ANALYSIS OF SHOOT TIP, LEAF AND SOIL SAMPLES AND YIELD OF SELECTED BLACK RASPBERRY PLANTINGS

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Willard Lloyd Koukkari

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THESIS

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By

Willard Lloyd Koukkari

AN ABSTRACT

Submitted to the College of Agriculture, Michigan State University
of Agriculture and Applied Science in partial fulfillment
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MASTER OF SCIENCE

Department of Horticulture

1958

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WILLARD LLOYD KOUKKARI ABSTRACT

A survey of 42 black raspberry plots in 21 plantings in Berrien and Van Buren counties was made in 1957 to determine the nutritional condition of each plot. Shoot tip and leaf samples collected twice from each plot were analyzed for nitrogen, phosphorus, potassium, calcium, magnesium, manganese, iron, copper and boron. Soil samples were analyzed for cation exchange capacity and also were tested for phosphorus, calcium, magnesium, potassium and pH. Cane diameters were measured during dormancy and yields were harvested in 1958.

The survey showed the shoot tips to contain higher amounts of nitrogen, phosphorus and potassium than the leaves. Calcium, magnesium, manganese, iron and copper showed higher accumulations in the leaves, while boron was approximately equally distributed in shoot tips and leaves.

The second samples collected revealed a decrease in composition for nitrogen and copper and an increase for phosphorus, calcium, magnesium and iron in the leaf. Potassium remained approximately the same in the second sampling. Boron showed an increase in Van Buren county and a decrease in Berrien county. Leaf analysis revealed a negative relationship between potassium and magnesium.

Yield records show iron and boron to decrease with increased yields.

Low levels of manganese in both soil and leaf samples were associated with low production. The poor production plots generally possessed a higher pH than the higher yielding plots.

Yields showed a closer relationship to cane diameter than to number of canes.

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INTRODUCTION

Michigan is credited with being the leading state in the production of black raspberries (*Rubus occidentalis*). The southwestern section of the state, especially Berrien and Van Buren counties, comprises the chief black raspberry area in America. Black raspberries ripen between the harvests of strawberries and tart cherries. The early ripening Logan is the chief variety grown in Michigan, and is sold mostly for food processing.

During the 1930's some research was directed towards fertilizer studies on black raspberries. A limited amount of early work in Michigan was carried on by Hoffman and Schlubatis (1928), and Marshall (1931).

The purpose of this investigation was to conduct research on the nutritional requirements of Michigan black raspberry plantings using shoot tip, leaf, and soil analysis to provide basic information and data to guide the planning of future fertilizer studies and recommendations.

REVIEW OF LITERATURE

Many factors may influence the growth and production of a black raspberry planting. Sudds (1935) recorded a difference in black raspberry stands when the same varieties were planted in similar locations by two different persons. One obtained a 92 percent stand, while the other obtained only a 45.5 percent stand, and both were experienced planters. He suggested also that differences in performance of surviving plants may be associated with the way they were set and not other cultural practices.

Johnston (1925), Teske and Gardner (1927), Cherry (1931), and Judkins (1945) all found a direct relation between vegetative vigor and production of black raspberry plantings. Khanmai (1939) noted a positive correlation in the red raspberry between the weight of leaves on fruiting laterals and the weight of fruit on these laterals.

Johnston (1925) found that thinning out lateral canes of Cumberland black raspberries resulted in greatly reduced yields without a material increase in size of berries. He also showed that the yield of canes and of laterals and size of berry were closely associated with cane diameter or size.

Teske and Gardner (1927) noted that the number and size of black raspberry canes directly influenced yields. Judkins (1945) indicated that higher yields of black raspberries were associated slightly more with large diameter of canes than with number of canes, though good correlation also existed between yields of berries per acre and number of the fruiting canes.

Teske and Gardner (1927) in Michigan showed that the physical properties of soil reflected greatly on the successful culture of Cumberland black raspberries. Highest yields occurred when a clay subsoil was present to retain moisture during periods of drought.

Marshall (1931), Woods (1942) and Thomas and Mack (1943) all noted that climatic conditions had a great effect on yields of black raspberries. Thomas and Mack (1943) indicated that differences in yields between pairs of similarly fertilized plots could have resulted from soil differences or differences in weather conditions or from both.

Marshall (1931) revealed that black raspberry plants were extremely sensitive to soil heterogeneity. In the most uniform field he could find in southwestern Michigan, the coefficient of variability for row yields was 20.67 percent.

Hoffman and Schlubatis (1928) found the black raspberry to be tolerant to a wide variation in soil acidity.

A study in Ohio with Logan black raspberry roots by Havis (1939) showed that fertilizer applications along the sides of the rows and to a distance of 2 to 3 feet outward to be the most economical.

Collison and Slate (1943) found nitrogen to be the effective element in fertilizers applied to Cumberland black raspberries in New York. Neither phosphorus nor potassium in the fertilizer produced any significant effects. In comparing the yields from different plots, Cherry (1931) found that 300 pounds of ammonium sulfate per acre showed an increase in yield, with the same cane diameter, over the treatment receiving no nitrogen fertilizer. Chandler (1920) noted that in plots receiving nitrogen the total cane growth was 1.004 times that of nontreated black raspberry plots.

Larger fruit was harvested from plots receiving heavy treatments of potassium by Clark and Powers (1945). The leaves reflected the potassium treatment more accurately than did the black raspberry fruit. Stene (1935) reported potassium and nitrogen to be very important in fertilizer programs for red raspberries in Rhode Island. Phosphorus was important only for cultural systems requiring a cover crop.

Powers and Wood (1945) found that applications of potash increased yields of black raspberries. When nitrate and phosphate were applied with no potash, leaf scorch appeared to be intensified.

Askew, Chittenden and Watson (1951) reviewed the work of McLarty and Fitzpatrick (1938) and Atkins and Wright (1942) and found them to agree that the use of boron gave better yields of red raspberries. Askew, Chittenden and Monk (1951) found that low soluble boron in the soil caused poor growth due to failure of buds to develop on fruiting canes of Red Antwerp raspberries.

Harris (1944) found that boron, magnesium and zinc deficiencies were likely to become pronounced enough in red raspberries to warrant their use in fertilizing programs. While working with black raspberries, Powers and Wood (1945) observed a response to the use of copper sulfate.

In the Leningrad region of Russia, Pehoto (1957) showed that the highest yields were obtained where, in addition to an annual dressing of 30 tons per hectare of farmyard manure, young plants received a spring application of 90 kilograms per hectare each of nitrogen, phosphate and potassium. Plants over 6 years old received 90 kilograms per hectare of nitrogen in the spring, and 90 kilograms per hectare of phosphorus and potassium after harvest.

Reports by Cherry (1931) showed that nitrogen, phosphorus and potassium all increased yields of black raspberries over the nonfertilized plots if used in sufficient quantities.

Seasonal variation in leaf and available soil potassium was found by Powers and Wood (1945) to be such that the standards for leaf potassium content of black raspberries must be based upon the stage of growth and standards for levels of available soil potassium to be based upon time of year.

A study on red raspberries by Ramig and Vandecaveye (1950) showed that leaf blades were preferable for the analysis of nitrogen and magnesium, while petioles were best for analysis of phosphorus, potassium and calcium.

The critical level of total nitrogen in leaf blades was approximately 2.9 percent. The critical level of phosphorus for both leaf and petiole was approximately 0.3 percent. With potassium the critical level was approximately 1.0 percent for blades, and 0.7 percent for petioles. A critical level for calcium was not found, but was thought to be about 0.2 percent in the petioles, which contained a higher percent of calcium than did the blades.

Askew, Chittenden and Monk (1951), using the fourth leaf back from the shoot tip, found 30 to 35 ppm of boron necessary for healthy development of red raspberries. They were found to tolerate up to 300 ppm of boron in dry matter without any signs of toxicity.

