sample 2	4.1	150	104	288	19
Sample 3	4.0	162	118	280	19
Sample 4	4.0	160	104	272	31
Mean	4.1	155	108	280	21

Table 12. Soil test results from four composite samples taken from a twelve year old blueberry plantation growing on Au Gres soil. Site G.

	pH	pounds per acre			
		P	K	Ca	Mg
Sample 1	4.0	246	98	266*	31
Sample 2	4.1	246	104	232	35
Sample 3	4.1	264*	98	224	35
Sample 4	4.0	244	92	224	31
Mean	4.1	247	98	236	33

*Outside the limits of acceptability

Table 13. Soil test results from four composite samples taken from a three year old blueberry plantation growing on Saugatuck sand. Site H.

	pH	pounds per acre			
		P	K	Ca	Mg
Sample 1	3.6	120	98*	208	31
Sample 2	3.5	116	112	224	35
Sample 3	3.6	120	112	208	35
Sample 4	3.6	112	118	224	35
Mean	3.6	116	110	216	34

*Outside the limits of acceptability

Only fourteen from a total of 135 chemical tests carried out on these seven plantations (B, C, D, E, F, G, and H) were outside of the established range set up for this study. Of these, 9 were only 2 to 10 pounds outside of the established ranges.

Considering the results obtained on the soils at these seven sites it was concluded that this procedure of taking soil samples can confidently be used to obtain a soil sample that will effectively represent the fertility level of the area sampled.

SUMMARY

The purpose of this study was to attempt to develop a suitable procedure for taking soil samples to be used for soil testing purposes from blueberry plantations.

Preliminary studies indicated that the State Soil Testing Laboratory could do a satisfactory job of testing soils and that the reproducibility of the test results from a given sample of soil was of a high order.

Soil tests from samples taken at random in a blueberry plantation without regard to location of bushes or previously applied fertilizer, or natural soil variation showed a high magnitude of variation. The variation was large enough that the test results could not be satisfactorily used for evaluating the fertility level or balance in the soil.

When the soil samples were taken at random within the plantation but within the fertilizer zone, it was found that with the use of 20 soil probes per composite, the soil test results were within or very close to the limits of acceptability established in this study. This situation was obtained by taking soil samples to a depth of 8 inches.

The method was used on four selected sites. Tests for pH and available phosphorus, potassium, calcium, and magnesium were made on replicated samples for each site. Of the 75

separate tests made, only 11 fell outside of the range considered to be acceptable. Five of these were just slightly outside of the acceptable range.

To further test this method, a summer worker who had not taken soil samples previously was given directions on this method of sampling soil. He took replicated soil samples from three plantations. The soil test results showed that the proposed method of taking soil samples from a blueberry plantation was satisfactory. It is hoped that this study has laid the foundation for attempting to correlate the growth of blueberries, and the response from fertilizer to soil test results.

GENERAL DISCUSSION

The following discussion is an effort to outline a suitable method for taking soil samples from blueberry plantations. The thoughts expressed in this section are based upon the research reported in this thesis as well as upon the research and observation of others. The outlines takes into consideration the requirements of the State Soil Testing Laboratory at the time this is written.

1. Equipment
    1. Clean pail - 10 to 12 quart size - to be used for collecting and mixing the soil samples
    2. Soil probe - for collecting subsamples for compositing procedure.
    3. Soils map of plantation.
    4. Notebook for recording the soil sample number as well as the location from which the samples were derived.
    5. Soil sample bags or carton.
2. Sampling method
    1. Inventory the condition in the plantation. Know where unrepresentative areas exist and do not take samples from such areas. Consider information on soils map as well as the characteristics that can be seen.

2. Question the farmer about methods and placement of commercial fertilizer.
3. Select areas of uniform soil to be sampled that are no larger than 10 acres.
4. Take composite soil samples composed of a minimum of 20 subsamples.
5. Take soil samples to a depth of 8 inches.
6. Take soil samples at random within the field but within the areas where fertilizer has previously been applied and from within the area occupied by the roots of the plant.
7. Avoid including areas where brush has been burned, where tile are located, where fertilizer was spilled, and areas near gravel roads.

3. Soil sample preparation
   1. Mix well the 20 subsamples. If the soil is too wet to mix, place in a sheltered location and allow to air dry before mixing.
   2. Take a subsample (one pint) of the composite and place in soil sample carton.
   3. Label each carton and keep a record in the notebook on each sample.
   4. Send soil sample to the State Testing Laboratory.

If these procedures are followed, reasonably accurate soil samples will be taken. They can with confidence be submitted to the State Soil Testing Laboratory as representative of the soil in part or in the whole of a blueberry plantation.

