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A LEAF ANALYSES SURVEY
OF APPLE ORCHARDS
IN WEST VIRGINIA

West Virginia University
Agricultural Experiment Station

SUMMARY

A leaf analyses survey was made in 1950 as the first part of a general apple nutrition project undertaken by the West Virginia University Agricultural Experiment Station. Nitrogen, phosphorus, potassium, calcium, and magnesium determinations were made on 209 leaf samples collected from orchards growing in limestone, shale, and chert soils. In a few orchards the levels of nitrogen, potassium, and magnesium in the leaves were below the generally accepted critical levels; however, no serious deficiencies existed. The survey supports the continued recommendation of nitrogen only as a fertilizer for apple orchards in West Virginia.

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A LEAF ANALYSES SURVEY OF APPLE ORCHARDS IN WEST VIRGINIA

A. H. Thompson, R. S. Marsh, and O. E. Schubert

Introduction

Since the need for annual applications of nitrogen to apple trees in West Virginia was first demonstrated in 1920 (1), the use of nitrogen fertilizers has been a standard commercial practice throughout the State. There has been much variation, however, in the attention given to this matter by apple growers. Many growers have applied adequate amounts of nitrogen to insure maximum growth and yield. Others have not maintained necessary levels of nitrogen in their apple orchards, and yields of fruit have been smaller. Although most apple growers of the State recognize the need for nitrogen, the majority have used only the minimum amount necessary for satisfactory yields.

The West Virginia University Agricultural Experiment Station has recommended use of nitrogen fertilizers in apple orchards for about thirty years. During this period some work has been done with other elements known to be necessary for plant growth. So far no evidence has been obtained to show a need for any element other than nitrogen in the orchard fertilizer application, with the exception of boron in a few scattered orchards.

Recent work (4,5,9,11,12) has indicated that deficiencies of potassium and magnesium are present in orchards from New England down the Atlantic seaboard to Maryland. Although most of these deficiencies have been encountered in peach orchards that have been cultivated for many years, several instances of low potassium and low magnesium have been found in apple orchards. These discoveries have been made by means of chemical analyses of leaves taken from the various orchards studied. Leaf analysis as a method for the diagnosis of mineral deficiencies is becoming widely used in the United States. By itself it often is not conclusive evidence of the tree's nutritional status. Leaf analysis, however, offers a possibility of obtaining first-hand information on the approximate nutrient status of fruit trees. In this way it is not necessary to resort to expensive and time-consuming orchard fertilizer experiments. Such experiments usually are impossible on a State-wide basis.

Leaf analyses are now widely regarded as essential forerunner of any fertilizer experiment on apple trees. Frequently in the past negative results have been obtained from sound fertilizer experiments. Leaf analyses would have eliminated many blocks of trees from consideration as a site for some of these experiments simply because the element or elements in question were already present in the trees in sufficient amounts.

Leaf analyses, then, for experimental purposes afford an inexpensive and rapid means of determining the mineral nutrient status of a given orchard. This method also makes it possible to survey rather quickly many apple orchards in a given area for the purpose of determining if deficiencies exist as well as the extent to which such deficiencies occur.

THE SURVEY

An apple nutrition project was started in 1950 at the West Virginia University Agricultural Experiment Station since deficiencies of potassium and magnesium are known to exist in near-by areas. Also certain information concerning the nutritional status of apple trees would be invaluable in the event deficiencies were found. A survey was planned to determine the nutrient status of West Virginia apple orchards as measured by leaf analyses. For this purpose, samples of leaves were collected from seventy-one orchards in the State between July 11 and August 11, 1950. Five median leaves on current season's growth were taken from each of three trees for a sample. The leaves were oven dried and ground in a Wiley mill. With the exception of the University orchard at Morgantown, the orchards sampled were located in Hampshire, Morgan, Berkeley, and Jefferson counties. The varieties sampled included York, Stayman, Delicious, Rome, Grimes and Golden Delicious. The 209 samples collected were analyzed in the laboratory of the University Experiment Farm at Kearneysville in the winter of 1950-51. Analyses were made according to methods outlined by Lindner (10). Determinations were made to include the nitrogen, phosphorus, potassium, calcium, and magnesium content of each sample.

The apple orchards in the Eastern Panhandle of West Virginia are growing on three general soil classes: limestone, shale, and chert. When the leaf analyses were summarized according to these three soil classes, certain interesting trends were noted. As can be seen in Table 1, it was found that the nitrogen content of leaves was lowest in trees growing in limestone soils.

Table 1. Leaf analyses of apple orchards summarized according to soil classes.

Soil Class	No. of Samples	Mineral content as per cent of dry weight				
		nitrogen	phosphorus	potassium	calcium	magnesium
limestone	115	1.93	.198	1.83	1.32	.294
shale	72	2.11	.190	1.68	1.17	.302
chert	17	2.12	.198	1.53	1.19	.268
LSD*		.102		.118	.120	

*Least Significant Difference.

