



144
969
THS

RELATION OF TISSUE ANALYSIS TO SOIL
ANALYSIS IN MICHIGAN ORCHARDS

Thesis for the Degree of M. S.
MICHIGAN STATE COLLEGE
Roscoe John Higdon
1951

This is to certify that the

thesis entitled

LEAF ANALYSIS IN RELATION TO
SOIL ANALYSIS IN MICHIGAN ORCHARDS

presented by

Robert L. Wigdon

has been accepted towards fulfillment
of the requirements for

B.S. degree in Horticulture

A. L. Kennedy

A. L. Kennedy

Major professor

Date February 19, 1951

RELATION OF TISSUE ANALYSIS TO SOIL ANALYSIS
IN MICHIGAN ORCHARDS

By

Roscoe John Higdon

A THESIS

Submitted to the School of Graduate Studies of Michigan
State College of Agriculture and Applied Science
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE IN HORTICULTURE

Department of Horticulture

1951

THESIS

Sift
A. 1/2/51

Acknowledgment

The writer wishes to express his appreciation to Dr. A. L. Kenworthy for guidance in the work reported in this paper, and for constructive criticism in the preparation of this manuscript. He also wishes to acknowledge his gratitude to Dr. W. W. Aldrich, Department of Horticulture, to Dr. L. M. Turk and Dr. A. E. Erickson, Soils Department, for their help in the preparation of this manuscript.

Table of Contents

	Page
Introduction	1
Review of Literature	1
Materials and Methods	4
Results	5
Apples	5
Peaches	7
Montmorency cherry	7
Correlation between Soil and Leaf Analysis	8
Discussion	8
Summary	11
Literature Cited	13, 14
Appendix	
Table 1: Leaf analysis	
Table 2: Soil analysis	

LEAF ANALYSIS IN RELATION TO SOIL ANALYSIS IN MICHIGAN ORCHARDS

by

Roscoe John Higdon

A survey of some Michigan orchards was conducted in 1948. One of the objectives of this survey was to determine the relationship of leaf composition and soil analysis. This comparison was essential because of the widespread use of soil analysis as a diagnostic tool. Experiences indicate that when used as a diagnostic tool, soil analysis did not furnish reliable information for formulating fertilizer suggestions for orchards.

In recent years many attempts have been made to further progress in the field of plant nutrition. Various efforts (1) (2) (5) (6) (11) have been made to correlate the nutrient-element content of plant tissue with that of the soil in which the plant grew. This paper presents the results of such a study made on some deciduous fruit varieties in Michigan.

Review of Literature

Lilleland and Brown (9) have shown that analyses of leaf samples from adjacent peach trees show large differences and that there are definite seasonal variations

in the analysis of leaves from peach trees. These workers also found that high soil nitrogen content was associated with low phosphorus content of the leaves and that prolonged drought would have the same effect. They state further that peach trees which are making good growth on a soil that is very low in phosphorus have a phosphorus content which approximated that found in many of the best orchards on the more fertile soils included in the survey.

Beattie and Ellenwood (1) working on apple tree nutrition in Ohio found that where nitrogen fertilizers were used, leaf nitrogen was higher and leaf potassium was lower than where no nitrogen was applied. There was an indication of a trend for leaf magnesium to be higher where nitrogen was applied.

Epstein and Lilleland (6) after some work on the manganese content of the leaves of some deciduous fruit trees, found that the total manganese content of the soil could not be correlated with the manganese content of the peach leaf.

Beckenbach, Robbins, and Shive (2) working with corn found that the magnesium content of the tissue was directly related to variation in the nitrate and calcium contents of the substrate. The calcium content of the tissue was directly affected by the nitrate content of the substrate, while the potassium content was inversely affected by the soil concentration of nitrate.

Carolus (5) working with vegetables in Virginia found that nitrogen deficiency in the presence of adequate supplies of other soil nutrients resulted in extremely high concentrations of phosphorus and low concentrations of nitrogen in the tissues. A low concentration of phosphorus in the presence of adequate supplies of other essential nutrients resulted in an extremely low concentration of phosphorus and usually in a very high concentration of nitrogen in the tissues. When potassium was deficient in the soil a high concentration in the tissues of nitrogen, magnesium, and calcium resulted. Low soil concentrations of magnesium resulted in low concentrations of magnesium and nitrogen and a high concentration of potassium in the tissues.

Lundegardh (10) states in a paper on soil conditions and nutrient requirements of plants that the total soil manganese has no great influence on the uptake of manganese by plants.

Ulrich (17), working with grapes found that there was a correlation between yields and petiole analysis for potassium, but no correlation existed between leaf analysis and the potassium content of the vineyard soil. He states that the failure to correlate soil analysis with crop responses may be caused by a difference in the ability of the grape varieties to absorb potassium from the soil.

Materials and Methods

Between July 15 and August 15, leaf samples of 100 or more leaves were collected from 100 blocks of fruit trees growing in Michigan. The following five varieties were included in the sampling: Jonathan and McIntosh apples, Elberta and Halehaven peaches, and Montmorency cherry. The number of samples of each variety varied according to the occurrence of the variety in the orchards visited. The orchards visited were of good vigor and showed no known symptoms of nutrient-element deficiency.

In each variety block, four adjacent trees were selected at random on the basis of uniformity for sampling. The leaves were collected at random from the lower limbs of the trees. Not over two leaves were taken from one shoot and shoots of average vigor for the trees were selected for sampling. The leaves collected were free of disease, insect or mechanical injury whenever possible. After the leaves were collected, all visible spray residues were removed by wiping the leaf surfaces with a damp cheesecloth. The leaves were dried at room temperature and ground with a Wiley mill, using a 20-mesh screen. The samples were sent to the National Spectrographic Laboratories, Inc., Cleveland, Ohio, to be analyzed for potassium, phosphorus, calcium, magnesium, manganese, and iron.

