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A Survey of the Nutritional Status of West Virginia Peach Orchards

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Agricultural and Forestry Experiment Station
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Survey of the Nutritional Status of West Virginia Peach Orchards

T. L. Auxt, S. Singha and S. H. Blizzard

Introduction

Research on peach fertilization in West Virginia in the late 1800s was among the earliest of such research in the United States (Alderman, 1915; Crane, 1924). Since then there has been virtually no study of peach nutrition in the state. Peaches are the second most important fruit in West Virginia, with an annual production of a half million bushels.

Information on the nutritional status of West Virginia peach orchards is needed for the improvement of West Virginia University's fertilizer recommendation services. Leaf analysis surveys conducted in other states (Smith, 1965; Boatwright et al., 1962; McClung and Lott, 1956; Kenworthy, 1953; Beattie and Judkins, 1952) have aided plant analysis laboratories in establishing standard ranges and balance indexes for nutrient elements. In addition, there is a need to economize orchard fertilization practices and an increasing awareness that nutrition may play a role in the complex problem of "peach tree decline" (Edwards et al., 1976; Brittain and Miller, 1976). Leaf analysis can be a valuable tool for diagnosing an existing nutritional problem as well as for detecting approaching deficiencies and toxicities (Kenworthy, 1973).

With these objectives in mind, a leaf and soil analysis survey of peach orchards was conducted in 1981. The previous year, apple orchards had been surveyed (Singha et al., 1982). Knowledge gained from this survey will be used to improve the program for making fertilizer recommendations and to plan future nutrition studies.

Experimental Procedures

Regions, Soils and Cultivars Selected

The survey was conducted in the Eastern Panhandle of West Virginia, a region within the Cumberland-Shenandoah fruit belt, ideally suited for the production of tree fruits. Ninety-five percent of the West Virginia peach crop is grown in Berkeley, Jefferson and Hampshire counties (W.Va. Dept. of Agr. Crop Reporting Service, 1982). Twenty-

six orchards were sampled in these counties July 28-30, 1981. Locations of the orchards are shown in Figure 1.

Peach orchards are planted on two general types of soils—those formed from limestone and those formed from shale. Orchards in Jefferson and Berkeley counties are planted on deep limestone soils (usually more than nine feet of rooting capability) with a high water-holding capacity. The soils in Hampshire County are formed from shale and are shallow (less than four feet) and droughty by comparison (Browning and Sudds, 1941).

Cultivars sampled for the survey were Redhaven and Loring. Redhaven, an early-season peach, currently comprises 16 percent of the state's total peach production, and Loring, a mid-season cultivar, leads with 25 percent of the crop (W.Va. Dept. of Agr. Crop Reporting Service, 1982). Trees sampled were between 7-20 years of age and were either on Lovell or Halford rootstocks. With the exception of some signs of nitrogen deficiency, these trees did not exhibit symptoms of nutritional disorders.

Soil and Leaf Sampling Technique

Nineteen blocks of Redhaven and 26 blocks of Loring were sampled (Appendix Tables 1, 2). Two replicate leaf and soil samples were gathered from each block, for a total of 90 leaf and 90 soil samples. Each leaf sample was a composite of ten leaves collected from the mid-region of current season's shoot growth from each of ten trees. Shoots were randomly selected from all sides of each tree at a height of three to six feet. Soil samples were obtained from a depth of six to eight inches under the driplines of the same trees from which leaf samples were collected.

Nutrient Analyses

Leaf samples were washed, dried at 45° C in a forced air oven, and ground in a Wiley Mill equipped with a 20-mesh stainless steel sieve. The samples were analyzed for nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), iron (Fe), manganese (Mn), zinc (Zn), copper (Cu), and boron (B) at the Department of Pomology, Cornell University, Ithaca, New York. Nitrogen was extracted with perchloric and sulfuric acids and determined with an ammonia specific electrode. The other nutrients were extracted by a dry ashing technique using nitric acid and analyzed with an inductively coupled argon plasma spectrograph.

Soil samples were air-dried and sieved through a 20-mesh screen. P, K, Ca, Mg, pH, and lime requirement were determined at the West Virginia University Soil Testing Laboratory (Ghazi et al., 1978).

Figure 1. Locations of peach orchards where leaf and soil samples were collected.

