EFFECTS OF FERTILIZER TREATMENTS ON YIELDS, AND SOIL AND LEAF ANALYSES OF BLACK RASPBERRIES

Thesis for the Degree of M. S.

MICHIGAN STATE UNIVERSITY

Clifford Machacek

1955

EFFECTS OF FERTILIZER TREATMENTS ON YIELDS, AND SOIL AND LEAF ANALYSES OF BLACK RASPBERRIES

By

Clifford Machacek

AN ABSTRACT

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

MASTER OF SCIENCE

Department of Horticulture

1955

Approved Elvin L. Kenworthy

ABSTRACT

Fertilizer trials were made in 1952 and continued through 1953 to determine the effects that various levels of different fertilizers would have on the yields, and leaf and soil analyses of black raspberries. Twelve different treatments, replicated three times, were used. The treatments consisted of nitrogen, phosphorus, and potassium fertilizers applied at different rates to the soil of a five-year old black raspberry planting in the spring of both years. Soil conditioner and straw was used the first year in addition to the fertilizer in two of the treatments.

Records were kept of each year's yield. In 1953, leaves, with attached petioles, from the current year's growth were analyzed for nitrogen, phosphorus, potassium, calcium, magnesium, manganese, iron, boron, and copper. Soil samples were tested for pH values, phosphorus, potassium, calcium, magnesium, manganese, and iron.

The study showed that high levels of nitrogen increased significantly the yield of this bramble when climatic conditions damaged the fruiting potential. When weather was conducive to good fruit production, as in 1953, and where the soil was above average in productivity, black raspberry yields benefitted very little by fertilizer applications. Under these favorable conditions, rates of fruit maturity were influenced very slightly by the various fertilizer treatments.

High levels of nitrogen and potassium in the fertilizer applications resulted in larger amounts of these two elements in the leaves. Use of high levels of complete fertilizers resulted in increases in the manganese content of leaves. Addition of soil conditioner to applications of complete fertilizer resulted in higher phosphorus content in leaves. Different fertilizer treatments caused no significant differences in calcium, magnesium, boron, iron and copper content of leaves.

Use of complete fertilizers resulted in greater amounts of "reserve" phosphorus, potassium, and iron in the soil. Applications of low levels of complete fertilizers increased "active" phosphorus in soil, while high levels of complete fertilizers increased "active" potassium and manganese in the soil. "Active" calcium, magnesium, and iron in the soil were not significantly influenced by different fertilizer applications.

EFFECTS OF FERTILIZER TREATMENTS ON YIELDS, AND SOIL AND LEAF ANALYSES OF BLACK RASPBERRIES

By

Clifford Machacek

A THESIS

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

MASTER OF SCIENCE

Department of Horticulture

1955

THESIS

ACKNOWLEDGEMENTS

The author wishes to express his sincere appreciation to Dr. A. L. Kenworthy for his assistance in outlining the problem, carrying out the research work, and preparing the manuscript; to Dr. E. J. Benne and his staff for carrying out the chemical analyses of the leaves; to Dr. J. C. Shickluna and his staff for carrying out the determinations of the soil samples; to Drs. Harry K. Bell and Donald P. Watson for their guidance and editing of the manuscript; and to Messrs. Charles and Robert Morrison for providing the facilities for carrying out the research.

TABLE OF CONTENTS

Page

INTRODUCTION

Much of the black raspberry (Rubus occidentalis) industry in Michigan - valued at two million dollars - has been concentrated in the southwestern part of the State. The United States Census of Agriculture (1910-1950) for red and black raspberries showed a decrease in yield from 1190 to 722 quarts per acre during this period. This same trend of about 25 per cent decrease in yield has occurred over the same forty-year period in Berrien County, the center of production in Michigan.

Numerous diseases, such as crown gall, anthracnose, and certain virus diseases, are important factors in reducing yields. Fertilizer trials have been limited because of the dominant effect of these diseases. The present experiment was undertaken to study the relationship of yield, soil and leaf analysis of black raspberries to treatment with different fertilizers.

REVIEW OF LITERATURE

Much of the previous research work dealt with both the black and red raspberries. Since both species are closely related the responses to fertilizers should be similar, although they differ with respect to fruiting habits and other morphological characteristics.

Chandler (1930) at New York used nitrogen, phosphorus, and potassium on both red and black raspberries and found that, for black raspberry, total cane growth was increased only 0.4 per cent when nitrogen was applied. No response to applications of phosphorus and potassium were observed.