At the time the leaf samples were taken, 300 soil samples were also collected. The soil samples included samples from the surface soil under the spread of the limbs, the surface soil between the trees, and the subsoil between the trees, respectively (See Figure 1). The subsoil sample was taken at the B horizon. The B horizon was found at variable depths because of variations in soil types and erosion.

The soil samples were air dried and screened to remove large fragments of foreign matter such as wood, trash, and stones. The determinations for the nutrient-elements considered in this study, as well as pH determinations were made in the horticultural laboratories, using a modification of the Spurway method (15). The principal modification was in the use of an electric colorimeter rather than the color charts for making the color determinations.

Results

The averages in composition for six nutrient-elements in leaves and soils from Michigan orchards are presented in Table 1.

Apples

The leaves of Jonathan had higher concentrations of potassium (1.66%) and calcium (1.58%) than McIntosh which had 1.58 percent potassium and 1.37 percent calcium. However, the soil from the McIntosh blocks had greater

To accompany Page 5

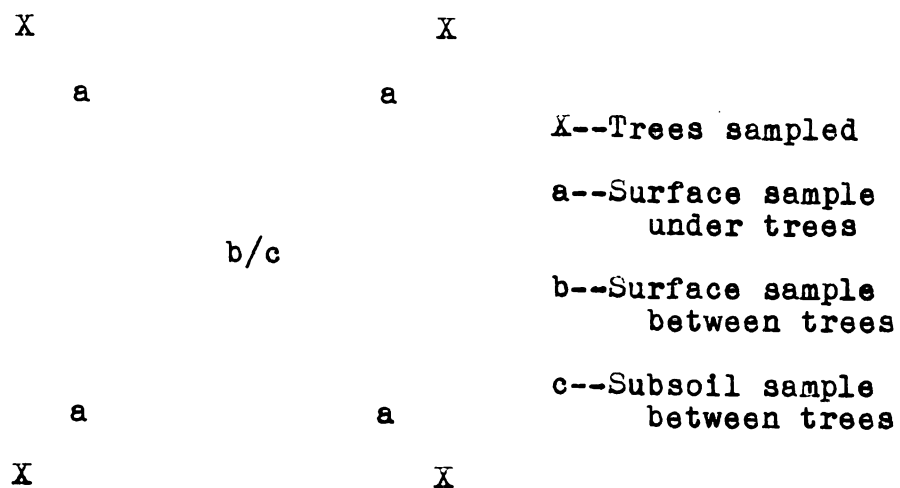


Fig. 1. Diagram of where soil samples were taken in relation to trees from which leaf samples were taken

Table 1. The Average in Composition for Six Nutrient-Elements in Leaves and Soil Samples from Michigan Orchards

Variety	Nutrient Element	Leaf Analysis %	Soil Samples			
			A	B	C	Average
			ppm	ppm	ppm	ppm
McIntosh	K	1.581	20.87	23.75	13.87	19.44
	P	0.283	6.25	5.25	5.20	5.44
	Ca	1.370	45.74	48.39	51.00	48.39
	Mg	0.439	1.84	1.88	1.47	1.71
	Mn	0.011	2.85	3.45	1.01	2.41
	Fe	0.027	18.49	11.23	9.19	11.36
	pH		4.50	4.94	4.79	4.74
Jonathan	K	1.660	18.30	17.65	10.25	15.40
	P	0.232	3.73	3.20	2.36	3.09
	Ca	1.580	33.69	45.60	42.00	40.44
	Mg	0.443	1.52	1.62	2.79	1.98
	Mn	0.011	2.29	2.91	1.05	2.08
	Fe	0.021	5.08	2.36	3.43	3.67
	pH		4.85	5.35	5.46	5.22
Elberta	K	1.590	47.30	39.20	28.30	38.25
	P	0.249	11.57	12.44	8.37	10.79
	Ca	1.915	28.60	26.10	75.80	43.50
	Mg	0.697	2.45	2.39	2.29	2.35
	Mn	0.017	4.50	3.71	1.58	3.26
	Fe	0.022	13.86	13.34	9.54	12.17
	pH		5.19	5.43	5.51	5.37
Halehaven	K	1.540	41.70	44.10	25.70	37.17
	P	0.293	9.65	9.74	3.64	7.67
	Ca	1.980	13.10	21.70	12.80	17.53
	Mg	0.633	1.40	1.46	1.33	1.39
	Mn	0.013	4.42	3.58	0.92	2.97
	Fe	0.015	14.10	13.97	13.84	13.94
	pH		5.02	5.23	5.47	5.24
Montmorency	K	1.467	31.65	27.23	18.79	24.53
	P	0.267	21.18	15.67	7.70	14.85
	Ca	1.878	39.09	41.32	108.59	62.92
	Mg	0.734	2.26	2.19	3.05	2.49
	Mn	0.011	3.02	2.48	1.18	2.23
	Fe	0.026	9.62	7.88	6.87	8.09
	pH		5.37	5.57	5.65	5.53

amounts of both potassium and calcium than the soil from the Jonathan blocks.

Both varieties contained approximately the same amounts of magnesium (0.40%), and there was no marked difference in soil analysis for the two varieties.

Phosphorus ranked next in order as the most abundant element in the leaves. McIntosh leaves contain slightly more of this element (0.28% compared to 0.23%) than Jonathan leaves, while the soil from the McIntosh blocks contained almost two times (5.44 ppm) the amount of phosphorus in the soil from the Jonathan block (3.09 ppm).

Leaves of both varieties had comparable amounts of iron (0.02%) and manganese (0.01%). The soil from the McIntosh blocks had an extremely high average content of iron (11.36 ppm) as compared to an average content of 3.67 ppm for the soil from the Jonathan blocks. The greater concentration of iron in the soil from the McIntosh blocks may be associated with soil acidity. The soil from the McIntosh blocks was more acid in reaction, having a pH of 4.7 as compared to an average pH of 5.2 for the soil from the Jonathan blocks. The manganese concentration (2.41 ppm) in the more acid soil from the McIntosh blocks is higher than the manganese content (2.08 ppm) of the soil from the Jonathan blocks.