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APPENDIX

SAUGATUCK SERIES

The Saugatuck series are imperfectly to poorly drained ground-water Podzols developed in deep, acid sands. Saugatuck soils have a very strongly cemented (ortstein) in the upper B horizons.

<u>Soil Profile</u>: Saugatuck Sand

A0	2-0"	Organic mat of partially decomposed leaves and twigs, with a mass of fine roots. 1 to 4 inches thick.
AL	0-2"	Sand: black (10YR 2/1 - 5 YR 2/1): very weak, fine granular structure; very friable; contains a mass of fine roots; strongly to extremely acid; abrupt smooth to wavy boundary. 1 to 6 inches thick.
A2	2-10"	Sand: light grayish brown (10YR 6/2) pinkish gray (7.5YR 7/2) or reddish gray (5YR 5/2) single grain (structureless); loose; very strongly to extremely acid; abrupt wavy to irregular boundary. 2 to 15 inches thick.

B21H 10-16" Sand: very dusky red (2.5YR 2/2) or dark reddish brown (5YR 2/2 - 3/4); sand strongly cemented; massive (structureless); very strongly to extremely acid; abrupt to clear wavy to irregular boundary. 4 to 12 inches thick.

B22 ir 16-26" Sand: reddish brown (5YR 4/4) reddish yellow (5YR 5/8-4/8) or dark reddish brown (5YR 3/4); massive to moderate, medium or thick, platy structure; contains a mass of fine roots along horizontal planes; strongly cemented in upper part, with gradual change to weakly cemented in lower part; strongly to extremely acid; gradual irregular boundary. 6 to 18 inches thick.

B3 26-36" Sand: strong brown (7.5YR 5/6), reddish yellow (7.5YR 7/6), or light yellowish brown (10YR 6/4) which contains numerous vertical channels or tubes, from less than 1 mm to about 3 mm in diameter and 1/4 to 5 inches long, and blotches of dark reddish brown (5 YR 3/3) and dark brown (7.5YR 4/4); the redder or stronger color is in the center of the channels, with a gradual fading of color outward; single grain ; (structureless); loose; medium to very strongly acid; gradual wavy boundary. 6 to 14 inches thick.

C 36"+ Sand: very pale brown (10YR 7/4), pale brown (10YR 6/3), or light brownish gray (10YR 6/2) which contains very thin channels or tubes of strong brown (7.5YR 5/6) and dark brown (7.5YR 4/4); channels are common in upper part, and diminish in quantity with depth; single grain (structureless) loose; medium to very strongly acid.

<u>Topography</u>: Nearly level to gently rolling areas in lake and till plains.

<u>Drainage and Permeability</u>: Imperfectly to poorly drained. Runoff is slow to medium. Permeability is slow to moderately rapid.

AU GRES SERIES

The Au Gres series includes imperfectly drained Podsols developed in thick sandy glacial drift.

Soil Profile: Au Gres Sand

A0	2-0"	Organic mat, including leaves and other plant remains in various stages of decomposition. One-half to 3 inches thick.
A1	0-1"	Very dark gray (7.5YR 3/1) or dark brown (7.5YR 3/2) sand; moderately high organic matter content; very weak fine granular structure; very friable; medium acid; abrupt smooth boundary. 1 to 4 inches thick.
A2	1-5"	Pinkish gray (7.5YR 7/2) or light gray (5YR 7/1) sand; very weak fine platy structure, to single grain; loose; strongly to medium acid; abrupt irregular boundary. 4 to 12 inches thick.
B21h	5-8"	Dark reddish brown (5YR 3/3) or dark brown (7.5YR 4/4) sand; very weak coarse subangular blocky structure; very friable to nearly loose; contains a few hard iron concretions; strongly to medium acid; gradual irregular boundary. 1 to 5 inches thick.

B22ir	8-14"	Dark brown (7.5YR 4/4), reddish brown (5YR 4/4), or strong brown (7.5YR 5/6) sand; single grain to very weak coarse subangular blocky structure; loose to very friable; contains a few hard concretions and chunks; strongly acid; grandual irregular boundary. 4 to 10 inches thick.
B3g	14-30"	Reddish yellow (7.5YR 6/6), mottled with strong brown (7.5YR 5/6) and very pale brown (10YR 7/3) sand; mottles are few to many, medium, and distinct; single grain; loose; strongly to medium acid; gradual irregular boundary. 10 to 20 inches thick.
Cg	30"+	Pinkish gray (7.5YR 7/2) or light gray (10YR 7/2), mottled with pale brown (10YR 6/3) and brownish yellow (10YR 5/6) sand; mottles are few to many, medium, and distinct; single grain; loose;medium acid to neutral.