Trees growing in shale and chert soils were higher in leaf nitrogen content, averaging 2.11 and 2.12 per cent respectively, the difference over limestone being significant at the 5 per cent level. The potassium content of leaves was less in the shale and chert orchards than in those orchards growing in limestone soil; the differences were statistically significant. The magnesium level of leaves in orchards growing in limestone and shale was somewhat above that of trees grown in chert soils, possibly a chance result.

No great differences in nitrogen content of leaves were recorded for the different varieties considered (See Table 2). Stayman trees averaged lower in nitrogen than all others, and Delicious, Grimes Golden, Golden Delicious, and York were definitely above the lowest Stayman. York was distinctly lowest, and Stayman and Rome Beauty leaves were intermediate in potassium content. This is in agreement with results of Batjer and Magness (2), who in a national survey of the potassium content of apple leaves, found that York and Jonathan leaves were significantly lower than Delicious leaves, whereas the potassium content of Rome Beauty leaves was intermediate. Grimes, Red Delicious, and Rome as a group are significantly higher in phosphorus content than York, Stayman, and Golden Delicious as a group. Calcium determinations showed that Delicious leaves were significantly lower in calcium than several other varieties, whereas Golden Delicious leaves were significantly higher than Rome, Stayman, and Delicious. Stayman leaves were the lowest in magnesium when compared to the other varieties in this survey. Although the average magnesium content of Stayman leaves was well above the critical level, it will be shown later that several samples of Stayman leaves were found below the critical level.

Many West Virginia apple orchards include blocks of trees that have produced fruit for thirty years or more. Many old trees do not produce as heavily as younger trees, and older orchards are generally more expensive to operate than young bearing orchards. In view of

Table 2. Leaf analyses of apple orchards summarized according to variety.

Variety	No. of orchards	Mineral content expressed as per cent of dry weight				
		nitrogen	phosphorus	potassium	calcium	magnesium
York Imperial	54	2.02	.179	1.35	1.33	.283
Delicious	38	2.06	.204	2.04	1.12	.298
Stayman	48	1.91	.175	1.75	1.24	.273
Rome Beauty	25	1.97	.197	1.84	1.21	.312
Grimes						
Golden	28	2.11	.212	1.95	1.37	.327
Golden						
Delicious	11	2.04	.175	1.97	1.41	.324
LSD*		.128	.014	.147	.150	.0376

* Least Significant Difference

these facts, it is of interest to consider the mineral content of apple leaves as affected by the age of the trees. In Table 3 the average for trees less than thirty years of age are compared with trees over thirty years of age. Analyses of Golden Delicious leaves are not included in Table 3 because insufficient samples were available for comparison.

Table 3. Leaf analyses of apple varieties in West Virginia according to tree age.

Variety	No. of orchards	Age of trees* (years)	Mineral content expressed as percent of dry weight				
			nitrogen	phosphorus	potassium	calcium	magnesium
York Imperial	13	30-	2.13	.190	1.40	1.19	.312
	41	31+	1.99	.176	1.32	1.37	.276
Delicious	18	30-	2.15	.202	2.09	1.11	.307
	20	31+	1.98	.205	2.00	1.13	.291
Stayman	18	30-	1.96	.168	1.82	1.18	.284
	30	31+	1.88	.179	1.71	1.28	.266
Rome Beauty	13	30-	2.01	.203	1.88	1.16	.309
	12	31+	1.92	.191	1.80	1.27	.314
Grimes Golden	9	30-	2.18	.191	2.05	1.38	.365
		31+	2.08	.222	1.90	1.37	.310

* Based on classification of trees into two groups: 30 years of age or under (30-) and 31 years of age or more (31+).

In each of the five varieties presented in Table 3, the older trees contained less nitrogen in the leaves than the younger trees. Although

the differences are not great, the trend is consistent. This is due largely to the frequent practice of increasing the nitrogen application with increased age and size of trees up to about twenty-five or thirty years, after which nitrogen fertilization is held to fairly constant amounts regardless of the size or bearing capacity of the trees. The potassium and magnesium levels in the leaves also were generally lower in the older trees than in the younger ones. Calcium, on the other hand, was higher in older trees with the single exception of the Grimes Golden samples. These showed no difference. No consistent trends were noted in the phosphorus content of apple leaves of young trees compared to older trees.

All averages shown in Tables 1, 2, and 3 are well above the generally accepted critical levels for each mineral element. Six orchards, however, contained trees that were low in potassium, and another six orchards included trees that were low in magnesium. The low potassium samples were taken from trees growing in all three soil classes, and the low magnesium leaves all came from trees in the Henandoah Valley growing in limestone soils. Detailed information on these twelve samples is presented in Table 4.