Ammonium sulfate when used with either phosphate or potash, as observed in Indiana by Cherry (1931), gave highest yields on Cumberland and Plum Farmer black raspberries. The use of phosphate or potash alone gave some increase, whereas a complete fertilizer showed none. There was a positive correlation between yield of berries and diameter of canes. Similar results, plus increased early season yields, with the use of a quickly available form of nitrogen, on Cumberland black raspberries were noted in Michigan by Marshall (1930), but in Oregon no benefits from the use of this element were observed (Waldo, 1935). Collison and Slate (1943) in New York found a like response on the black raspberry from nitrogen, but noted that phosphate and potash was of no significance. They found the influence of nitrogen to be related to the correlation between yields and diameter or number of canes. Work in Oregon, by Clark and Power (1945), showed that a complete fertilizer high in potash gave highest yields of black raspberries.

Chandler (1920) found that nitrogen increased total cane growth of red raspberries 87 per cent and, also, the total yield, although the two were not correlated. Similar results regarding yields were shown at West Virginia by Childs and Hoffman (1932) who found 300 pounds per acre of nitrate of soda superior to 200 pounds. Increased yields correlated with wood production but time of application had no affect on yields. Stene (1933, 1934, 1935) in Rhode Island found that the best yield of red raspberries resulted from potash in combination with nitrates. He concluded that potassium was as important or even more so than nitrogen. Similar findings with nitrogen on red raspberries were observed by Havis (1939) in Ohio.

Harris (1944) in British Columbia, showed that boron and manganese increased the yield of red raspberries, although the increase from boron was not significant at the five per cent level. Applications of copper and zinc had no affect on the yield, but zinc increased the carbohydrate content and dry-weight of the berries. Powers and Wood (1946) in Washington, however, showed that applications of copper sulfate increased black raspberry yields. Wallace and Hewitt (1946) in England, noted a common occurrence of iron deficiency in terminal leaves of shoots in conjunction with a manganese deficiency in the older leaves of red raspberries. The availability of both elements was affected by copper. The deficiency of iron, which resulted in a high proportion of soluble nitrogen in the leaves could have been caused by cobalt, magnesium, zinc, phosphorus, potassium deficiency, and the Ca/K ratio in the nutrient medium. They concluded that iron deficiency was extremely difficult to control although it was one of the most serious nutritional problems in fruit culture.

Deficiencies of boron on black raspberries reported by Askew, Chittenden, and Monk (1951) revealed rosetting of the leaves similar to that caused by green mosaic. They found in New Zealand that satisfactory growth occurred when the boron content on the dry basis was about 35 p.p.m. in leaves from fruiting canes and 50-60 p.p.m. in leaves from new canes. Their field trials indicated that there was a wide range in the level of boron because even with values up to 300 p.p.m. in the dry matter of leaves from new canes no toxic evidence was present.

Darrow and Magness (1938) at Beltsville, Maryland, using eight tons of rye straw plus 600 pounds of nitrate of soda per acre on red and black raspberries found that increases of 400 per cent in yields correlated very well with ratio of cane length. They explained the overall differences in plant survival, cane length, and sucker growth to necessary trace minerals which were leached from the straw. Similar results from use of mulch were shown in New Jersey by Clark (1939) and in Ohio by Havis (1939) who, also, noticed a need for extra nitrogen with mulch. The additional yield from mulched red raspberries, though slightly delayed in ripening, was the result of bigger berries or more fruiting wood or both (Childs,1941).

Judkins (1945) in Ohio concluded that increases in yield of black raspberries resulted more from larger diameter canes than greater number of canes, but that this bramble benefitted less by mulch than the red raspberry. Increased yields were obtained by Bailey (1949) in Massachusetts from mulched red raspberries, but no benefits were derived by the addition of 0 to 450 pounds of nitrate of soda.

STATEMENT OF PROBLEM

The purpose of this following study was to determine if the addition of different levels of the nitrogen, phosphorus, and potassium, plus straw and the soil conditioner, Krilium[1], would result in different yield levels. Relationships of fertilizer treatment to level of nutrients in leaves and soil were considered. These same factors were studied in relation to rapidity of ripening.