The leaf analysis of both apple varieties show fairly

constant amounts of each of the nutrient-elements, while the concentration of potassium, phosphorus, calcium, and iron varies considerably in the soil.

Peaches and Montmorency Cherry

The leaves of Halehaven and Elberta contained approximately equal amounts of all of the nutrient-elements considered. Peach leaves differed from apple leaves in having a higher calcium than potassium content. The apple varieties had more potassium than calcium in the leaves. Both Montmorency and peach leaves contained appreciably more magnesium than apple leaves. Peach leaves have a smaller iron-manganese ratio than either apple or Montmorency leaves.

The soils for both Halehaven and Elberta show fairly constant concentrations of each of the nutrient-elements, while the soil for Montmorency contains more phosphorus, Calcium, and magnesium, and less potassium and iron than does the soil for peaches.

The iron content of all soils was rather high due, possibly, to the acid reaction of the soils. Also the glacial origin of these soils would probably result in the presence of large amounts of iron.

Phosphorus, calcium, and magnesium content of the soil was somewhat low, and may in some instances where unusually low, be limiting factors in tree growth, and fruit production.

The average manganese content of the subsoils was lower than in the surface soils. This relationship was true for all soils.

The soil was slightly more acid under the trees than between the trees. The accumulation of spray residues and the addition of acid commercial fertilizers under the trees may be the cause of this lower pH under the trees.

Correlation between Soil and Leaf Analysis

Correlation analysis were made on the results obtained in the soil and leaf analyses. The correlation coefficients obtained are presented in Table 2.

There was only an occasional significant correlation coefficient (Table 2). There would appear to be a significant correlation between the manganese content of Montmorency cherry leaves and the manganese content of the soil. The other correlation coefficients were erratic in occurrence. This would indicate that, perhaps, all of the significant correlation coefficients occurred by chance and that actually there was no correlation between soil analysis and leaf composition.

Discussion

The results of this study are in general agreement with those obtained in similar studies by other workers. Very few significant correlations have been found to exist between leaf and soil analysis for fruit trees (1) (2)

Table 2. Correlation between Leaf Analysis and Analysis of Soil Samples in Michigan Orchards

Variety	No. of Samples	Nutrient Element	Soil Samples			
			A	B	C	Average
McIntosh	13	K	.004	.190	-.087	.068
		Ca	-.170	-.261	-.215	-.247
		P	-.244	-.413	-.895**	-.443**
		Mg	-.441*	.100	-.164	-.157
		Mn	-.081	.221	.142	.020
		Fe	-.044	.012	.302	.154
Jonathan	13	K	.119	-.054	.091	.030
		Ca	-.160	-.279	-.254	-.003
		P	-.317	-.254	.046	-.257
		Mg	.537	.010	.270	.293
		Mn	-.019	-.024	-.033	-.026
		Fe	.318	.671	.021	.416
Elberta	10	K	.291	.488	.411	.450
		Ca	.032	.277	.269	-.257
		P	.420	.197	.219	.521
		Mg	.034	-.309	.155	-.032
		Mn	.120	.583	.568	.058
		Fe	.262	.253	.060	.216
Halehaven	10	K	.008	.054	.464	.178
		Ca	.005	.241	.566	.337
		P	.317	.074	.590	.019
		Mg	.168	.348	.237	.045
		Mn	-.114	.136	.236	.107
		Fe	-.307	-.600	-.514	-.539
Montmorency	22	K	.419	.367	.207	.355
		Ca	.409	.371	.048	.162
		P	.002	.031	.174	.036
		Mg	.009	.003	.002	.032
		Mn	.594**	.681**	.259	.665**
		Fe	.063	.094	.315	.002

* Significant

** Highly significant

(5) (6) (9) (11), and (16). Significant correlations between leaf and soil analysis cannot be expected for most fruit varieties when such conditions as: nutrient-element levels in the soil, climate, and rootstocks are not controlled.

The recent concept of nutrient-element balance by Shear, Crane, and Meyers (12) indicates that balance of soil nutrients whether or not total concentrations is high or low plays a dominant role in the nutrient-element content of plants. This theory states that the concentration of a nutrient-element in the soil must be considered in relation to the concentration of the other nutrient-elements in the soil.

Sudds (13), and Sudds and Yerkes (14) have shown that apple rootstocks have an influence on the performance of apple varieties. Hayward and Long (8) showed that three rootstocks commonly used in commercial peach propagation differ widely in the amounts of some of the nutrient-elements they withdrew from the soil. Thomas and White (16) report large differences in the ability of four different peach rootstocks to take up minerals from the soil.

Rootstocks for fruit tree propagation are obtained largely by growing seedlings of the species desired. This results in all of them being genetically unlike. Wide variations are to be expected in genetically unlike seedlings. Some of the easily observed variations are: type and amount of top growth, as well as size and density of

root system. Sax (11), after experiments with apple rootstocks, states that clonal rootstocks are more uniform than are sexually reproduced seedlings and that greater uniformity of trees propagated on clonal stock may be expected.

Leaf analysis has been shown by Lilleland and Brown (9) to vary throughout the growing season. Goodall (7) showed that the position of the leaves on the trees has an influence on the leaf content of some nutrient-elements. He reports that iron and potassium concentration was greater in leaves from flowering spurs than in leaves from non-flowering spurs.

The influence of climate may be greater than that of soil on nutrient-element uptake by plants, as demonstrated by LeClerc and Yoder (4) in tri-local soil exchange experiments with wheat. They found that wheat grown on Maryland soil in Kansas contained 6.13 per cent more protein, and 5.01 per cent more potassium in its ash than wheat grown on Maryland soil in Maryland, while wheat grown on Kansas soil in Kansas had 7.88 per cent more protein, and 5.96 per cent more potassium in its ash than the wheat grown in Kansas soil in Maryland. Borden (4), working with sugar cane in 1935 showed that the influence of climate may prevail over the soil influence in localities only a few miles apart.