A deficiency of an element may greatly reduce yields in numerous ways. Goodall and Gregory (1947) define deficiency by stating that "a plant is deficient in a certain element if supplying that element to the plant in a suitable form causes an increase in the yield, this effect being specific to the element in question".

Goodall and Gregory (1947), Shear et al. (1948) and Kenworthy (1949) report that the total level of nutrients should be in proper balance for optimum results. Goodall and Gregory (1947) stressed that the relative concentration of the nutrient element in the tissue may be no measure of the level of supply, but may depend upon the total supply of all elements and vary according to the particular element. Shear et al. (1948) emphasized the consideration of several elements because information on a single element could lead to erroneous conclusions.

EXPERIMENTAL PROCEDURE

Survey

In 1957, 21 black raspberry commercial plantings in southwestern Michigan (Figures 1 and 2) were selected for leaf and soil sample studies. Both a good and a poor plot were sampled in each planting (Figure 3). The variety used with the Logan.

Ten adjacent plants were selected for each of the 42 plots and used for collecting samples of leaf, shoot tip and soil. A leaf sample consisted of the first mature leaf back from the tip collected from 50 main canes; a shoot tip sample consisted of the terminal 3 inches of growth from about 50 canes (Figure 4). The first samples from Berrien County were collected on July 31, 1957, 2 weeks before the first samples from Van Buren County. The second samples were collected September 4 to 9, 1957. The soil samples were taken from the top 6 to 8 inches of soil at each plot.

Fruit yield records were obtained from 14 of the original 42 plots. Those areas were excluded that were injured by frost and affected appreciably by disease. Four harvests were obtained from each location.

Cane Measurements

The diameter of all canes in every third hill in each plot were measured for diameter during dormancy. Vernier calipers were used, with the measurement taken at a point 6 inches above the crown.

Figure 1

Map of Berrien County showing the location of 13 plantings which provided plots for analysis.

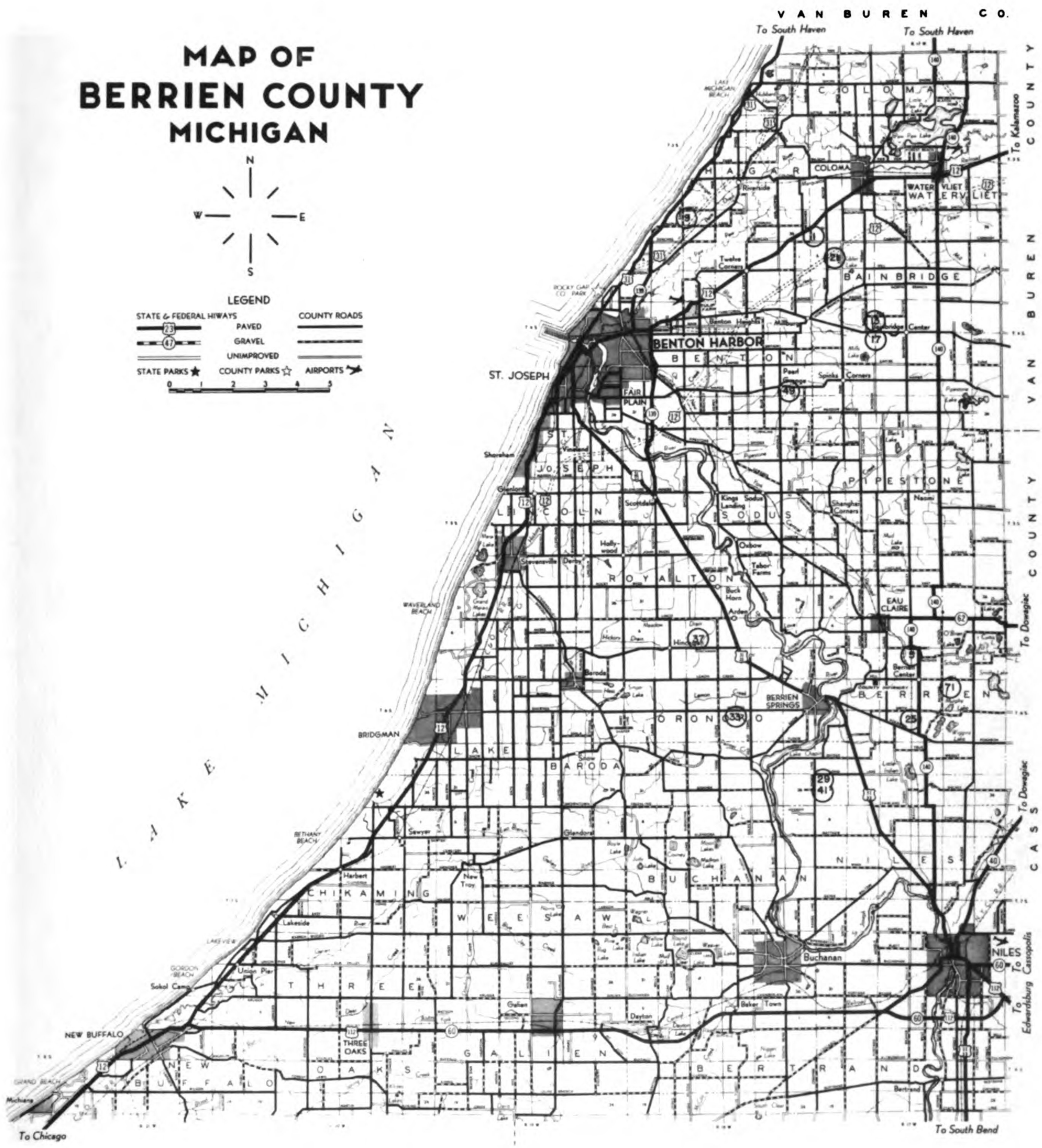

MAP OF
BERRIEN COUNTY
MICHIGAN
N
S
W
E
LEGEND
STATE & FEDERAL HIWAYS
COUNTY ROADS
PAVED
GRAVEL
UNIMPROVED
STATE PARKS
COUNTY PARKS
AIRPORTS
VAN BUREN CO.
To South Haven
To South Haven
LAKE MICHIGAN
ST. JOSEPH
BENTON HARBOR
COLOMA
WATERVLIET
BAINBRIDGE
BENTON
PIPESTONE
SODUS
LINCOLN
ROYALTON
EAU CLAIRE
BERRIEN SPRINGS
BERRIEN
ORONOKO
LAKE
BARODA
BRIDGMAN
CHIKAMING
WEESAW
BUCHANAN
NILES
THREE OAKS
GALIEN
NEW BUFFALO
BERTRAND
VAN BUREN COUNTY
CASS
To Kalamazoo
To Dowagiac
To Dowagiac
To Cassopolis
To Edwardsburg
To Chicago
To South Bend

Figure 2

Map of Van Buren County showing the location of eight plantings which provided plots for analysis.