---

1 Trademark of the Monsanto Chemical Company for substances such as CRD-186 and CRD-189 sold as soil conditioners.

EXPERIMENTAL PROCEDURE

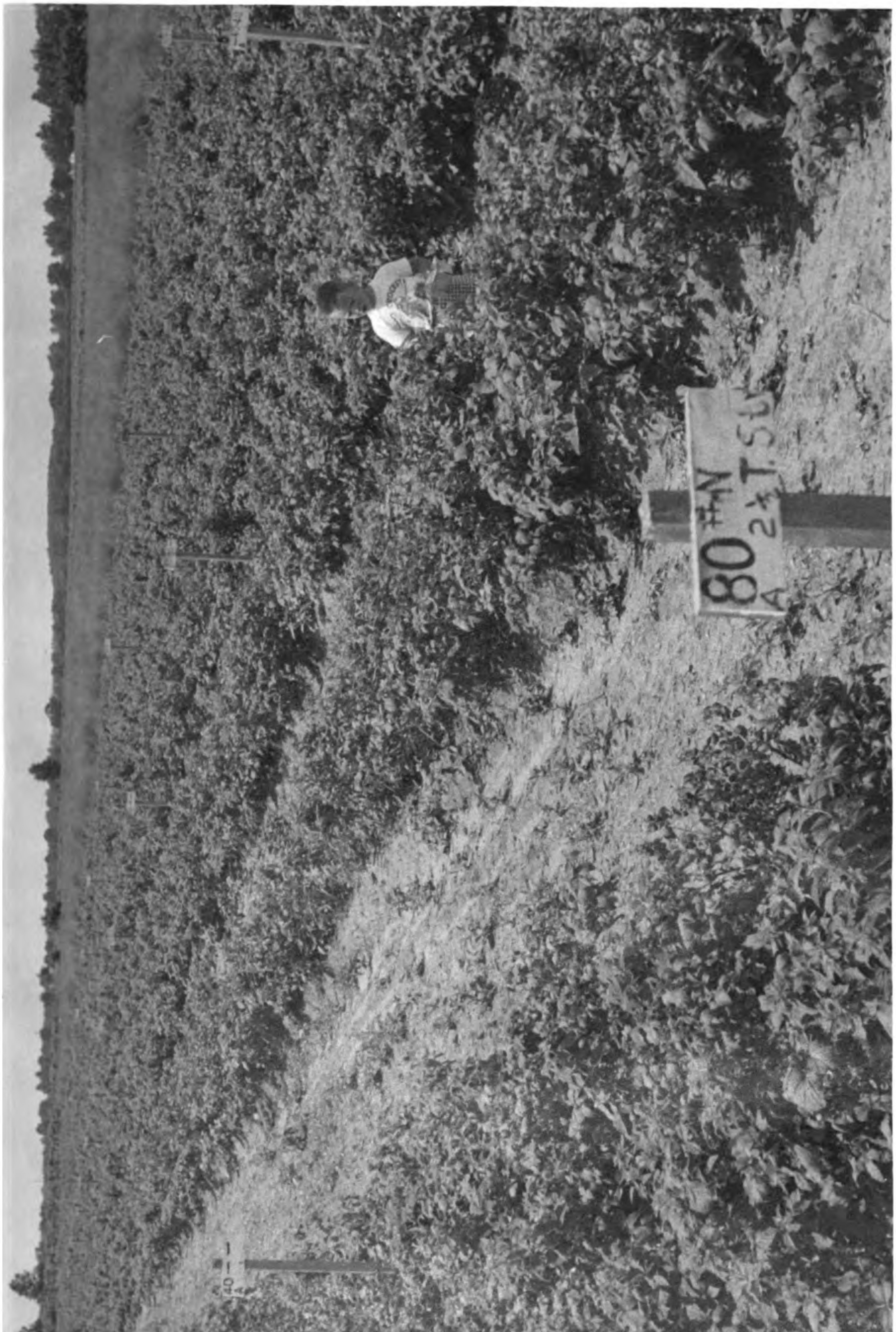
Plots and Plants

In the spring of 1952 a series of fertilizer treatments were established in a five year old Cumberland black raspberry field, (Figure 1), northeast of Paw Paw, Michigan, by Dr. J. P. Tompkins. Twelve treatments were used with each treatment being replicated three times. A plot consisted of nine plants in a single row with the plants being spaced 2½ feet apart. There was a buffer row between replicates but no buffer plants between plots. All plants previously had received the usual cultural treatment given to commercial plantings.

Soil and Topography

The soil was classified on the soil survey map as Plainfield sand, above average in productivity. Prior to this study applications of barnyard manure had been made periodically to maintain the organic matter. Annual applications of ammonium nitrate and 0-9-27 fertilizer had been made to the planting. Usually a cover crop was seeded after harvest to help maintain the level of organic matter and to prevent soil erosion. The topography of the site was gently sloping with no pronounced pockets in the field nor any outstanding eroded spots. The surface drainage was good, and a gravelly subsoil permitted good internal drainage.

Figure 1. General layout of the fertilizer field trial on black raspberries near Paw Paw, Michigan.