Summary

Leaf and soil samples from some deciduous fruit orchards were collected and analyzed for six nutrient-elements. No significant correlation between leaf and soil analysis was found for the elements under consideration.

The order of greatest concentration is reversed for potassium and calcium in the foliage of the drupe and pome varieties; apple foliage had more calcium than potassium, while the Montmorency cherry and peach foliage had more potassium than calcium.

The results of this study indicate that the nutrient-element content of fruit tree leaves from Michigan orchards is not directly related to, or affected by, the total concentration of the nutrient-elements in the orchard soils.

No definite indication of an inter-relation or interaction of one nutrient-element upon another is shown by the data compiled in this study.

The various biological, physiological and chemical factors involved in the absorption of nutrient-elements has as great, if not a greater, influence upon leaf analysis than the availability of the elements in the soil.

Factors which were not controlled such as climate, rootstock, and response to fruiting, which influence the uptake of nutrient-elements by fruit trees in the field, possibly cause the failure of leaf analysis to reflect, element for element, the level of each in the soil.

Boynton and Compton (3) after some experiments at Cornell with fruit trees, concluded that the chemical analysis of leaves cannot, as yet, take the place of careful observations of plant behavior and appearance, of the development of visible leaf or fruit symptoms, and of past climatic and management conditions, but that when coupled with such observations the chemical analysis of leaves makes diagnosis possible, which neither alone would have permitted.

The relation of mineral nutrition of fruit trees to growth and yields is of a complex nature. New tissue growth in early spring is largely at the expense of stored reserves, while yields are the result of fruit bud formation, fruit setting, and subsequent development. It is known that relatively larger amounts of potassium and phosphorus are required for fruit production than for vegetative growth alone, and that more of these two nutrient-elements enters the fruit than falls with the leaves. The magnitude of this influence in relation to studies in foliar diagnosis requires investigation.

Literature Cited

1. Beattie, James M. and Ellenwood, C. W.
A survey of the nutrient status of Ohio apple trees.
Proc. Amer. Soc. Hort. Sci. 55: 47-55. 1950.
2. Beckenbach, J. R., Robbins, W. R., and Shive, J. W.
A statistical interpretation of the relation between the ionic concentration of the culture solution and the element content of the tissues.
Soil Sci. 45: 403-426. 1938.
3. Boynton, D., and Compton, O. C.
Leaf analysis in estimating the potassium, magnesium, and nitrogen needs of fruit trees. Soil Sci. 59: 339. 1945.
4. Browne, C. A.
Some relationships of soil to plant and animal nutrition--The major elements. Soils and Men. Yearbook, United States Department of Agriculture. 788-792. 1938.
5. Carolus, R. L.
The use of rapid chemical plant nutrient tests in fertilizer deficiency diagnosis and vegetable crop research. Va. Truck Sta. Bul. 98: 1527-1556. 1938.
6. Epstein, Emanuel and Lilleland, Omund
A preliminary study of the manganese content of the leaves of some deciduous fruit trees. Proc. Amer. Soc. Hort. Sci. 41: 11-18. 1942.
7. Goodall, D. W.
The mineral composition of different types of leaf on apple trees in early summer. Jour. Pomology Hort. Sci. 21: 103-107. 1945.
8. Hayward, H. E. and Long, E. M.
Vegetative responses of the Elberta peach on Lovell and Shalil rootstocks to high chloride and sulfate solutions. Proc. Amer. Soc. Hort. Sci. 41: 149-155. 1942.
9. Lilleland, Omund and Brown, J. G.
The phosphate nutrition of fruit trees IV. The Phosphate content of peach leaves from 130 orchards in California and some factors which may influence it. Proc. Amer. Soc. Hort. Sci. 41: 1-10. 1942.

10. Lundegardh, H.
Soil conditions and nutrient requirements of plants.
Kgl. Landtbruks--Akad. Handl. Tid. 73: 225-289.
1934.
11. Sax, Karl.
The use of Malus species for apple rootstocks. Proc.
Amer. Soc. Hort. Sci. 53: 219-220. 1949.
12. Shear, C. B., Crane, H. L., and Meyers, A. T.
Nutrient-element balance; application of the concept
to the interpretation of foliar analysis. Proc.
Amer. Soc. Hort. Sci. 51: 319-326. 1948.
13. Sudds, R. H.
Sixteen years results of orchard tests with apple
trees on selected rootstocks. Kearneysville, West
Va. Proc. Amer. Soc. Hort. Sci. 54: 144-148. 1949.
14. _____ and Yerkes, G. E.
Influence of the stocks on the performance of cer-
tain apple varieties. Proc. Amer. Soc. Hort. Sci.
36: 116-120. 1938.
15. Spurway, C. H. and Lawton K.
Soil testing. Mich. Agr. Exp. Sta. Tech. Bul. 132
(4th revision). 1949.
16. Thomas, Frank B. and White, David G.
Foliar analysis of four varieties of peach rootstocks
grown at high and low potassium levels. Proc. Amer.
Soc. Hort. Sci. 55: 56-60. 1950.
17. Ulrich, Albert.
Potassium content of grape leaf petioles and blades
contrasted with soil analysis as an indicator of the
potassium status of the plant. Proc. Amer. Soc.
Hort. Sci. 41: 204-212. 1942.