Range in Characteristics: The A1 is absent in some areas. Where Au Gres soils grade toward the Saugatuck soils the upper B horizon is weakly cemented, and it contains numerous chunks of cemented material. The degree of development of the Podzol solum ranges from weak to strong. The thickness of the solum ranges from 25 to about 40 inches. The depth to mottling ranges down to about 18 - 20 inches. Where Au Gres soils grade toward the Croswell soils the depth to mottling approaches the maximum given. The reaction of the solum ranges from strongly to slightly acid. Sand and loamy sand types have been recognized. Colors refer to moist conditions.

Topography: Level to gently sloping areas in outwash plains and till plains.

Drainage and Permeability: Imperfectly drained. Runoff is slow to very slow.

Remarks: AuGres soils were formerly included with the Saugatuck Series. Saugatuck soils have Ortstein B horizons.

NEWTON SERIES

Newton series comprises Humic-Gley soils developed in strongly to very strongly acid sands.

Soil Profile: Newton loamy fine sand.

Ap	0-8"	Loamy fine sand: very dark brown (10YR 2/2) or very dark gray (10YR 3/1); very weak, medium, granular structure; very friable; medium to very strongly acid; abrupt smooth boundary, 7 to 10 inches thick.
A2	8-12"	Loamy fine sand: very dark gray (10YR 3/1); few, fine distinct mottles of yellowish brown (10YR 5/6-5/8) in lower part; very weak, coarse, granular structure; very friable; strongly to very strongly acid; clear wavy boundary. 2 to 6 inches thick.
Bg	12-30"	Loamy sand to sand: grayish brown (10YR 5/2) or gray (10YR 5/1) mottled with yellowish-brown (10YR 5/6-5/8), dark yellowish brown (10YR 4/4), and strong brown (7.5YR 5/6), mottles are common, medium, and distinct in the upper part, with gradual change to many, coarse and distinct in lower part; single grain structure; loose; strongly to very strongly acid; diffuse irregular boundary. 14 to 30 inches thick.

Cg	30" +	Sand: yellowish brown (10YR 5/6) or brownish yellow (10YR 6/6 - 6/8) mottled with gray (10YR 5/1), dark yellowish brown (10YR 4/4), and dark brown (7.5YR 4/2 - 4/4); mottles are common, medium, and distinct; single grain structure; loose; strongly to very strongly acid; gradual structure; loose; strongly to very strongly acid; gradual change below 60 inches to medium or slightly acid reaction.

Topography: Nearly level to slightly depressed areas in outwash and lake plains.

Drainage and Permeability: Poorly to very poorly drained. Runoff is very slow to ponded. Permeability is very rapid.

Native Vegetation: Marsh grasses, reeds, and sedges with some aspen, pin and black oak.

Soil Analysis Carried Out by the Michigan State University Soil Testing Laboratory

1. pH, determined by Glass Electrode using a Beckman Model H-2 pH meter using a 1:1 soil to water ratio.

2. Phosphorus, extrated by .025 NHCl + .03 N NH_4F (Bray P_1).

3. Potassium, calcium, and magnesium were extracted with neutral normal ammonium acetate. The potassium and calcium were determined quantitatively on the Model 21 Coleman Flame Photometer and the magnesium was determined flame photometrically using a Beckman DU with a flame attachment at a wavelength of 285.2 millimicrons.

   Potassium, calcium, magnesium and phosphorus were extracted from the soil employing soil to extract ratios of 1:8.

Table 14. Summary Comparison of Guide Lines Established for Each Site and Soil Test Results

	Pounds per acre			
	P	K	Ca	Mg
Site B				
Mean	71	109	226	57
Guide Line Range	64 - 78	99 - 119	201 - 251	27 - 87
Soil Test Range	66 - 75	83 - 136	208 - 248	50 - 78
Site C				
Mean	174	161	472	54
Guide Line Range	167 - 181	151 - 171	447 - 497	24 - 84
Soil Test Range	162 - 192	144 - 180	409 - 512	19 - 78
Site D				
Mean	81	86	168	22
Guide Line Range	74 - 88	76 - 96	143 - 193	0 - 52
Soil Test Range	77 - 82	69 - 98	144 - 200	16 - 35
Site E				
Mean	172	151	184	23
Guide Line Range	165 - 179	141 - 161	159 - 209	0 - 53
Soil Test Range	168 - 174	144 - 166	168 - 200	19 - 31

Table 15. Deviations from Established Guide Line for Site B through E

	pH	Pounds per acre			
		P	K	Ca	Mg
Site B	none	none	16 - 17	none	none
Site C	none	5 - 11	7 - 9	38 - 15	none
Site D	none	none	9 - 2	0 - 7	none
Site E	none	none	0 - 5	none	none

Soil Description, Age, and Fertilizer Program on Several Blueberry Plantations

Site A

This soil is an Au Gres which is acid in nature, imperfectly drained, and sandy. The surface soil is dark gray to pinkish gray underlaid with a dark reddish brown to dark brown sand, containing some iron concretions. A detailed description of this soil can be found in the Appendix.