80 #N
A

Fertilizer Treatment of the Plots

The first fertilizer treatments were applied to all the plots in the spring of 1952. Ammonium nitrate, super and treble phosphate, and muriate of potash were used as sources of fertilizer. The applications were broadcast from each side of the row. No special efforts were used to incorporate the fertilizer with the soil.

The level of fertilizer treatment, in pounds of the actual elements per acre, and the combinations used in the plots were as follows: 0-0-0, 40-0-0, 40-40-0, 40-0-40, 40-40-40, 0-40-40, 40-40-40 plus Krilium, 80-0-0, 80-80-0, 80-0-80, 80-80-80, and 80-0-0 plus two and one-half tons of rye straw. The Krilium was worked into the soil according to the manufacturers' recommendation. The straw, added to each side of the row and between plants, was mixed with the soil.

The same fertilizer treatments were repeated to each respective plot in the spring of 1953. No further additions of Krilium and straw were made.

Harvest in 1952 and 1953

Total production of fruit was recorded in 1952 and 1953. The plots were harvested four times in 1952 and six times in 1953. The 1952 yields were low because of winter injury to buds and fruiting wood.

Leaf Sampling and Analysis

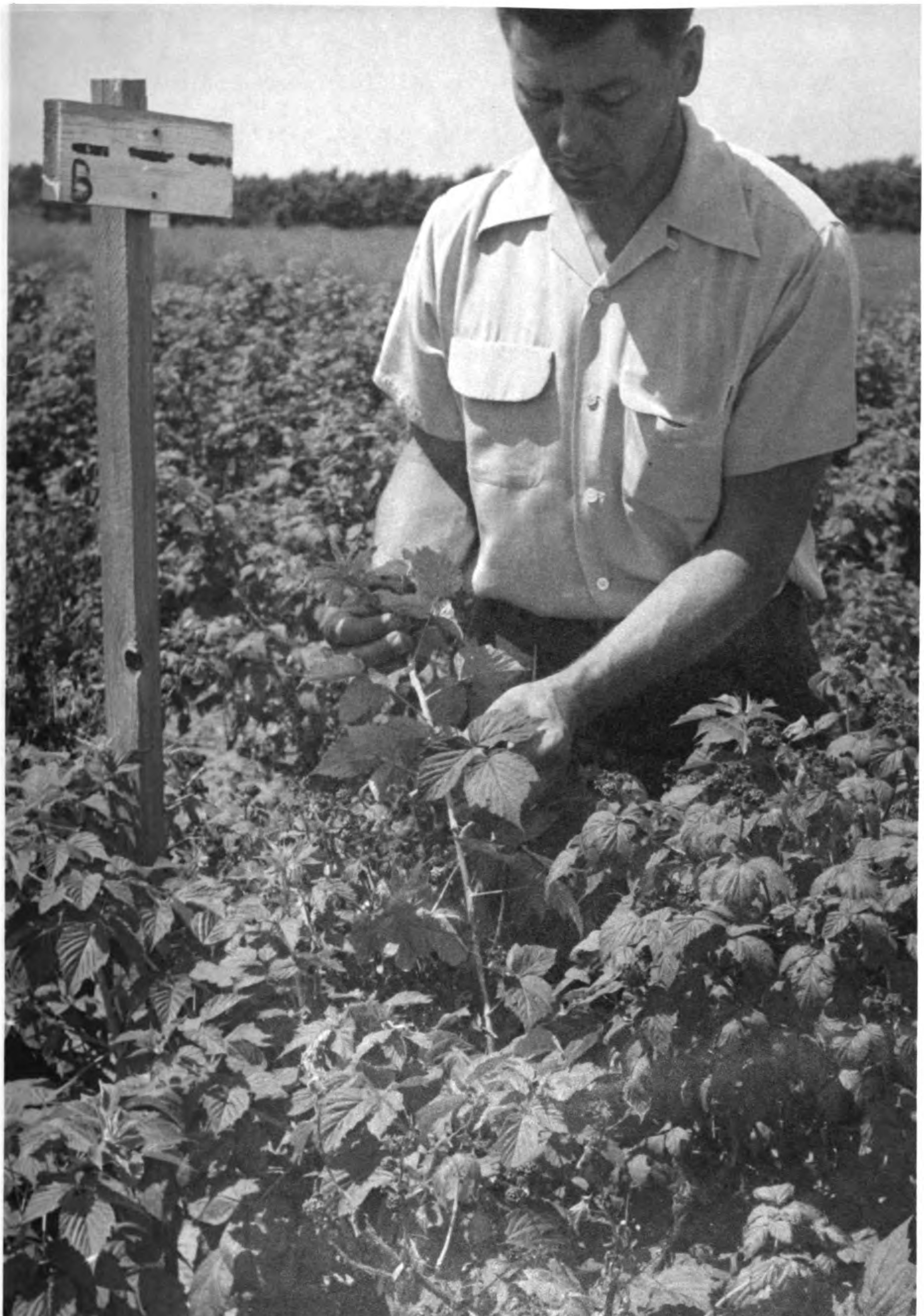
One hundred, damage-free, leaves with petioles attached were gathered per plot from the new canes after the harvest in 1953. The first fully developed leaf back of the growing tip, (Figure 2), was selected at random. These leaf samples were dried for forty-eight hours in a forced draft dehydrator, then ground in a Wiley mill (20 mesh screen), and stored in glass sample bottles. The ground samples were oven-dried for 24 to 48 hours at 100° C before chemical or spectrographic analysis.