Appendix Table 1. Leaf Analysis in Per cent Dry Weight

No. of Sample	P	K	Ca	Mg	Mn	Fe
<u>McIntosh Apple</u>						
4	.270	2.31	1.49	.635	.017	.063
6	.205	1.38	2.64	.460	.008	.008
9	.173	1.01	1.30	.343	.004	.004
18	.585	2.00	2.32	.335	.009	.025
22	.199	0.68	1.11	.423	.008	.009
23	.749	2.07	1.67	.745	.019	.006
26	.461	1.63	2.00	.445	.009	.018
29	.267	1.46	1.00	.317	.006	.026
33	.184	1.30	1.12	.385	.008	.039
45	.340	1.18	1.67	.480	.012	.049
48	.687	2.61	2.28	.522	.017	.058
57	.315	1.56	2.16	.334	.014	.036
64	.515	1.95	1.57	.523	.013	.047
73	.250	2.38	1.29	.557	.015	.046
76	.135	1.19	0.96	.435	.008	.022
77	.143	1.23	0.76	.450	.015	.040
79	.120	1.31	0.73	.410	.012	.011
82	.140	1.86	0.81	.410	.010	.025
85	.097	1.92	0.81	.451	.005	.013
89	.160	1.61	0.97	.355	.009	.015
96	.104	1.36	0.97	.426	.007	.016
100	.117	1.39	0.90	.278	.006	.025
<u>Jonathan Apple</u>						
2	.113	1.19	1.77	.395	.017	.004
19	.240	1.33	1.14	.320	.005	.009
31	.268	1.04	1.36	.292	.010	.026
52	.315	1.51	2.04	.585	.012	.048
55	.139	0.60	1.25	.393	.004	.005
58	.120	2.58	2.67	.435	.014	.025
62	.538	1.94	2.21	.478	.013	.049
63	.403	1.71	2.45	.540	.017	.033
66	.350	2.82	1.89	.619	.019	.078
81	.152	1.68	0.84	.382	.010	.034
83	.194	2.30	1.24	.520	.015	.027
88	.100	1.91	0.92	.367	.007	.010
97	.090	0.88	0.80	.382	.004	.009

Appendix Table 1 Cont'd.

No. of Sample	P	K	Ca	Mg	Mn	Fe
<u>Elberta Peach</u>						
8	.116	1.42	1.88	.410	.004	.004
20	.170	1.29	2.40	.730	.002	.012
43	.240	0.83	2.47	.920	.010	.004
47	.495	1.89	1.89	.600	.080	.043
51	.487	1.39	2.71	.870	.019	.044
59	.271	2.35	1.58	.443	.012	.022
65	.382	2.25	2.00	.145	.022	.054
93	.140	1.48	1.61	.676	.007	.009
94	.092	1.34	1.37	.450	.007	.009
99	.095	1.66	1.24	.430	.009	.011
<u>Halehaven Peach</u>						
1	.350	1.32	2.65	.610	.009	.004
7	.100	1.10	1.83	.430	.004	.003
10	.275	1.82	2.38	.576	.005	.006
24	.720	2.07	1.68	.750	.019	.006
27	.310	1.16	1.90	.720	.020	.021
32	.367	1.08	2.10	.550	.007	.004
74	.228	1.38	1.50	.631	.014	.029
75	.227	1.75	1.75	.650	.027	.038
92	.125	1.07	1.39	.511	.007	.010
98	.227	2.63	2.67	.900	.015	.031
<u>Montmorency Cherry</u>						
3	.117	1.21	2.13	.63	.005	.002
5	.145	1.25	2.50	.65	.006	.002
11	.155	0.96	1.34	.48	.003	.002
21	.293	1.33	1.63	.67	.008	.009
25	.670	1.33	1.08	.54	.006	.006
30	.310	0.41	1.56	.54	.013	.026
44	.523	1.56	2.93	.78	.021	.008
46	.366	1.46	2.37	.61	.011	.039
49	.389	1.09	2.59	.98	.010	.049
53	.620	2.39	3.00	1.13	.011	.073
54	.203	0.74	1.48	.75	.006	.030
60	.200	2.56	2.65	1.03	.013	.026
67	.169	1.49	1.35	.54	.015	.051
68	.365	2.57	2.39	1.02	.028	.073
69	.267	1.65	2.03	.83	.013	.041
70	.403	2.82	2.45	.88	.017	.074

Appendix Table 1 Cont'd.

No. of Sample	P	K	Ca	Mg	Mn	Fe
<u>Montmorency Cont'd</u>						
80	.115	1.49	0.91	.45	.009	.009
86	.112	1.29	1.47	.78	.012	.010
87	.165	1.21	1.69	.82	.010	.005
90	.094	1.31	1.05	.40	.007	.011
91	.093	.94	1.35	.57	.005	.009
95	.102	1.22	1.37	.66	.006	.010

Appendix Table 2. Soil Analysis in ppm

Sample No.		P	K	Ca	Mg	Mn	Fe	pH
<u>McIntosh Apples</u>								
4	Soil A	2.1	11.0	29	1.6	2.5	12.0	4.4
	" B	6.3	7.2	30	2.2	2.4	11.0	5.0
	" C	7.6	11.0	30	1.3	1.7	10.0	4.3
6	Soil A	2.1	13.0	29	1.6	2.4	13.0	3.8
	" B	1.3	29.0	30	2.0	2.5	8.4	4.5
	" C	6.7	11.0	29	1.3	0.4	5.2	4.6
9	Soil A	1.3	14.0	29	1.8	2.5	10.1	4.5
	" B	6.3	51.0	30	2.0	2.1	7.6	5.0
	" C	5.9	21.0	29	1.3	0.3	0.3	5.3
18	Soil A	3.4	12.0	71	1.7	5.7	20.0	4.8
	" B	3.1	31.0	30	1.9	5.7	20.0	4.5
	" C	0.7	13.0	29	1.3	1.1	20.0	4.6
22	Soil A	3.5	11.0	29	1.8	2.7	31.0	3.7
	" B	3.0	8.7	31	2.3	7.1	30.0	3.8
	" C	1.3	12.0	30	0.9	1.0	15.0	4.8
23	Soil A	4.6	12.0	29	1.8	3.8	20.0	4.2
	" B	3.5	42.0	29	2.1	7.1	10.0	4.2
	" C	1.3	9.5	29	1.3	2.0	10.0	4.7
26	Soil A	5.9	11.0	29	1.8	3.8	20.0	4.2
	" B	3.3	32.0	29	2.1	7.1	10.0	4.2
	" C	3.1	13.0	29	1.3	2.0	10.0	4.7
28	Soil A	5.9	32.0	29	1.9	1.1	2.0	4.7
	" B	1.1	29.0	29	1.8	1.1	10.0	4.4
	" C	7.0	9.5	29	1.3	0.7	0.8	4.4
29	Soil A	6.3	16.0	31	2.2	1.5	8.0	5.5
	" B	1.9	7.2	29	1.6	1.3	4.4	5.9
	" C	6.9	12.0	33	1.8	1.0	20.0	5.1
33	Soil A	1.1	18.0	29.	1.9	2.1	0.4	4.6
	" B	6.3	48.0	29	1.9	3.3	10.0	5.1
	" C	5.0	16.0	34	1.3	0.2	22.0	4.9
45	Soil A	2.2	13.0	34	1.8	3.5	5.4	4.5
	" B	2.3	7.7	33	1.8	3.5	10.0	4.7
	" C	2.2	11.0	30	1.6	1.1	18.0	4.5
48	Soil A	8.0	12.0	29	1.7	6.5	17.0	4.4
	" B	2.7	57.0	29	1.7	7.5	18.0	4.8
	" C	1.7	8.7	29	1.2	1.1	14.0	4.9