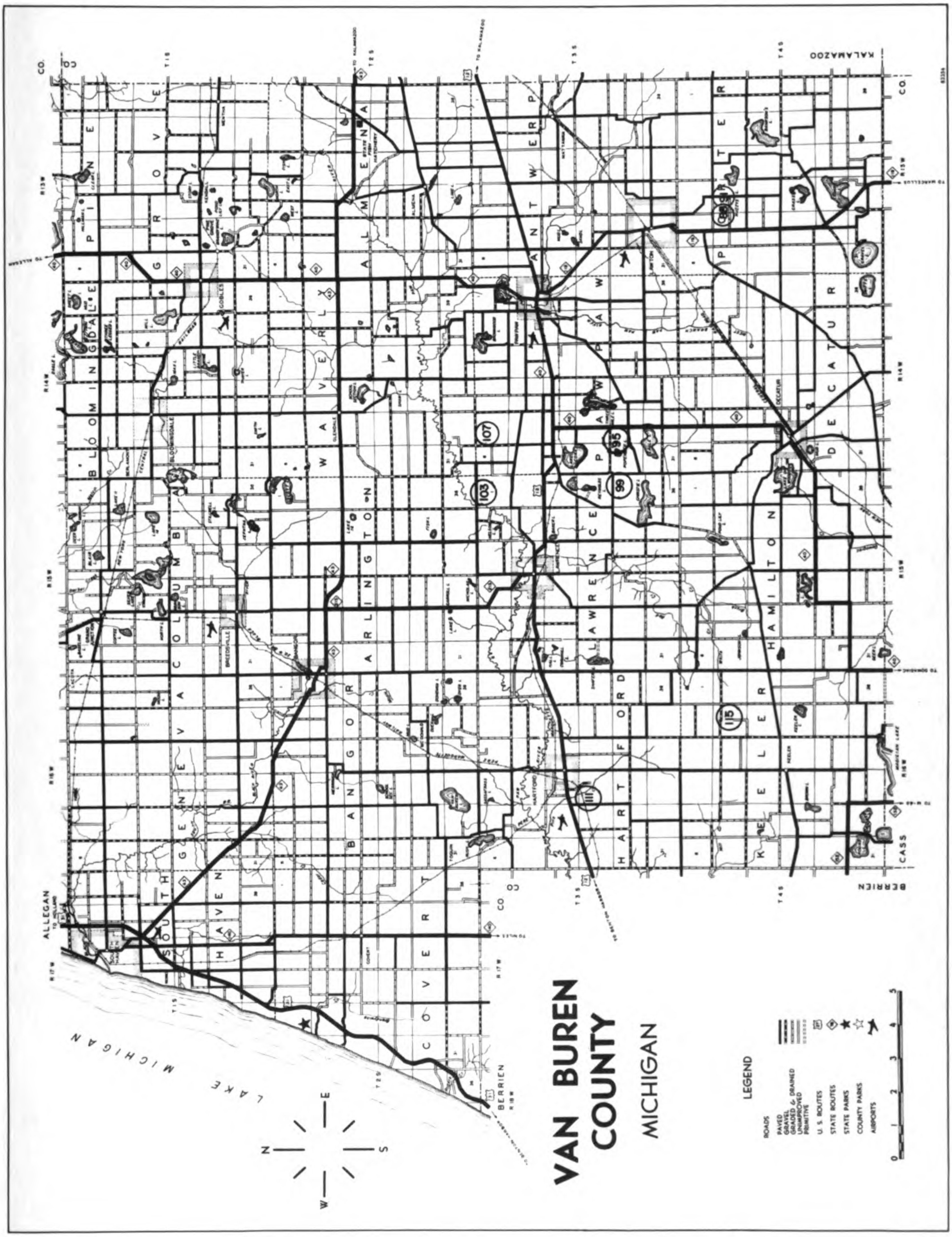

VAN BUREN
COUNTY
MICHIGAN
LAKE MICHIGAN
LEGEND
ROADS
PAVED
GRAVEL
GRADED & DRAINED
UNIMPROVED
PRIMITIVE
U. S. ROUTES
STATE ROUTES
STATE PARKS
COUNTY PARKS
AIRPORTS
ALLEGAN
BERRIEN
CASS
KALAMAZOO

Figure 3

A "Good" (left) and a "Poor" (right) plot as they appeared in the same planting.

Figure 4

Black raspberry cane showing location of:

Leaf sample - - - - 1

Shoot tip sample - - 2


1
2

Tissue Analysis

The leaf and shoot tip samples were collected and air dried in ventilated paper bags. They were then oven dried at 150 degrees F, and ground to pass a 20-mesh screen using a Wiley mill. Samples were analyzed in the laboratories of the Agricultural Chemistry Department. Phosphorus, calcium, magnesium, manganese, iron, copper and boron were determined by use of spectrographical procedures. Nitrogen determinations were made by the standard Kjeldahl method. Potassium analyses were made on a flame photometer. Because of unusually high levels of manganese, colorimetric determinations for manganese were made on the 14 leaf samples that provided yield records.

Soil Analysis

The soil samples were tested for phosphorus, potassium, magnesium and calcium by the Spurway Active Test, and for phosphorus and potassium using the Spurway Reserve Test developed by Spurway and Lawton (1949). Soil pH tests were determined by using a Beckman pH meter. The tests were made in the Experiment Station Soil Testing Laboratory.

Cation exchange capacity determinations were made by placing 20-gram samples of air dried soil and 100 ml of sodium acetate (1 N) into a 125-ml Erhlenmeyer flask, and shaking for 30 minutes. The contents were then filtered and leached with 100 ml of 95 percent ethyl alcohol. After discarding the filtrate a clean flask was used to collect the filtrate obtained by leaching the soil with 100 ml of ammonium acetate (1N). The ammonium acetate leachate was used to determine exchangeable sodium as a measure of the cation exchange capacity. The flame photometer was used for the final sodium determinations.

RESULTS

General Field Observations

In general, environmental factors such as site, location and weather appeared to affect yields of black raspberries in the plots more than did cultural practices. Temperature variations, especially the advent of spring frosts, caused production losses in certain locations. In locations where damaging spring frosts did not occur, peak production was usually found in the lower sites of a field, but when frost damage was prevalent the higher sites of a field had a higher production than the lower sites.

Soil erosion contributed to poorer stands of plants and plant vigor on hillsides when the rows ran perpendicular to the contour of the land. The non-eroded parts of a field produced higher yields where conditions existed for good air drainage. Some of the growers located on rolling ground used cover crops of oats and rye, while a few relied on weeds. Cover cropping was more of an exception than the rule.

Most of the farmers removed the fruiting canes soon after harvest, while others waited until spring when more labor was available. Early removal of the old canes may have reduced the spread of disease. However, some of the growers left the old canes in the field and chopped them up for mulch. Mulching was not practiced, except by one grower who attributed part of his good production to the use of sawdust mulch.

A complete fertilizer of 1-1-1 ratio (10-10-10, 12-12-12, or 13-13-13) was used by a majority of the growers at rates which varied from 400 to 750 pounds per acre. Some growers used a fertilizer with a 1-4-4 ratio (3-12-12, 5-20-20, or 4-16-16) at rates varying from 200 to 600 pounds per acre. Farm manure was used when available. Most growers made additional applications of nitrogen just before harvest. This was either applied as a foliar spray of urea or broadcast as ammonium nitrate.

The most prevalent diseases in the plantings were anthracnose, crown gall, and viruses. Most of the plantings showed some evidence of anthracnose. Control, when properly practiced, involved applications of lime-sulfur in the "delayed dormant stage" and ferbam in the "preblossom stage". Crown gall was also a serious disease, which, through poor control, was spread widely in a few plantings. An unidentified fungus disease, which hardened the berries before maturity, was also beginning to appear in various plantings. This fungus disease was responsible for reduced yields in several locations, and is being studied by Dr. R. H. Fulton of the Department of Botany and Plant Pathology at Michigan State University.

Survey

The analysis of shoot tips and leaves for all the plots are presented in Appendix Tables I through VI. The analysis of shoot tips and leaves showed significant differences in nutrient composition. Tables 1 and 2 reveal the shoot tips to be higher in nitrogen (N), phosphorus (P), and potassium (K), while the leaves contained higher amounts of calcium (Ca), magnesium (Mg), manganese (Mn), copper (Cu) and Iron (Fe). Boron (B) was approximately equal in both parts of the plant analyzed.

A significant difference between copper content in leaves and shoot tips was found for samples from Berrien County, but not for those from Van Buren County. Boron showed no significant difference in either county.