The critical level of potassium in apple leaves, according to Batjer and Magness (2), is about 1.0 per cent for York, and about 1.5 per cent for Delicious and Rome. Below these levels leaves are regarded as inefficient in potassium and deficiency symptoms may appear. All samples in this survey below these levels are listed in the low potassium group in Table 4. Four samples of York leaves, one of Delicious, and one of Rome showed less than the critical level of potassium. In no case was any of the typical leaf scorch symptom of potassium deficiency found on trees from which these samples were taken. The nitrogen levels of these low potassium leaves were relatively high, as can be seen in Table 4. Tree vigor was fair to good in 1 of the orchards from which these samples were taken, though the trees varied in age from thirty-five to fifty years.

Samples of four varieties, Stayman, York, Grimes, and Delicious, were found to be low in magnesium (See Table 4). All of these samples were taken from orchards in Berkeley and Jefferson counties; the age of the trees varied from thirty to forty-five years. Only three of these samples were taken from trees exhibiting good vigor. All others came from trees showing fair to poor vigor. The nitrogen levels in these trees were all relatively low. Only one sample, No. 139, was as high as 2.0 per cent in nitrogen. The magnesium content varied from 0.118 to 0.195 per cent. Considering 0.200 per cent as the critical level of magnesium below which a deficiency exists, it can be seen from the

Table 4. Survey samples found to be low in potassium or in magnesium.

Laboratory Sample No.	Variety	Soil Type	Vigor	1950 Crop	Tree age (years)	Mineral content expressed as per cent of dry weight		
						Nitrogen	Potassium	Magnesium
LOW POTASSIUM GROUP								
32	York	shale	good	mod.	41	2.42	.980	--
48	York	shale	good	heavy	42	2.03	.935	--
147	York	limestone	fair	heavy	50	1.93	.675	--
164	York	limestone	good	heavy	37	1.96	.790	--
45	Delicious	shale	fair	light	40	2.20	1.290	--
73	Rome	chert	good	heavy	35	2.32	1.170	--
LOW MAGNESIUM GROUP								
117	Stayman	limestone	poor	mod.	45	1.67	--	.195
133	Stayman	limestone	poor	mod.	45	1.83	--	.168
134	York	limestone	poor	heavy	45	1.82	--	.148
138	Stayman	limestone	good	heavy	35	1.68	--	.155
139	York	limestone	good	heavy	35	2.03	--	.165
156	York	limestone	fair	heavy	40	1.90	--	.151
158	Grimes	limestone	fair	heavy	35	1.94	--	.165
171	Stayman	limestone	good	mod.	45	1.80	--	.155
172	York	limestone	poor	light	45	1.22	--	.118
175	Delicious	limestone	poor	heavy	30	1.64	--	.128
176	Stayman	limestone	fair	mod.	35	1.87	--	.161
177	York	limestone	poor	light	40	1.49	--	.138

figures in Table 4 that some of the samples were critically low in magnesium. However, no clear cut deficiency symptoms appeared on the foliage of the trees from which these samples were taken.

SIGNIFICANCE OF THE SURVEY

This survey, although not all inclusive, was reasonably representative of the orchards of West Virginia. It included six major varieties, the three major soil classes upon which orchards are grown, and a cross section of orchards varying from vigorous, well-managed, high-producing blocks to marginal ones in the major apple region of the State. The analyses made indicate that generally the orchards of West Virginia are receiving adequate nutrition. Most of the trees sampled showed levels of nitrogen, phosphorus, calcium, potassium, and magnesium well above the critical levels of these elements. A few individual orchards in addition to those in the low magnesium group (Table 4) had varying degrees of nitrogen deficiency. No phosphorus deficiency was found, and only six low magnesium and six low potassium samples were found in the 209 samples collected. It is apparent, therefore, that the general recommendation of nitrogen only for the apple orchards of West Virginia remains sound.

It is evident, however, that instances of low potassium and low magnesium levels in apple trees do exist in the State. This should not be interpreted as a signal for widespread use of these elements in the orchard fertilization program. The frequency of these deficiencies in the survey reported here was small, and the orchards were scattered throughout the Eastern Panhandle, rather than being concentrated in any particular region or on any particular soil type. Furthermore, the existence of an actual deficiency is only suggested by this survey. It remains to be determined whether or not the orchards in question will respond to applications of potassium or of magnesium.

Recent research has demonstrated that no single element can be considered by itself, but must be regarded in terms of its position with reference to the levels of other elements present. For example, it is known that the addition of large quantities of nitrogen fertilizers to apple trees will depress the potassium level in the leaves (6,8). It is of interest to note that in all the orchards that showed low potassium, the nitrogen in the leaves was at an average or higher than average level. Furthermore, no visual symptoms of potassium deficiency could be found in any of these orchards.