Appendix Table 2 Cont'd

Sample No.			P	K	Ca	Mg	Mn	Fe	pH
<u>McIntosh Apples Cont'd</u>									
57	Soil	A	3.2	12.0	30	1.6	3.5	22.0	3.9
	"	B	0.8	9.2	30	1.6	4.4	20.0	4.5
		C	3.3	6.7	29	1.0	1.2	0.4	4.5
64	Soil	A	4.2	15.0	31	1.7	1.6	14.0	4.7
	"	B	1.5	10.0	32	1.6	1.2	10.0	5.3
	"	C	2.3	5.3	29	1.2	0.6	7.6	4.7
73	Soil	A	8.0	13.0	29	1.6	2.1	21.0	4.5
	"	B	3.7	13.0	29	1.7	2.2	3.6	5.5
	"	C	2.4	10.0	29	1.7	0.7	3.6	5.6
76	Soil	A	5.9	12.0	31	1.8	2.1	17.0	4.3
	"	B	3.8	8.7	29	1.6	2.2	19.0	4.3
	"	C	2.0	6.3	31	1.4	0.8	4.0	4.5
77	Soil	A	2.2	12.0	29	1.6	0.3	19.0	4.1
	"	B	2.8	9.2	29	1.6	0.3	10.0	4.2
	"	C	5.9	7.2	34	1.5	0.2	9.0	4.3
79	Soil	A	2.3	12.0	29	1.9	2.0	19.0	4.2
	"	B	2.9	5.3	30	1.4	1.7	9.0	4.2
	"	C	6.3	6.7	34	1.4	1.2	8.0	4.2
82	Soil	A	2.6	13.0	29	1.6	1.4	11.0	4.2
	"	B	1.5	14.0	74	1.7	1.5	4.1	6.2
	"	C	6.7	11.0	30	1.4	0.2	8.2	4.8
85	Soil	A	17.0	75.0	360	2.0	7.9	4.4	5.6
	"	B	18.6	43.0	370	2.5	6.7	6.0	6.1
	"	C	18.0	36.0	540	2.3	2.2	5.2	6.5
89	Soil	A	12.0	75.0	29	2.2	3.8	6.0	5.3
	"	B	7.0	22.0	76	2.2	2.5	1.2	5.9
	"	C	13.0	17.0	10	2.0	0.4	0.2	5.3
96	Soil	A	18.0	34.0	29	2.2	2.0	14.0	4.5
	"	B	15.0	31.0	27	1.9	6.7	11.0	5.0
	"	C	5.4	35.0	29	2.0	1.8	7.6	4.9
100	Soil	A	22.0	32.0	29	2.3	4.4	17.0	4.8
	"	B	22.0	31.0	29	2.2	3.1	15.0	5.0
	"	C	5.0	30.0	18	1.9	1.9	8.4	4.9

Appendix Table 2 Cont'd

Sample No.			P	K	Ca	Mg	Mn	Fe	pH
<u>Jonathan Apples</u>									
2	Soil	A	5.6	6.0	20	1.1	1.0	2.8	4.2
	"	B	2.8	8.7	18	1.3	0.9	0.3	5.8
	"	C	1.3	12.0	17	1.4	0.3	0.1	5.6
19	Soil	A	4.0	48.0	27	1.0	4.0	11.0	5.2
	"	B	3.7	14.5	10	1.7	4.6	2.8	5.5
	"	C	1.8	3.2	9	2.0	0.8	2.8	5.0
31	Soil	A	2.5	11.0	20	1.8	2.1	9.2	4.9
	"	B	2.8	25.5	20	1.6	0.4	0.3	5.1
	"	C	3.7	3.2	29	1.7	0.4	1.2	5.7
52	Soil	A	6.3	3.6	5	1.7	0.7	3.6	5.0
	"	B	1.9	2.0	27	1.6	0.7	0.5	5.6
	"	C	2.8	6.0	18	2.2	1.1	0.5	5.2
55	Soil	A	0.85	12.0	14	1.6	0.8	3.6	4.6
	"	B	2.80	5.3	10	1.2	1.8	2.0	4.6
	"	C	2.20	4.8	20	1.5	0.6	0.4	5.2
58	Soil	A	0.62	3.2	10	1.4	2.6	3.6	4.3
	"	B	0.10	1.5	29	1.6	3.3	2.0	4.6
	"	C	1.40	1.5	8	1.3	1.1	1.2	5.0
62	Soil	A	1.1	4.3	27	1.5	0.7	2.8	5.0
	"	B	2.5	2.6	8	1.3	0.4	3.6	5.9
	"	C	3.0	6.0	18	2.1	0.4	4.4	4.8
63	Soil	A	0.60	30.5	29	1.6	4.2	11.0	4.4
	"	B	1.00	4.8	20	1.5	7.1	6.4	4.8
	"	C	0.10	5.3	29	1.8	0.7	3.6	4.8
66	Soil	A	6.3	7.7	18	1.9	0.8	9.2	4.5
	"	B	5.4	3.6	29	1.9	0.7	7.6	4.3
	"	C	3.7	6.3	14	1.9	0.3	5.2	4.7
81	Soil	A	4.0	3.6	18	1.6	1.4	6.8	5.2
	"	B	2.7	26.0	162	1.9	1.6	0.4	6.7
	"	C	2.4	17.0	10	1.7	0.2	6.8	5.7
83	Soil	A	3.5	49.0	205	1.9	3.6	2.0	6.6
	"	B	4.2	45.0	240	1.8	3.6	4.4	7.4
	"	C	1.7	18.0	250	16.0	2.2	0.1	8.4
88	Soil	A	6.8	54.0	18	1.5	5.7	0.1	4.6
	"	B	5.2	46.0	10	2.0	8.7	0.1	4.5
	"	C	3.2	36.0	119	1.5	3.6	19.0	6.1