Statistically, according to the "t" test, there were significant changes in composition between the first and second samples. These differences are shown in Table 3. The decrease of nitrogen and copper in the second samples was significant at the 1 percent level in Berrien County.

Phosphorus, calcium and iron showed a significant increase in the second samples from Van Buren County.

Boron showed unusual fluctuation; there was a decrease in Berrien County and an increase in Van Buren County at the second sampling.

No significant differences occurred for potassium between the two sampling dates, but in general, the trend was towards a slight decrease in potassium in the second sample from both counties. Magnesium increased significantly both in Berrien and Van Buren counties between sampling dates.

The 14 plots that provided yield records were harvested 4 times. The

TABLE 1

Average Composition of Leaves and Shoot Tips Obtained During the First Sampling in Berrien and Van Buren Counties. Berrien County Samples Collected July 31, 1957; Van Buren County Samples Collected August 15, 1957.

	Nutrient-Element								
	Percent Dry Weight					Ppm Dry Weight			
	N	P	K	Ca	Mg	Mn	Fe	Cu	B
Berrien County (26 Plots)									
Shoot Tip	3.55	.31	2.30	.62	.33	257	177	45	33
Leaf	3.12	.22	1.60	1.00	.43	344	262	65	34
"t" value	7.71**	11.01**	7.57**	4.84**	4.22**	2.84**	2.65*	3.17**	.05
Van Buren County (16 Plots)									
Shoot Tip	2.95	.26	2.14	.62	.43	204	134	40	26
Leaf	2.51	.18	1.02	.96	.53	335	193	47	24
"t" value	4.13**	9.03**	9.94**	4.42**	2.34*	3.17**	3.47**	.83	.94

*Statistically significant at the 5 percent level.
**Statistically significant at the 1 percent level.

TABLE 2

Average Composition of the Leaves and Shoot Tips Obtained During the Second Sampling in Berrien and Van Buren Counties. Samples Collected September 4 and 9, 1957.

	Nutrient-Element								
	Percent Dry Weight					Ppm Dry Weight			
	N	P	K	Ca	Mg	Mn	Fe	Cu	B
Berrien County (26 Plots)									
Shoot Tip	2.03	.27	2.24	.66	.44	280	168	34	26
Leaf	2.72	.21	1.43	1.09	.51	369	230	44	27
"t" value	3.56**	5.02**	5.86**	8.35**	3.96**	3.10**	3.43**	2.47*	.37
Van Buren County (16 Plots)									
Leaf	2.48	.21	0.90	1.40	.65	350	271	43	45

*Statistically significant at the 5 percent level.
**Statistically significant at the 1 percent level.

TABLE 3

Seasonal Differences in Leaf Composition Between First and Second Samples of Selected Black Raspberry Plantings, 1957.

County	Element	First Sample	Second Sample	"t"
Berrien	Nitrogen %	3.12	2.72	6.34**
Van Buren	Nitrogen %	2.51	2.48	.34
Berrien	Phosphorus %	.22	.21	.28
Van Buren	Phosphorus %	.18	.21	2.47*
Berrien	Potassium %	1.60	1.43	1.68
Van Buren	Potassium %	1.02	.90	.98
Berrien	Magnesium %	.43	.51	3.39**
Van Buren	Magnesium %	.53	.65	2.10*
Berrien	Calcium %	1.00	1.09	1.05
Van Buren	Calcium %	.96	1.40	3.92**
Berrien	Boron ppm	35	27	2.66*
Van Buren	Boron ppm	24	45	5.42**
Berrien	Iron ppm	262	230	1.05
Van Buren	Iron ppm	193	271	3.43**
Berrien	Copper ppm	65	44	3.48**
Van Buren	Copper ppm	47	43	.50

*Statistically significant at the 5 percent level.
**Statistically significant at the 1 percent level.

data are presented in Table 4. The plots were divided into three groups according to yield, with the high producing plots yielding over 4500 grams for 3 hills, and the low producing plots yielding less than 3500 grams for 3 hills. Medium producing plots comprised the plots which yielded 3500 grams to 4500 grams for 3 hills.

Table 5 shows that the low producing plots had fewer canes per hill and smaller cane diameters. The cane measurements showed a correlation (significant at the 10 percent level) with yield. No relationship seemed to exist between average number of canes and diameter. The correlation coefficient between yield and number of canes was not significant.

The leaf and soil analysis for the high, medium, and low producing plots are presented in Tables 6, 7, 8 and 9. The nitrogen, magnesium and calcium contents of the leaves all showed some evidence of decreasing with increased fruit yields. Potassium and phosphorus both showed a slight increase with yield. Manganese also showed a direct relationship to yield with the high producing plots generally possessing a higher percentage of manganese in both leaf and soil analysis. Low yielding areas, with the exception of one plot, had a zero test for soil manganese. Leaf analyses showed similar results with the same four low yielding plots containing lower amounts of manganese.

High pH and increased amounts of calcium in the soil and leaf showed a

TABLE 4

Yield Records for Black Raspberry Plots Harvested in 1958
(Grams for Three Hills)*.

Plot	Harvest Dates				Total Yield
	July 7	July 9	July 12	July 16	
			High Production		
29	2818.0	916.0	1904.7	1067.5	6706.2
33	2950.2	1344.1	1763.4	363.2	6420.9
5	1283.1	1057.6	1283.1	1043.7	4667.5
115	1789.3	629.6	1120.0	1110.9	4649.8
Average	2210.1	986.8	1517.8	896.3	5611.1
			Medium Production		
35	1547.6	852.2	957.9	804.9	4162.6
7	1026.0	1228.5	903.7	917.8	4076.0
111	1668.4	880.3	655.4	491.7	3695.8
31	1894.8	438.0	845.3	444.8	3622.9
117	1686.4	535.3	790.4	527.9	3540.0
Average	1564.6	786.8	830.5	637.4	3819.4
			Low Production		
109	927.4	385.5	1022.0	996.1	3331.0
107	905.6	1252.7	548.4	624.1	3330.8
93	- 1/	1252.7	777.1	300.7	2330.5
113	711.4	375.4	295.4	423.5	1805.7
91	- 1/	573.1	539.5	258.1	1370.7
Average	848.1	767.8	636.4	520.5	2433.7

1/ First and Second harvests combined and collected July 8, 1958.

* To convert values given to lbs/acre, multiply grams by 1.3 if planted 3 ft. x 8 ft.

TABLE 5

Number and Diameter of Canes in Harvested Black Raspberry Fields, 1958.

Plot	Ave. No. Canes	Ave. Diam. Canes (cm)
	High Production	
29	6.3	1.26
33	10.3	1.09
5	4.0	1.16
115	9.0	1.07
Average	7.4	1.14
	Medium Production	
35	16.3	1.12
7	7.6	1.23
111	7.0	1.16
31	5.6	1.02
117	6.6	1.08
Average	8.6	1.12
	Low Production	
109	5.6	1.15
107	6.6	1.12
93	5.6	1.10
113	7.0	1.11
91	6.0	0.97
Average	6.1	1.09

Yield/Hill vs Ave. No. Canes - Corr. Coeff. 0.2513.
Yield/Hill vs Ave. Diam. Canes - Corr. Coeff. 0.5256.

TABLE 6

Leaf Analysis for Black Raspberry Plots Harvested in 1958. Major Nutrients.