Similarly, the low magnesium levels (reported in Table 4) may or may not be indications of a simple magnesium deficiency. The levels

of other elements are known to have a marked influence on the level of magnesium in apple leaf tissue. Conclusive evidence has recently been obtained to show that under certain conditions applications of potassium fertilizers can induce a magnesium deficiency in the apple orchard (7), and that the appearance of a magnesium deficiency is usually closely associated with a high potassium level in the trees. Also, it has been found that the magnesium level of apple leaves increases when the nitrogen level is increased (3,8).

In this survey, every low magnesium sample came from trees that had an optimum—though not high—level of potassium, but generally a low level of nitrogen. In the orchard where the lowest magnesium level was found (sample No. 172, Table 4), analyses showed that the leaves contained only 0.118 per cent magnesium and only 1.22 per cent nitrogen. In the fall of 1950 the operator applied nitrogen in this orchard for the first time in several years. This application, which consisted of five pounds of nitrate of soda per tree, was followed by two spray applications of urea each at five pounds per 100 gallons in the spring of 1951. Another sampling was made in this orchard on August 10, 1951. Analyses of these samples (Table 5) showed an increase in the nitrogen level of the leaves from 1.22 per cent to 1.93 per cent a year later. It is of interest to note that the magnesium level also was considerably higher in 1951. These trees in 1951 contained 0.210 per cent magnesium in the leaves, or approximately the amount regarded as the critical level below which deficiency symptoms are likely to appear. This illustrates that the low magnesium levels found in this survey may indicate actual magnesium deficiencies, or they may in some cases be simply a reflection of insufficient nitrogen fertilization in the orchard.

The information obtained in these analyses will be used in planning further nutrition work to determine the nature of the deficiencies found, and the most economical means of dealing with them.

Table 5. Effect of nitrogen applications on the levels of nitrogen and magnesium in apple leaf tissue (York variety).

Sample number	Year*	Mineral content of leaves expressed as per cent of dry weight	
		Nitrogen	Magnesium
172	1950	1.22	.118
—	1951	1.93	.210

*These trees were fertilized with 5 pounds per tree of nitrate of soda in the fall of 1950; two sprays of urea each at 5 pounds per 100 gallons were applied in the spring of 1951.

LITERATURE CITED

- Alderman, W. H. and Crane, H. L., *The Fertilization of Apple Orchards*. W. Va. Agr. Exp. Sta. Bull. 174: 1-51, 1920.
- Batjer, L. P. and Magness, J. R., "Potassium Content of Leaves from Commercial Apple Orchards." *Proc. Amer. Soc. Hort. Sci.* 36: 197-201 (1938).
- Beattie, James M., and Ellenwood, C. W., "A Survey of the Nutrition Status of Ohio Apple Trees." *Proc. Amer. Soc. Hort. Sci.* 55: 47-50 (1950).
- Boynton, Damon, Reuther, Walter, and Cain, J. C., "Leaf Analysis and Apparent Response to Potassium in Some Prune and Apple Orchards." *Proc. Amer. Soc. Hort. Sci.* 38: 17-20 (1941).
- , Cain, J. C., and Van Geluwe, J., "Incipient Magnesium Deficiency in Some New York Apple Orchards." *Proc. Amer. Soc. Hort. Sci.* 42: 95-100 (1943).
- , and Compton, O. C., "The Influence of Differential Fertilization with Ammonium Sulfate on the Chemical Composition of McIntosh Apple Leaves." *Proc. Amer. Soc. Hort. Sci.* 45: 9-17 (1944).
- , and Burrell, A. B., "Potassium-induced Magnesium Deficiency in the McIntosh Apple Tree." *Soil Sci.* 58: 441-454 (1944).
- Cain, J. C. and Boynton, Damon., "Some Effects of Season, Fruit Crop, and Nitrogen Fertilization on the Mineral Composition of McIntosh Apple Leaves." *Proc. Amer. Soc. Hort. Sci.* 51: 13-22 (1948).
- Chucka, J. A., Waring, J. H., and Wyman, O. L., "Magnesium Deficiency in Maine Apple Orchards." *Proc. Amer. Soc. Hort. Sci.* 46: 13-14 (1945).
- Lindner, R. C., "Rapid Analytical Methods for Some of the More Common Inorganic Constituents of Plant Tissues." *Plant Physiol.* 19 (1): 76-89 (1944).
- Schrader, A. Lee., Scott, L. E., and Dunbar, C. O., "The Nutritional Status of Maryland Orchards in Terms of Mineral Content of Leaves and Occurrence of Deficiency Symptoms." *Proc. Md. State Hort. Soc.* 3-10 (1949).
- Southwick, Lawrence, "Magnesium Deficiency in Massachusetts Apple Orchards." *Proc. Amer. Soc. Hort. Sci.* 42: 85-94 (1943).