Results and Discussion

Soil and Leaf Analyses Compared by Soil Type

Leaf analysis is a more reliable indicator of fertilizer needs of fruit trees than soil analysis (Singha et al., 1982; Kenworthy, 1973). Soil analysis is of value, however, because it indicates the relative availability of nutrients to tree roots and more importantly, because it provides information on soil pH and lime requirement. Results of soil

analyses (Table 1) show that the limestone soils had a higher average pH and lower mean lime requirement than the shale soils. The differences in soil acidity were not as great as those observed in the survey of apple orchards (Singha et al., 1982). This is probably a reflection of differences in managing peaches versus apples. Peach growers are aware of the importance of a proper pH in controlling peach tree decline (Singh et al., 1978). Additionally, since the life span of a peach orchard is shorter than that of an apple orchard, lime is incorporated into the soil more frequently as part of preplant preparations. On shale soil, concentrations of P, Ca, and Mg were higher in the peach orchards than those earlier reported in apple orchards (Singha et al., 1982). This difference is probably an indirect effect of better pH management.

Leaf analysis is the best tool available to growers for determining the nutrient status of fruit trees (Childers, 1966). Results of the leaf analyses (Table 2) indicate that, with the exception of Ca, Mn, and B, the nutrient concentration in the peach leaves was not influenced by soil type. Calcium, Mn, and B are influenced by pH. Significant correlation coefficients existed between lime requirement and the level of Ca and Mn in the leaves (Table 5). Other reports have indicated that Mn in leaves fluctuates more than other elements largely due to a strong relationship with soil pH (Smith, 1965).

Soil and leaf nutrient levels in peach orchards did not show a strong correlation (Table 5). Similar results were obtained in the survey of apple orchards in West Virginia. This clearly emphasizes the fact that leaf analysis is a more reliable indicator of the nutritional status of the plant than soil analysis. Variations in leaf nutrient concentrations (Appendix Tables 1, 2) were more closely related to differences in orchard management practices than to differences between soils.

Table 1.
Soil analyses summarized by soil type.

Soil Type	No. of Samples	pH	LR** (tons/acre)	Nutrient Element (lbs./acre)			
				P	K	Ca	Mg
Limestone	68	6.4*	0.9*	64.3	151.6*	2073.2	178.5
Shale	22	6.0	1.4	52.7	101.0	1705.4	168.6

*Significant difference at the 5% level.

**Lime required to adjust pH to 6.6.

Table 2.
Leaf analyses summarized by soil type.

Soil Type	No. of Samples	Nutrient Element									
		N	P	K	Ca	Mg	Fe	Mn	Cu	B	Zn
		[%]					(ppm)				
Limestone	68	3.70	0.25	2.25	1.85*	0.60	62.6	68.2*	11.8	33.9*	31.6
Shale	22	3.44	0.23	1.87	1.48	0.50	60.0	101.0	11.5	26.0	39.7

*Significant difference at the 5% level.

Table 3.
Leaf analyses summarized by cultivar.

Cultivar	No. of Samples	Nutrient Element									
		N	P	K	Ca	Mg	Fe	Mn	Cu	B	Zn
		[%]					(ppm)				
Redhaven	38	3.73	0.26	2.19	1.71*	0.60	63.5	69.2	12.1	32.4	32.1
Loring	52	3.56	0.24	2.13	1.80	0.55	60.8	81.4	11.4	31.6	34.7

*Significant difference at the 5% level.

Leaf Analyses Compared by Cultivar

Differences in leaf nutrient concentrations among orchards were generally more significant than differences between cultivars (Table 3, Appendix Tables 1, 2). The variations among orchards could be explained by differences in fertilizing and liming practices, spray programs, management of orchard floors, and other cultural and environmental factors.

Foliar calcium levels in Loring were significantly higher than those in Redhaven (Table 3). No significant differences existed between the two cultivars in the levels of other macro- or micronutrients. The variations in Ca levels may reflect differences in the stage of fruit development between the early and mid-season varieties.

Table 4.

Percentage of orchard blocks which were deficient or above standard range in various nutrients.

Nutrient	Standard Range*	% Below Standard Range	% Above Standard Range
N	3.00-4.00%	7	13
P	0.15-0.45%	0	0
K	1.20-2.50%	9	27
Ca	1.00-2.50%	0	4
Mg	0.30-0.70%	2	22
Fe	80-500 ppm	96**	0
Mn	50-300 ppm	22**	0
Cu	5-35 ppm	0	0
B	25-50 ppm	7	0
Zn	20-50 ppm	0	4***

*Oberly, G. H. 1981. (Personal communication). These levels should be used as a general guideline only. Minor variations can be expected.