Plot	N	P	K	Mg	Ca
			(Percent Dry Weight		
			High Production		
29	2.39	.21	1.18	.51	0.84
33	2.33	.20	1.04	.54	1.12
5	2.78	.34	-	.50	0.95
115	2.79	.27	1.27	.53	1.37
Average	2.57	.25	1.16	.52	1.07
			Medium Production		
35	2.61	.22	1.36	.49	0.92
7	2.85	.27	1.66	.46	0.94
111	2.75	.19	0.90	.66	1.57
31	2.81	.27	1.70	.40	1.14
117	2.52	.22	1.26	.43	1.10
Average	2.70	.23	1.37	.48	1.13
			Low Production		
109	2.39	.19	0.98	.55	1.18
107	2.20	.20	1.06	.54	1.32
93	2.60	.18	0.50	.87	1.13
113	2.77	.21	1.23	.50	1.32
91	2.72	.19	0.85	.66	1.02
Average	2.53	.19	0.92	.62	1.19

TABLE 7

Leaf Analysis for Black Raspberry Plots Harvested in 1958. Minor Nutrients.

Plot	B	Cu (ppm)	Fe	Mn
		High Production		
29	23	35	174	350
33	28	31	163	400*
5	43	37	296	1420
115	49	45	284	840
Average	35	37	229	752
		Medium Production		
35	24	34	190	870
7	32	40	188	470
111	43	49	368	400*
31	31	100	298	590
117	19	40	195	580
Average	29.8	52.6	248	582
		Low Production		
109	28	39	179	200
107	37	45	251	190
93	56	33	265	120
113	42	41	396	640
91	62	34	310	140
Average	45	38	280	258

*Spectrographical analyses for Mn used. Chemical determinations made for other values.

TABLE 8

Cation Exchange Capacity, pH, and Reserve Test of Soil Samples from Black Raspberry Plots Harvested in 1958.

Plot	Cat. Exch. Cap.	pH	P	K (lbs/acre)
		High Production		
29	17.39	5.5	38	144
33	26.95	4.5	102	261
5	11.73	4.2	34	185
115	7.36	5.1	34	96
Average	15.85	4.6*	52	171
		Medium Production		
35	24.23	6.5	126	240
7	12.39	4.6	48	198
111	11.08	5.6	26	89
31	21.73	4.8	42	240
117	5.10	5.1	26	55
Average	14.90	5.0*	53	166
		Low Production		
109	3.60	6.3	102	117
107	5.69	6.6	55	55
93	8.50	6.8	40	41
113	23.04	5.4	96	254
91	5.43	6.4	26	34
Average	9.25	6.0*	64	100

*Calculated as average H^+ ion concentration.

TABLE 9

Soil Analysis for Black Raspberry Plots Harvested in 1958.
Active Test (Pounds/Acre)

Plot	Mn	P	K	Ca	Mg
		High Production			
29	8	10	130	800	24
33	8	22	233	320	16
5	60	10	178	320	16
115	16	10	62	600	8
Average	23	13	150.7	510	16
		Medium Production			
35	8	21	158	1000	32
7	40	10	151	320	12
111	8	6	48	320	16
31	40	6	117	320	16
117	16	6	41	320	4
Average	22.4	9.8	103	456	16
		Low Production			
109	0	18	117	320	16
107	0	14	69	800	32
93	0	5	178	800	32
113	4	14	178	320	16
91	0	8	27	800	16
Average	0.8	11.8	113.8	608	22.4

slight relationship to yield. The majority of high producing plots had a low pH and low calcium content according to both soil and leaf analysis.

The relationship of leaf analysis and soil analysis to yield was determined by means of correlation. The correlation coefficients are presented in Table 10. Only boron and iron content of the leaves showed a significant relationship to yield. All other correlation coefficients were not significant. Leaf analysis in general had a closer relationship to yield than did soil analysis.

Magnesium had highly significant negative correlation to potassium in the leaf. This relationship is presented in Figure 5. These two elements also had a similar relationship to yield, as shown in Tables 4 and 6.

TABLE 10

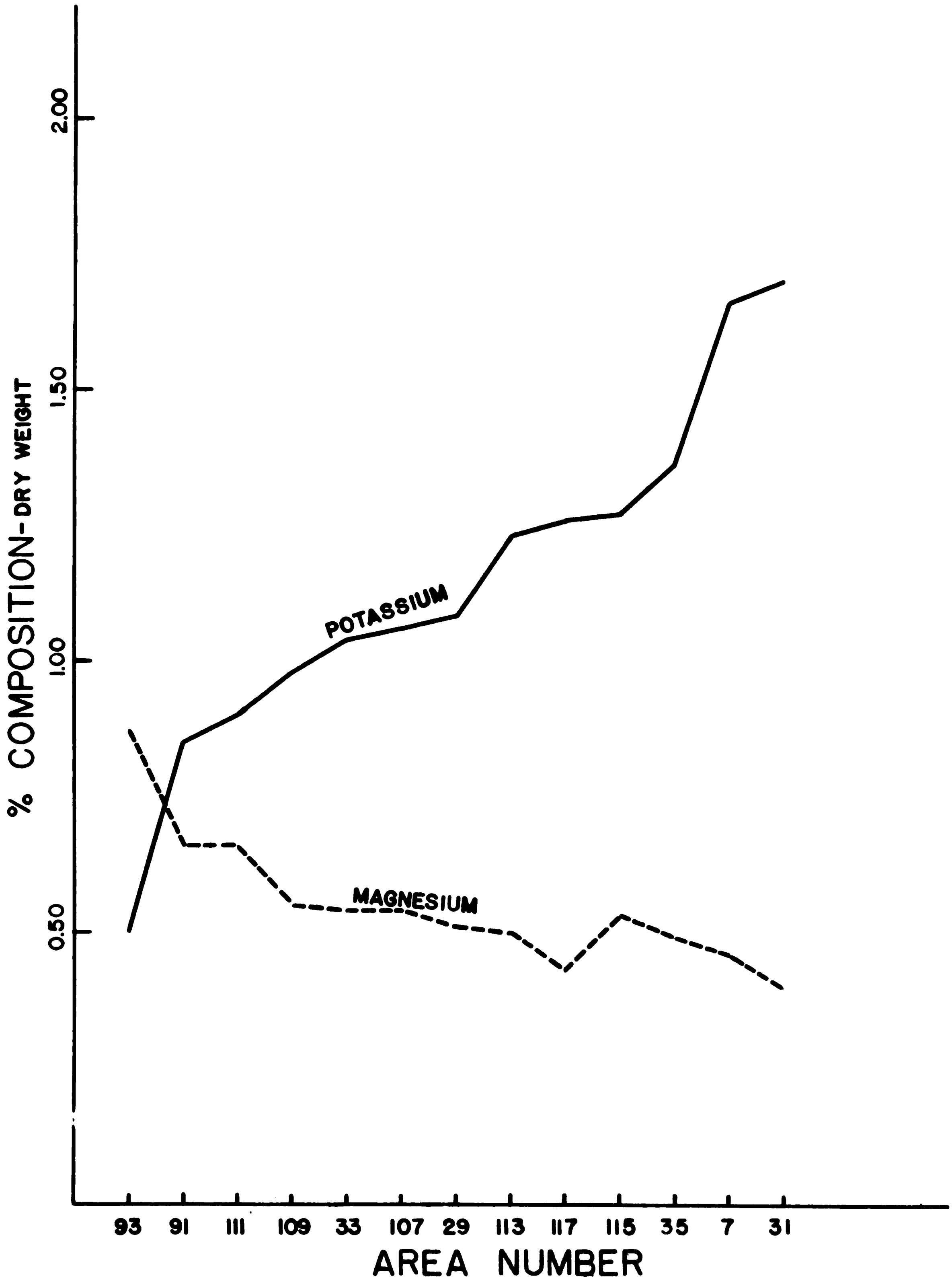
The Relationship Between Nutrient Content of Leaves and Soil Analysis to Yield.