The blueberry plantation was established in 1958 with three year old plants. In 1959 they were fertilized with a 12:12:12 at the rate of 3 ounces per plant in a 10 inch ring around the plants. In 1960 the same procedure was followed only the rate was increased to 4 ounches. In 1961, 1962, and 1963 ammonium sulfate was applied at the rate of 5 ounces per bush in a band 24 inches long and 2 inches wide approximately 18 inches from the plant. Only 1 ounce was used in 1964. The placement was the same.

Site B

The soil on this site is also an Au Gres sand, described in Table 16. The three year old plants were transplanted to this field in 1961. In 1962 and 1963 they were fertilized with ammonium sulfate at the rate of 4 ounces per plant in a band 24 inches long and 2 inches wide approximately 18 inches from the base of the plant. In 1964 they were again fertilized with ammonium sulfate at the rate of 1 ounce per bush and in 1965 a 16:8:8 fertilizer was used at the rate of 250 pounds per acre plus 3 ounces of ammonium sulfate per bush.

Site C

The soil on Site C is classified as a Newton sand. The soil is acid in reaction and the top 8 to 12 inches is dark brown or dark gray underlain with grayish brown sand. See Appendix for detail description.

This plantation was established in 1941 by transplanting 3 year old plants. From 1942 to 1955 the plants were fertilized with an 8:8:8 fertilizer, using from 800 to 1100 pounds per acre, broadcast within the blueberry row. From 1956 to 1960 an 11:11:11 fertilizer was used at the rate of 500 to 800 pounds per acre. From 1961 to 1965 a 16:8:8 fertilizer was used at the rate of 400 to 500 pounds per acre. All fertilizer was applied in the same manner.

Site D

The soil on this site is classified as a Saugatuck sand. The surface soil is black to light grayish brown underlaid at 10 to 16 inches with sand strongly cemented, dark reddish brown, and acid in reaction. Detailed description can be found in the Appendix.

This plantation was established in 1962 when 3 year old stock was planted. They were fertilized in 1963 at the rate of 200 pounds per acre with a 16:8:8 fertilizer broadcast in the blueberry rows. In the fall of 1963 the cover crop was fertilized with an 0:10:16 at the rate of 200 pounds per acre, broadcast between the rows. In 1964 a 16:8:8 fertilizer was spread in the blueberry rows at 250 pounds per acre. The same fertilizer and application was used in 1965 only the rate was increased to 350 pounds per year.

<u>Site E</u>

The soil on this site is a Newton sand, previously described in Table 18.

This plantation was established in 1950 when 3 year old plants were established in this field. In 1951 to 1955 an 8:8:8 fertilizer was used at the rate of about 11 ounces per bush per year, broadcasted between the blueberry rows. From 1956 to 1960 an 11:11:11 fertilizer was used at the same rate. A 16:8:8 fertilizer was used from 1961 to 1965 at the rate of 5 to 8 ounces per bush. In addition, 400 pounds of sulfate potash magnesia and 1,000 pounds of dolomite lime per acre was applied.

Site F

The soil on this site was classified as Au Gres. Soil characteristics have been described previously.

This plantation was established in 1955 with 3 year old stock. The fertilizer program is incomplete because of change in ownership. This fertilizer was broadcast the last 2 years with 250 pounds of an 8:12:24 fertilizer per acre plus 80 pounds of nitrogen per acre.

Site G

The soil on this site was classified as Au Gres which has been described previously.

The three year old plants were transplanted into this field in 1953. Since this plantation has changed hands the fertilizer program is incomplete. From 1960 to 1964 an 8:16:16 fertilizer was used at the rate of 400 pounds to the acre broadcast over the entire area. In 1965 a 16:8:8 fertilizer was used at approximately 415 pounds per acre. It was applied in the same manner.

Site H

The soil on this site is classified as Saugatuck which has been described previously.

This plantation was established in 1962 with three year old plants which were planted in the spring. They were fertilized in 1963 at the rate of 200 pounds per acre with a 16:8:8 fertilizer broadcast in the blueberry rows. In the fall of 1963 the cover crop was fertilized with an 0:10:16 at 200 pounds per acre, broadcast between the rows. In 1964 a 16:8:8 fertilizer was spread in the blueberry rows at 250 pounds per acre. The same fertilizer and application was used in 1965 with the exception that the rate was increased to 350 pounds per acre.