**Several samples had values below the standard range but not sufficiently low enough to warrant amelioration.

***Excessive levels were probably due to contamination by pesticides.

The General Nutrient Status of West Virginia Peach Orchards

The results show no general shortage of macronutrients (Tables 3, 4). Rather, there is an indication that a number of orchardists are overfertilizing with N, K, or Mg (Table 4). Shortages of N, K, or Mg were found in a few isolated blocks. Although not deficient, Ca levels in many orchards were at the lower end of the standard range. In most cases, low Ca was associated with a high lime requirement (Table 5). Micronutrient levels were generally adequate. Foliar levels of Fe and Mn were below the standard range in many orchards, but they were not low enough to warrant amelioration. The ranges that have been established for both of these nutrients are very wide (Kenworthy, 1953; Smith, 1965). Perhaps with further study, more exact ranges can be established for our orchard conditions.

Peach tree decline has been attributed to several interrelated factors, including cold injury, nutrition, nematodes, and various insects and diseases. Knowledge of soil-related factors is incomplete, but reports indicate that peach tree decline is less severe where levels of Ca are adequate, aluminum (Al) and Mn are not present in toxic quantities, and soil pH is maintained between 6.5 and 7.0 (Singh et al., 1978; Brittain and Miller, 1976; Edwards et al., 1976; Jones and Jones,

1974). Nitrogen has a secondary effect in that high levels are correlated with greater peach hardness (Proebsting, 1957).

As reported in surveys in other states, N, P, K, Ca, Mg and Fe were higher in peach leaves than in apple leaves (Kenworthy, 1953; Boynton et al., 1950).

Table 5.

Degree of correlation among levels of various nutrients.

Factors Compared			Correlation Coefficients
Soil Concentrations		Leaf Concentrations	
K	and	K	0.07
Ca	and	Ca	0.07
Mg	and	Mg	-0.07
Ca	and	N	-0.24
Mg	and	N	-0.33*
LR	and	Ca	-0.30*
LR	and	Mn	0.34*
Soil Concentrations			0.32*
pH and K			-0.46**
LR and Ca			0.42**
P and Ca			0.37**
Mg and Ca			
Leaf Concentrations			-0.31*
N and Ca			0.62**
P and K			0.59**
K and Ca			0.42**
P and Ca			0.47**
P and Mg			0.81**
Ca and Mg			0.35**
N and Mn			0.36**
P and Mn			0.76**
P and Fe			0.41**
K and Cu			0.81**
P and B			0.67**
Ca and B			0.61**
Zn and Mn			

*Significant at the 5% level.

**Significant at the 1% level.

Interrelationships Among Nutrient Concentrations

In determining fertilizer needs, interrelationships of nutrients should be considered because excessive levels of one nutrient can impede the

uptake of another nutrient. The degree of association between concentrations of various nutrient elements was determined by correlation coefficients (Table 5).

Levels of nutrients in the soil did not correlate with concentrations of the same nutrients present in the leaves. However, inverse relationships existed between soil Mg and leaf N and between lime requirement and leaf Ca (5 percent level), and a positive correlation existed between lime requirement and leaf Mn (5 percent level).

In orchard soil samples, negative correlations between lime requirement and Ca and positive correlations between pH and K, P and Ca, and Mg and Ca were found. Similar relationships have been reported by other researchers (Ferree and Thompson, 1970).

An examination of interrelationships in leaf concentrations revealed a significant negative correlation between N and Ca and highly significant positive correlations between P and K, K and Ca, P and Ca, P and Mg, Ca and Mg, N and Mn, P and Mn, P and Fe, K and Cu, P and B, Ca and B, and Zn and Mn. A number of these correlations have been previously noted (Smith, 1965).

Summary and Conclusions

A survey of the leaf and soil nutrient status of West Virginia peach orchards was conducted in July, 1981. Two leading cultivars, Loring and Redhaven, were sampled from two general soil types, limestone and shale.

With one exception, soil and plant nutrient concentrations failed to show a significant correlation. Foliar Ca and Mn were, however, affected by soil pH. The only significant difference found between cultivars was in foliar Ca levels. Variations in leaf nutrient concentrations were associated more with differences in orchard management practices than with differences in soil types or cultivars.

Survey results did not expose any severe deficiencies or toxicities. In many cases, leaf analysis revealed that over-fertilization was occurring.

A number of interrelationships among leaf nutrient concentrations were found. Many of these had been previously reported.

Information gained from this groundwork will be used to design further nutrition studies. The results of the survey indicate that further studies are warranted on acid orchard soils and on imbalances of N, K and Mg, especially as related to the problem of peach tree decline.

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Appendix

Table 1.
Leaf and Soil Analyses for Redhaven Orchards Surveyed.

Orchard Code*	Soil Class	Soil Analysis**					Leaf Analysis**																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
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*For orchard locations, see Figure 1.