14 Areas		Correlation Coefficient
	Leaf Analysis	
Yield	Nitrogen	-0.3193
	Phosphorus	0.2759
	Potassium	0.2758
	Magnesium	-0.3594
	Calcium	-0.3061
	Boron	-0.5735*
	Copper	-0.0914
	Iron	-0.5800*
	Manganese	0.2764
	Soil Analysis	
Yield	pH	-0.1600
	Phosphorus (Reserve)	0.0292
	Potassium (Reserve)	0.1173
	Manganese	0.0834
	Phosphorus	-0.0157
	Potassium	0.0109
	Calcium	-0.0200
	Magnesium	-0.0146
	Cation Exchange Capacity	0.1220

*Statistically significant at the 5 percent level.

Figure 5

Relationship of potassium and magnesium in the first mature leaf of the second sampling, chosen from the areas that provided yield records.


% COMPOSITION-DRY WEIGHT
2.00
1.50
1.00
0.50
POTASSIUM
MAGNESIUM
93 91 111 109 33 107 29 113 117 115 35 7 31
AREA NUMBER

DISCUSSION

A great deal of variability exists within most black raspberry fields. Since only two small plots in each planting were selected to find the prevailing nutritional conditions, a random sample from a large area might have yielded different results. If a field contained plants having a nutrient deficiency while other plants in the area were growing well, the mean nutrient content of the random sample would not reflect the disorder. Ulrich (1943) very clearly showed the influence of these factors.

Although the plantings were all of the Logan variety, the nursery stock was obtained from various sources. The plantings also varied in age, type of cultural practices, degree of disease, infection, and susceptibility to frost damage due to site. By selecting 42 different plots in 21 plantings, some of these difficulties were eliminated.

Shoot tips and leaves were selected from each plot for analysis and both were obtained at two different sampling dates. This method is supported by Goodall and Gregory (1947), who state "It seems clear that in order to obtain a clear idea of the range of nutritional conditions in the field or planting, it will be necessary to take more than one sample, and to analyze each separately".

With black raspberries, as well as other fruit crops, a portion of the plant that could be easily obtained without altering production or injuring the plant, but still suitable for analysis, was desired. Two parts of the plant (leaf and shoot tip) were selected in the beginning to determine the suitability of each.

Shoot tips, although they showed higher concentrations of nitrogen, phosphorus, and potassium, were not as favorable for analytical work as were the mature leaves. The shoot tip samples possessed two very noticeable types of tissue, leaf and cane, which differed in texture and weight. This condition which reduced the accuracy in weighing samples for analysis may have been prevented by grinding the samples to a finer mesh. The leaf samples were more homogenous and easier to weigh. Thomas (1937) and Ulrich (1943) reported similar experience with potatoes and grapes. Another disadvantage of shoot tips was that their removal caused the formation of laterals. Normal production practices require removal of the shoot tips in early July. Thus, the use of shoot tips would require the collection of such samples just before or during the usual tip removal operation.

The newly developing shoot tips, composed of younger tissue contained higher amounts of potassium, phosphorus and nitrogen than the leaves. This same accumulation was found in other crops by Nightingale (1942) and Burkhart and Page (1941).

The amount of calcium in the shoot tips was low as compared to the amounts found in the leaves. This has been reported in other plants by Goodall and Gregory (1947). Bukovac and Wittwer (1957) traced the mobility of calcium and found it to be very immobile in the leaf. This possibility accounts for the low amounts of calcium in the shoot tips, as compared to that in the leaves.

The cell structure of and metabolism in the leaf favored a higher concentration of manganese, iron and copper. These elements are not greatly needed by the newly developing shoot tip, but are necessary for the structure and manufacture of the more complex organic compounds in the leaf. Boron did not show a significant difference between the two types of tissue, but is essential, especially in the regions of new growth.

The nutrient composition of the leaves varied with the stage of plant development. Increases in phosphorus, iron, calcium and magnesium, and conversely, decreases of nitrogen and copper, supported evidence for separating the first samples from each county. The counties were kept separate because of the time of collecting the samples. The plots in each county were in the same general location, and, therefore, reached similar stage of plant development simultaneously. Two different stages of development would have been present if the counties had been grouped together.

The nitrogen and copper content of the leaves decreased as the season progressed in Berrien county. There was a greater production of vegetative plant growth at the time of the first sample than at the time the second sample was taken. This indicated a higher content of nitrogen during the earlier stages of plant development.

In the second sample, phosphorus and magnesium increased in both counties, while calcium and iron increased in Van Buren county. This possibility was due to the increased maturity of the leaf and the higher requirement for these elements necessary for metabolic activities and the formation of organic compounds. The marked increase of magnesium has been observed for grape petioles in the same general area by Bergman (1957).

As black raspberries ripen, they need to be picked almost immediately, or the berries will turn soft and drop. The plantings are usually picked commercially three or four times, but because of low market value, the berries were harvested only two or three times during 1958. The 14 plots which supplied yield records were harvested four times. Generally, the first harvest produced higher yields. The high producing plots averaged 2. 5 times those of the poorer areas.

Boron and iron increased significantly as yields decreased. According to information on other fruit, especially red raspberries, by Askew, Chittenden and Monk (1951), the amounts of boron in black raspberry leaves (less than 62 ppm) were considerably less than reported for toxicity (over

300 ppm). However, many plantings were near the deficient level reported by Askew, Chittenden and Monk (1951).

The amount of nitrogen in the leaves indicated a normal amount for all the plots; there were no significant differences. Magnesium and calcium both decreased slightly as yields increased; potassium showed an opposite reaction. This same trend of high amounts of potassium and low amounts of magnesium in leaves showed evidence of increased amounts of potassium in the soil depressing the absorption of magnesium. The easier release of potassium, compared to magnesium, from the soil was reported by Bray (1942) and Wadleigh (1949).

In general, highest yields were obtained on the more acid soils having a lower pH and calcium content. The five low yielding plots had a higher pH, averaging 6. 3, while the four high yielding plots had an average pH of 4. 8. Hoffman and Schlubatis (1928) observed the best black raspberry plots to have a lower pH than the poorer plots.

Low yielding plots generally contained less manganese according to both soil and leaf analysis. Where manganese was low, calcium was often high in the soil. The possibility of applying manganese to areas which were high in lime to increase yields, finds some support from Askew and Watson (1951) in their work with Red Antwerp raspberries in New Zealand.

Phosphorus and copper were not limiting factors in production, although phosphorus showed an increase with yield.

Some of the differences in production were due to factors other than nutrition, such as plant origin and disease. It was probable that the cation exchange capacity and other nutritional factors did not show as great a response because of these factors.

Yield, as related to cane measurement, manifested itself mostly when considering the diameter of canes. Highest production was obtained in the plots having vigorous canes of large diameter. The positive relationship of cane diameter to yield is also shown by the studies of Johnston (1925), Teske and Gardner (1927), and Judkins (1945).

SUMMARY

A survey of Logan black raspberry plantings was conducted in southwestern Michigan. Shoot tip, leaf and soil samples were obtained at two dates in 1957, and analyzed. Cane diameters were measured during dormancy and yield records were obtained in July, 1958. The shoot tips contained higher amounts of nitrogen, phosphorus and potassium than the leaves. Magnesium, calcium, manganese, iron and copper showed higher accumulation in the leaves, while boron was approximately equal.

Changes in percent composition of the leaves showed nitrogen and copper to decrease from the first to the second sampling, while increases were recorded for phosphorus, calcium, magnesium and iron. Potassium remained approximately the same in the second sampling. Boron, which showed fluctuation, increased in Van Buren county and decreased in Berrien county. Leaf analysis revealed a negative relationship between potassium and magnesium.

Boron and iron increased with decreased yield, while the other elements showed very little relationship to yield. Low manganese in the leaf and soil samples was associated with the poor producing plots. Generally, the poorest producing plots had a higher pH than the best yielding plots.

Yield showed a closer relationship to cane diameter than to number of canes.