Appendix Table 2 Cont'd

Sample No.		P	K	Ca	Mg	Mn	Fe	pH
<u>Jonathan Apples Cont'd</u>								
97	Soil A	6.3	5.0	27	1.4	2.1	0.4	4.6
	" B	6.5	44.0	10	1.9	4.0	0.4	4.7
	" C	3.3	14.0	5	1.4	1.9	0.3	4.8
<u>Elberta Peach</u>								
8	Soil A	7.9	43.0	29	2.7	1.8	8.4	5.7
	" B	11.2	51.0	18	1.9	1.7	4.4	5.7
	" C	4.7	13	29	2.4	0.5	2.0	5.5
20	Soil A	9.4	37.0	27	1.9	7.5	13.6	5.0
	" B	10.0	54.0	29	2.8	7.6	16.8	5.2
	" C	3.6	6.0	28	2.7	1.9	6.0	4.9
43	Soil A	4.7	42.0	29	2.4	6.5	10.0	5.6
	" B	4.7	56.0	29	2.2	3.0	9.2	5.8
	" C	2.6	38.1	29	2.4	0.6	10.0	5.2
47	Soil A	7.2	41.0	29	2.1	2.9	10.0	4.6
	" B	12.6	41.0	29	2.3	3.5	15.0	4.6
	" C	1.7	45	20	2.1	3.1	6.8	4.7
51	Soil A	8.2	49.0	29	2.4	7.9	6.8	4.6
	" B	20.0	35.3	29	2.3	4.2	2.8	5.0
	" C	15.6	21.7	29	2.4	1.1	2.8	5.0
59	Soil A	20.1	22.0	29	2.4	2.3	7.6	4.5
	" B	20.1	42.5	29	2.3	2.2	7.6	5.0
	" C	9.4	34.5	10	2.0	0.4	0.2	5.2
65	Soil A	9.4	51.0	27	2.8	6.7	30.0	5.0
	" B	7.2	7.0	22	2.0	8.2	27.0	5.2
	" C	5.1	20.0	29	2.4	2.6	19.4	5.2
93	Soil A	8.8	44.0	29	2.2	2.3	13.2	5.8
	" B	9.6	7.0	29	2.2	1.7	13.2	5.8
	" C	13.0	43.0	460	1.6	1.7	19.4	7.1
94	Soil A	22.0	90.0	27	3.2	2.5	15.0	5.7
	" B	16.0	61.0	29	2.5	1.9	18.0	5.9
	" C	13.0	27.0	95	2.4	1.1	10.0	6.3
99	Soil A	18.0	54.0	29	2.4	4.6	24.0	5.4
	" B	13.0	37.0	20	2.5	3.1	19.4	6.1
	" C	15.0	34.0	29	2.5	2.8	18.0	6.0

Appendix Table 2 Cont'd

Sample No.			P	K	Ca	Mg	Mn	Fe	pH
			<u>Halehaven Peach</u>						
1	Soil	A	11.0	14.0	20	1.4	7.6	20.0	4.5
	"	B	19.0	18.0	5	1.1	7.1	30.0	4.8
	"	C	6.7	26.0	10	1.3	2.0	20.0	4.9
7	Soil	A	4.3	54.5	18	1.4	3.6	27.0	5.6
	"	B	10.0	87.5	29	1.6	4.6	30.0	6.0
	"	C	3.3	35.0	10	1.0	1.1	35.0	6.0
10	Soil	A	7.2	80.0	27	1.6	2.2	18.0	5.6
	"	B	9.2	68.0	29	1.5	2.4	15.0	6.0
	"	C	1.9	34.0	5	1.3	0.4	8.6	6.0
24	Soil	A	14.6	28.0	10	1.3	6.5	8.6	4.2
	"	B	11.7	51.0	5	1.3	5.5	30.0	4.6
	"	C	3.5	41.0	5	1.5	0.8	31.0	5.1
27	Soil	A	13.0	39.0	5	1.1	2.8	35.0	4.4
	"	B	6.0	43.0	18	1.5	3.2	20.0	4.6
	"	C	5.0	34.0	10	1.2	1.0	17.0	4.6
32	Soil	A	6.1	42.0	20	1.2	2.9	9.2	4.7
	"	B	4.3	22.0	18	1.3	2.0	2.0	5.7
	"	C	4.0	15.0	10	1.3	0.5	6.8	5.4
74	Soil	A	4.4	32.0	28	1.7	5.5	10.0	5.1
	"	B	2.1	37.0	29	1.5	2.4	6.0	5.8
	"	C	0.9	7.0	29	1.2	1.0	0.4	5.8
75	Soil	A	1.3	34.0	5	1.6	5.2	2.8	5.1
	"	B	2.8	29.5	28	1.7	4.4	0.3	5.5
	"	C	0.8	7.5	10	1.7	0.4	9.2	5.7
92	Soil	A	14.6	51.0	30	1.3	6.0	2.8	5.4
	"	B	13.4	42.0	29	1.9	2.7	3.6	5.5
	"	C	6.3	17.0	29	1.5	1.1	5.2	6.0
98	Soil	A	20.0	43.0	18	1.6	1.9	7.6	5.4
	"	B	18.9	43.0	27	1.4	1.5	2.8	5.8
	"	C	4.0	40.0	10	1.4	0.9	5.2	5.2