**Means of 2 replicates.

Table 2.
Leaf and Soil Analyses for Loring Orchards Surveyed.

Orchard Code*	Soil Class	Soil Analysis**							Leaf Analysis**									
		pH (T/A)	LR (T/A)	(lbs./A)				(%)										
				P	K	Ca	Mg	N	P	K	Ca	Mg	Fe	Mn	Cu	B	Zn	
(ppm)																		
A	Limestone	7.0	0	67	372	2545	295	3.44	0.23	2.31	2.23	0.62	55.8	97.6	9.6	33.6	27.3	
B	Limestone	5.9	1.8	31	145	1530	206	4.15	0.24	2.30	1.75	0.53	80.6	76.9	12.1	30.5	37.6	
C	Limestone	5.9	1.8	30	128	1415	193	3.92	0.23	2.28	1.71	0.70	60.0	54.9	15.3	32.2	33.0	
D	Limestone	7.2	0	99	81	3850	156	3.76	0.26	2.55	2.38	0.87	71.5	70.2	10.1	36.6	26.3	
E	Limestone	7.0	0	58	177	2560	246	4.05	0.24	2.50	2.07	0.56	65.0	47.6	10.8	31.7	27.3	
F	Limestone	6.7	0	45	53	1885	174	3.67	0.25	1.93	2.55	0.94	61.7	65.1	10.8	35.6	29.3	
G	Limestone	7.0	0	80	55	2195	118	3.35	0.25	1.81	2.15	0.62	52.9	37.1	20.8	38.2	28.6	
H	Limestone	5.3	2.8	49	126	905	45	3.14	0.30	3.25	2.19	0.47	62.5	84.9	10.7	41.6	26.3	
I	Limestone	7.2	0	56	119	2355	72	3.73	0.25	2.14	1.17	0.32	44.1	30.5	9.8	27.9	28.5	
J	Limestone	5.1	2.8	20	73	965	73	3.79	0.18	1.05	1.56	0.38	52.9	115.5	9.6	27.1	28.4	
K	Limestone	7.1	0	62	212	1780	366	3.76	0.27	2.63	1.64	0.42	57.2	46.1	13.1	39.9	28.3	
L	Limestone	5.9	2.0	33	71	1110	96	4.16	0.25	2.46	1.52	0.38	61.5	63.4	12.5	32.1	30.4	
M	Limestone	6.9	0	85	117	1955	351	3.79	0.27	2.18	1.70	0.45	73.8	68.4	11.9	31.7	28.7	
N	Limestone	5.8	2.0	36	46	1385	254	3.04	0.21	1.97	2.53	1.06	53.0	79.1	9.6	36.4	64.4	
O	Limestone	7.2	0	121	482	3065	131	3.95	0.24	2.70	1.76	0.36	68.7	50.5	9.9	32.5	24.4	
P	Limestone	5.3	2.6	58	148	1420	94	3.71	0.22	1.73	1.92	0.73	59.8	101.2	10.4	33.2	41.7	
Q	Limestone	7.6	0	103	110	4490	126	3.10	0.27	2.54	1.85	0.41	61.8	79.9	10.4	34.4	36.9	
R	Limestone	5.2	2.6	25	111	1565	157	3.49	0.21	2.46	1.88	0.63	67.6	72.5	12.0	34.5	27.4	
S	Shale	7.1	0	40	47	2950	137	3.45	0.21	1.92	1.40	0.36	58.1	113.0	11.6	33.5	43.9	
T	Shale	4.7	3.0	30	155	140	20	2.77	0.22	2.50	1.03	0.30	51.7	162.5	12.1	27.5	67.2	
U	Shale	5.5	2.4	47	99	905	121	3.71	0.21	1.34	1.81	0.44	63.8	96.0	10.0	26.3	34.3	
V	Shale	5.7	2.0	22	59	1450	181	3.29	0.21	1.12	1.70	0.95	54.4	95.2	10.1	22.6	34.0	
W	Shale	7.1	0	73	127	3920	137	3.96	0.26	1.45	1.34	0.42	72.9	80.5	13.7	26.6	31.6	
X	Shale	5.0	2.8	43	158	1315	72	2.83	0.22	3.13	1.65	0.33	52.2	168.0	11.5	27.6	33.5	
Y	Shale	6.1	1.4	56	68	1300	154	3.23	0.21	1.62	1.77	0.68	61.1	95.6	10.0	29.3	48.0	
Z	Shale	6.6	0	45	49	1695	45	3.40	0.20	1.51	1.41	0.35	56.2	65.1	9.5	19.5	35.5	

*For orchard locations, see Figure 1.

**Means of 2 replicates.