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A P P E N D I X

APPENDIX TABLE I

Shoot Tip and Leaf Analysis in Berrien County for Nitrogen, Phosphorus, and Potassium

Plot*	N (per cent)		P (per cent)		K (per cent)	
	Shoot Tip	Leaf	Shoot Tip	Leaf	Shoot Tip	Leaf
1	3.32	2.98	.30	.23	2.24	1.73
1a	2.33	2.60	.24	.20	1.28	2.06
3	3.28	3.17	.28	.21	2.22	1.56
3a	2.64	2.53	.28	.22	1.40	2.23
5	3.92	3.31	.40	.28	2.12	1.98
5a	3.20	2.78	.41	.34	1.43	-
7	3.81	3.39	.35	.25	2.57	1.89
7a	3.50	2.85	.34	.27	2.58	1.66
9	3.72	3.24	.28	.20	2.05	1.32
9a	3.24	2.84	.29	.21	2.34	1.40
11	3.29	2.63	.27	.20	1.83	0.81
11a	2.26	2.43	.23	.20	1.62	0.90
13	3.83	3.36	.39	.27	2.48	1.84
13a	3.15	2.81	.25	.20	2.38	1.48
15	3.43	3.17	.33	.26	2.15	1.28
15a	3.22	2.67	.27	.18	0.25	0.94
17	3.42	3.03	.35	.24	2.10	1.59
17a	3.60	3.05	.25	.20	2.59	1.64
19	3.60	3.21	.30	.21	2.45	2.11
19a	3.57	3.17	.26	.20	2.82	1.78
21	3.67	3.20	.31	.22	2.93	2.08
21a	3.14	2.93	.30	.23	2.46	1.47
23	3.68	3.10	.30	.21	2.61	2.33
23a	3.22	3.20	.27	.22	2.49	1.91
25	3.31	2.89	.30	.21	2.38	1.10
25a	2.91	2.51	.26	.21	2.48	1.00
27	3.22	2.89	.30	.23	1.83	1.02
27a	2.95	2.54	.26	.24	2.06	0.91
29	3.62	2.89	.29	.20	2.72	1.44
29a	2.78	2.39	.26	.21	2.60	1.18
31	3.13	2.97	.32	.26	2.13	1.73
31a	3.26	2.81	.30	.27	2.49	1.70
33	3.60	3.37	.31	.23	2.22	1.67
33a	2.61	2.33	.24	.20	2.48	1.04
35	3.38	3.05	.30	.21	2.06	1.58
35a	2.84	2.61	.24	.22	2.35	1.36

*a - second sample.

APPENDIX TABLE I - CONT'D

Plot*	N (per cent)		P (per cent)		K (per cent)	
	Shoot Tip	Leaf	Shoot Tip	Leaf	Shoot Tip	Leaf
37	3.81	3.39	.34	.21	2.36	1.64
37a	3.05	3.03	.31	.21	2.50	1.12
39	3.68	3.29	.32	.20	2.11	1.72
39a	2.86	2.86	.28	.24	2.54	1.44
41	3.68	3.28	.33	.22	2.12	1.64
41a	3.10	2.64	.28	.22	2.63	1.47
43	3.70	3.21	.32	.23	2.14	1.45
43a	3.43	2.91	.34	.25	2.67	1.25
49	3.64	3.18	.31	.18	2.36	1.99
49a	3.15	2.98	.23	.17	2.35	2.04
51	2.63	3.21	.30	.17	2.41	1.84
51a	3.06	2.78	.22	.16	2.35	1.41
71	3.59	2.98	.34	.28	2.59	1.43
71a	2.81	2.34	.30	.26	2.43	1.29
73	3.51	2.90	.29	.17	2.06	1.05
73a	2.79	2.36	.24	.18	2.71	1.20

*a - second sample.

APPENDIX TABLE II

Shoot Tip and Leaf Analysis in Berrien County for Calcium, Magnesium, and Manganese

Plot*	Ca (per cent)		Mg (per cent)		Mn (per cent)	
	Shoot Tip	Leaf	Shoot Tip	Leaf	Shoot Tip	Leaf
1	.58	1.00	.38	.37	.0219	.0229
1a	.70	1.20	.54	.61	.0195	.0375
3	.68	.85	.35	.34	.0200	.0390
3a	.61	.92	.50	.55	.0266	.0400
5	.50	.74	.24	.30	.0400	.0400
5a	.52	.95	.44	.50	.0400	.0400
7	.56	.74	.25	.29	.0400	.0400
7a	.52	.94	.40	.46	.0400	.0400
9	.75	1.99	.33	.39	.0242	.0400
9a	.64	1.30	.50	.53	.0294	.0400
11	1.05	1.82	.35	.50	.0122	.0285
11a	.75	1.40	.57	.58	.0260	.0400
13	.65	1.22	.36	.37	.0208	.0400
13a	.63	.74	.42	.38	.0162	.0309
15	.99	1.46	.35	.38	.0400	.0400
15a	.65	1.37	.46	.50	.0400	.0400
17	.66	1.54	.30	.39	.0257	.0400
17a	.76	1.14	.42	.43	.0220	.0400
19	.50	.72	.27	.33	.0067	.0125
19a	.61	1.27	.45	.51	.0079	.0160
21	.50	.83	.31	.32	.0400	.0400
21a	.56	1.11	.45	.56	.0400	.0400
23	.85	.83	.25	.26	.0400	.0400
23a	.62	1.10	.51	.55	.0400	.0400
25	1.04	1.06	.28	.42	.0234	.0400
25a	.72	1.10	.45	.53	.0400	.0400
27	.55	.78	.30	.61	.0400	.0400
27a	.63	1.56	.43	.70	.0400	.0400
29	.51	.78	.43	.50	.0192	.0371
29a	.72	.84	.35	.51	.0200	.0400
31	.69	.77	.31	.41	.0400	.0400
31a	1.18	1.14	.38	.40	.0400	.0400
33	.50	.68	.36	.47	.0245	.0400
33a	.94	1.12	.40	.54	.0170	.0400

*a - second sample.

APPENDIX TABLE II - CONT'D

Plot*	Ca (per cent)		Mg (per cent)		Mn (per cent)	
	Shoot Tip	Leaf	Shoot Tip	Leaf	Shoot Tip	Leaf
35	.55	.57	.29	.39	.0190	.0260
35a	.73	.92	.38	.49	.0400	.0400
37	.50	1.28	.39	.54	.0140	.0400
37a	.51	1.37	.41	.53	.0220	.0400
39	.50	.97	.32	.42	.0219	.0400
39a	.63	1.16	.41	.53	.0219	.0400
41	.50	.91	.40	.47	.0253	.0400
41a	.64	.93	.42	.50	.0307	.0400
43	.50	.89	.39	.52	.0400	.0400
43a	.50	.97	.48	.56	.0400	.0400
49	.50	.64	.39	.42	.0145	.0225
49a	.58	.80	.45	.46	.0124	.0400
51	.50	.90	.40	.50	.0026	.0031
51a	.56	1.32	.37	.44	.0027	.0037
71	.64	1.18	.34	.54	.0400	.0400
71a	.70	.70	.34	.36	.0400	.0400
73	.50	.94	.37	.64	.0146	.0231
73a	.61	.98	.41	.48	.0154	.0325

*a - second sample.