Appendix Table 2 Cont'd

Sample No.		P	K	Ca	Mg	Mn	Fe	pH
<u>Montmorency Cherry</u>								
3	Soil A	15.0	44.0	29	2.0	4.0	1.8	5.4
	" B	16.0	40.0	29	1.8	3.6	5.6	5.9
	" C	10.0	22.0	18	2.0	0.4	5.6	5.2
5	Soil A	18.0	8.7	27	2.2	3.1	4.0	5.2
	" B	12.0	9.2	29	2.3	2.9	2.4	5.2
	" C	6.1	7.2	29	1.9	1.6	10.0	4.9
11	Soil A	13.0	6.7	29	1.8	1.4	9.2	5.7
	" B	13.0	7.5	27	2.0	1.5	9.2	5.7
	" C	13.0	7.2	29	1.9	1.1	8.4	5.3
21	Soil A	12.0	8.7	27	2.2	2.3	20.0	4.8
	" B	3.7	7.7	29	2.1	1.7	10.0	5.1
	" C	12.0	10.0	49	2.4	1.1	8.0	5.4
25	Soil A	20.0	10.0	20	2.4	0.7	1.8	4.8
	" B	15.0	10.5	28	2.5	0.3	1.9	5.1
	" C	8.2	7.7	27	2.1	0.1	7.6	5.2
30	Soil A	15.0	9.2	29	2.3	3.0	1.0	5.8
	" B	12.0	8.7	18	2.2	4.2	10.0	5.6
	" C	8.8	7.5	27	2.0	0.2	2.8	5.8
44	Soil A	18.0	9.2	240	2.3	5.2	6.0	6.2
	" B	15.0	8.7	400	2.2	6.0	1.8	6.4
	" C	9.3	7.5	400	2.0	2.7	9.2	5.8
46	Soil A	75.0	7.5	74	2.0	2.9	12.0	6.2
	" B	6.7	10.0	29	2.4	2.2	8.0	5.9
	" C	5.5	9.2	29	2.3	0.3	8.0	5.2
49	Soil A	7.4	9.2	29	2.3	6.7	4.0	5.5
	" B	15.0	7.7	30	2.1	4.6	3.6	5.8
	" C	4.5	8.7	20	2.2	2.2	2.8	5.7
53	Soil A	18.0	53.0	29	2.5	6.7	9.0	4.9
	" B	15.0	46.0	18	2.0	3.0	4.4	5.0
	" C	2.2	16.5	28	2.2	2.0	5.2	4.5
54	Soil A	30.0	48.0	29	2.2	2.6	8.4	5.5
	" B	21.0	42.0	28	2.2	2.2	7.6	5.6
	" C	2.6	22.0	20	2.1	0.8	3.6	5.6
60	Soil A	34.0	51.0	30	2.0	2.2	10.0	5.2
	" B	34.0	45.0	28	2.3	2.2	9.0	5.2
	" C	12.0	26.0	28	2.2	1.1	6.0	5.3

Appendix Table 2 Cont'd

Sample No.		P	K	Ca	Mg	Mn	Fe	pH
<u>Montmorency Cherry Cont'd</u>								
67	Soil A	29.0	55.0	28	2.1	2.4	8.0	4.8
	" B	18.0	47.0	29	2.1	1.8	6.4	5.4
	" C	9.0	30.0	29	2.5	0.4	2.0	5.2
68	Soil A	8.0	55.0	30	2.5	6.7	15.0	5.4
	" B	9.0	42.0	27	2.5	6.0	12.0	5.7
	" C	1.4	22.0	30	2.7	1.1	8.4	5.7
69	Soil A	16.0	30.0	29	2.2	4.0	8.4	5.9
	" B	19.0	28.0	27	2.1	0.4	11.0	6.0
	" C	20.0	26.0	30	2.7	3.0	10.0	5.1
70	Soil A	25.0	45.0	29	2.1	2.8	12.0	5.6
	" B	30.0	31.0	18	2.0	2.7	10.0	5.2
	" C	4.6	25.0	10	2.3	0.4	6.8	5.2
80	Soil A	30.0	32.0	29	2.8	1.1	12.0	5.5
	" B	18.0	22.0	29	2.4	0.4	6.0	5.6
	" C	6.1	24.0	5	2.5	0.4	10.0	5.0
86	Soil A	24.0	36.0	27	2.5	1.5	20.0	5.3
	" B	24.0	46.0	29	2.1	2.3	16.0	6.0
	" C	0.5	31.0	500	10.0	2.3	6.0	8.1
87	Soil A	24.0	51.0	29	2.4	1.8	10.0	4.4
	" B	21.0	39.0	29	2.1	1.8	9.0	4.8
	" C	0.5	27.0	600	12.0	2.7	0.1	8.3
90	Soil A	19.0	27.0	18	2.2	1.1	12.0	5.0
	" B	15.0	26.0	18	1.8	1.1	10.0	5.1
	" C	18.0	19.0	28	2.5	0.4	11.0	5.4
91	Soil A	6.5	53.0	29	2.5	2.4	15.0	5.2
	" B	9.0	41.0	5	2.4	2.3	12.0	5.2
	" C	5.4	29.0	29	2.0	0.5	10.0	5.4
95	Soil A	9.0	47.0	30	2.2	1.8	12.0	6.0
	" B	3.2	34.0	29	2.5	1.5	7.6	7.0
	" C	10.0	29.0	400	2.5	1.2	7.6	7.0

ROOM USE ONLY

ROOM USE ONLY

MICHIGAN STATE UNIVERSITY LIBRARIES



3 1293 03085 2317