APPENDIX TABLE III

Shoot Tip and Leaf Analysis in Berrien County for Iron, Copper and Boron

Plot	Fe (ppm) Shoot Tip	Fe (ppm) Leaf	Cu (ppm) Shoot Tip	Cu (ppm) Leaf	B (ppm) Shoot Tip	B (ppm) Leaf
1	172	229	39	66	19	24
1a	258	397	29	36	31	46
3	176	243	29	71	21	25
3a	232	235	34	26	32	35
5	475	693	60	100	76	57
5a	207	296	30	37	31	43
7	386	596	67	100	44	43
7a	139	188	27	40	24	32
9	170	240	32	54	22	33
9a	240	250	50	44	27	19
11	157	295	32	100	17	43
11a	220	329	39	37	22	29
13	238	337	71	100	47	47
13a	224	310	57	76	31	30
15	218	447	51	100	31	65
15a	276	381	55	58	46	54
17	228	279	92	100	38	33
17a	166	211	35	45	24	16
19	158	239	33	59	43	48
19a	166	203	28	73	28	23
21	176	395	35	48	35	50
21a	214	231	41	68	29	22
23	156	296	31	38	32	34
23a	194	362	36	65	18	25
25	152	186	48	77	30	26
25a	124	162	34	41	22	18
27	164	159	48	29	30	26
27a	163	184	31	31	27	25
29	130	162	35	64	27	26
29a	138	174	42	35	25	23
31	278	240	60	74	31	33
31a	190	298	28	100	21	31
33	90	170	24	37	35	23
33a	99	163	24	31	16	28

*a - second sample.

APPENDIX TABLE III - CONT'D

Plot	Element					
	Fe (ppm)		Cu (ppm)		B (ppm)	
	Shoot Tip	Leaf	Shoot Tip	Leaf	Shoot Tip	Leaf
35	167	150	37	58	34	21
35a	100	190	28	34	19	24
37	140	218	63	37	39	32
37a	137	189	52	32	39	29
39	107	190	100	37	30	36
39a	137	177	39	40	23	19
41	111	171	29	67	29	26
41a	114	173	20	34	17	18
43	102	137	29	43	28	25
43a	183	191	26	34	37	19
49	115	150	27	47	32	27
49a	124	179	27	31	21	20
51	112	175	28	54	30	20
51a	97	175	25	37	19	24
71	115	261	32	75	31	39
71a	121	164	26	34	24	27
73	103	148	45	44	29	40
73a	112	156	31	33	26	22

*a - second sample.

APPENDIX TABLE IV

Shoot Tip and Leaf Analysis in Van Buren County for Nitrogen, Phosphorus, and Potassium

Plot*	N (per cent)		P (per cent)		K (per cent)	
	Shoot Tip	Leaf	Shoot Tip	Leaf	Shoot Tip	Leaf
87	2.98	2.54	.29	.16	2.06	0.64
87a	3.26	2.60	.32	.23	2.41	0.61
89	2.81	2.49	.28	.18	1.78	0.32
89a	-	2.32	-	.22	-	0.45
91	2.79	2.78	.24	.15	1.69	0.47
91a	2.82	2.72	.25	.19	1.63	0.86
93	2.76	2.81	.23	.16	1.78	0.40
93a	-	2.60	-	.18	-	0.50
95	3.50	2.65	.31	.20	2.45	1.08
95a	3.34	2.62	.26	.23	-	0.72
97	3.32	2.56	.28	.17	2.45	1.08
97a	-	2.54	-	.18	2.47	0.78
99	2.69	2.24	.25	.18	2.13	0.94
99a	-	2.23	-	.19	-	0.84
101	2.63	2.12	.25	.16	2.09	0.96
101a	-	2.20	-	.19	-	0.95
103	2.95	2.47	.27	.21	2.32	1.23
103a	-	2.41	-	.21	-	1.15
105	2.27	1.88	.24	.21	2.12	1.14
105a	-	2.12	-	.26	-	1.00
107	2.55	2.35	.24	.18	2.20	1.14
107a	-	2.20	-	.20	-	1.06
109	3.15	2.46	.29	.20	2.18	1.47
109a	2.89	2.39	.27	.19	2.50	0.98
111	3.31	2.83	.25	.19	2.20	1.15
111a	-	2.75	-	.19	-	0.90
113	3.24	2.73	.25	.20	2.48	1.56
113a	-	2.77	-	.21	-	1.23
115	3.24	2.79	.28	.24	2.26	1.41
115a	3.52	2.79	.31	.27	2.36	1.27
117	3.14	2.55	.26	.21	2.08	1.38
117a	2.78	2.52	.25	.22	2.26	1.26

*a - second sample.

APPENDIX TABLE V

Shoot Tip and Leaf Analysis in Van Buren County for Calcium, Magnesium, and Manganese

Plot*	Element					
	Ca (per cent)		Mg (per cent)		Mn (per cent)	
	Shoot Tip	Leaf	Shoot Tip	Leaf	Shoot Tip	Leaf
87	.50	.77	.39	.75	.0090	.0187
87a	.93	2.58	.45	1.05	.0073	.0232
89	.50	.82	.43	.77	.0140	.0400
89a	-	1.77	-	.99	--	.0400
91	.50	1.00	.46	.63	.0085	.0135
91a	.64	1.02	.48	.66	.0109	.0172
93	.61	1.06	.50	.77	.0056	.0100
93a	-	1.13	-	.87	--	.0145
95	.50	.81	.33	.41	.0400	.0400
95a	.54	1.69	.32	.77	.0400	.0400
97	.50	.80	.31	.39	.0117	.0400
97a	-	1.40	-	.69	--	.0400
99	.50	.92	.37	.56	.0191	.0400
99a	-	1.22	-	.54	--	.0400
101	.59	.88	.57	.67	.0155	.0293
101a	-	1.19	-	.60	--	.0400
103	.57	.57	.45	.45	.0209	.0400
103a	-	1.10	-	.48	--	.0400
105	.90	.98	.66	.50	.0400	.0400
105a	-	1.44	-	.64	--	.0400
107	.56	1.14	.50	.50	.0136	.0400
107a	-	1.32	-	.54	--	.0354
109	.61	.81	.38	.47	.0112	.0250
109a	.65	1.18	.44	.55	.0129	.0308
111	.52	1.19	.46	.33	.0133	.0400
111a	-	1.57	-	.66	--	.0400
113	.50	.92	.36	.39	.0245	.0400
113a	-	1.32	-	.50	--	.0400
115	1.14	1.33	.37	.44	.0400	.0400
115a	.59	1.37	.39	.53	.0400	.0400
117	1.04	1.45	.43	.53	.0400	.0400
117a	.72	1.10	.43	.43	.0400	.0400

*a - second sample.

APPENDIX TABLE VI

Shoot Tip and Leaf Analysis in Van Buren County for Iron, Copper, and Boron

Plot*	Fe (ppm)		Cu (ppm)		B (ppm)	
	Shoot Tip	Leaf	Shoot Tip	Leaf	Shoot Tip	Leaf
87	291	155	100	61	32	18
87a	120	229	19	26	21	42
89	202	160	88	60	31	19
89a	-	331	-	43	-	48
91	121	198	35	75	21	19
91a	141	310	24	34	40	62
93	108	158	44	60	27	25
93a	-	265	-	33	-	56
95	145	159	49	42	32	28
95a	99	220	23	40	21	38
97	110	156	24	47	30	21
97a	-	194	-	40	-	33
99	98	268	45	100	27	37
99a	-	260	-	98	-	52
101	85	158	33	44	16	23
101a	-	204	-	45	-	53
103	91	154	29	31	19	22
103a	-	213	-	37	-	43
105	123	226	31	38	20	39
105a	-	437	-	40	-	81
107	139	289	33	39	24	22
107a	-	251	-	45	-	37
109	125	134	33	27	32	18
109a	128	179	25	39	20	28
111	117	217	32	36	30	25
111a	-	368	-	49	-	43
113	123	244	26	35	26	24
113a	-	396	-	41	-	42
115	135	226	24	30	28	26
115a	131	284	26	45	27	49
117	129	188	20	21	23	22
117a	100	195	31	40	21	19

*a - second sample.