The analyses were made by the Department of Agricultural Chemistry for the nine essential elements. The standard Kjeldahl method was used for the nitrogen determinations. The Perkins-Elmer flame photometer was used in determining potassium. The analyses of phosphorus, boron, iron, magnesium, manganese, calcium, and copper were made by means of spectrographic procedures.

Soil Sampling and Analysis

After the harvest in 1953, nine sample cores were taken from the surface six inches of soil in each plot in the following manner: three from each side of the row approximately one and one-half to two feet from the center of the row and three from the center of the row in the spaces between plants. The core samplings were placed in a box, thoroughly mixed and then one-half pint of this composite mixture was retained in a container for the analyses. The samples were

Figure 2. A photograph showing the selection of leaves for leaf analysis. The most recently matured leaf on new cane growth were used (as shown by the left hand).


B

air-dried and screened. Soil pH was determined with a Beckman pH meter. "Reserve" tests for phosphorus, potassium, manganese, and iron were conducted on all samples with use of the Spurway "Reserve" test method. The Spurway "Active" test was used to make determinations for phosphorus, potassium, manganese, iron, magnesium, and calcium.

RESULTS

Effect on Yields

The yield of fruit in 1952 was approximately one-fourth of that obtained in 1953, (Table 1). The lower yield in 1952 was attributed to winter injury in 1951-1952. The highest yield in 1952 was obtained from plots receiving high levels of nitrogen alone (80-0-0). The yield resulting from the use of 80-0-0 was significantly greater than that obtained from the use of 80-0-0 plus 2½ tons of straw, 80-80-0, or no fertilizer. The use of 80-0-80 resulted in significantly larger yield than obtained from the check plots and the 80-0-0 plus straw plot. Low levels of nitrogen, either alone or with phosphorus, significantly increased yields over the check plot. The lowest yield occurred with the use of nitrogen plus straw. The use of 80-0-0 plus straw resulted in yields significantly lower than obtained from plots receiving applications of 40-40-40, 40-0-0, 40-40-0, and 80-80-80. The use of soil conditioner with the complete fertilizer (40-40-40) caused an insignificant depressing effect on yield as compared to results of the complete fertilizer when used alone.

The 1953 yields showed no significant differences between any of the fertilizers applied to the plots, but the following trends were noted. High levels of a complete fertilizer, low levels of nitrogen with one other element, or low levels of phosphorus with potassium gave the highest yields. The lowest yield was noted for the 40-40-40

TABLE 1. Yield[1] of Black Raspberries in Relation to Fertilizer Treatments

Treatment	1952 Total (ounces)	1953 Total (ounces)	1953 First 3 pickings (ounces)
0-0-0	65.7	319.5	218.4
40-0-0	84.5	307.1	239.3
40-40-0	85.8	350.8	275.0
40-0-40	76.2	340.3	265.1
40-40-40	82.7	306.4	225.3
0-40-40	78.8	343.7	235.4
40-40-40 plus Krilium	77.5	320.8	243.5
80-0-0	90.8	320.3	243.0
80-80-0	69.7	309.4	230.5
80-0-80	87.9	312.4	243.7
80-80-80	82.6	339.3	257.1
80-0-0 plus 2½ tons straw	61.1	315.9	242.3
L.S.D. 5% =	18.2	N.S.[2]	N.S.
1% =	24.8		

[1] Yields are in ounces per plot. Each replicate has been corrected to nine plants per plot and to 21.78 feet (.005 of an acre). Note - 1 ounce per plot equals 12.5 pounds per acre or approximately 10 quarts per acre.

[2] F value not significant.

plot followed closely by plots with applications of 40-0-0, 80-80-0, and 80-0-80. In between these two extremes were those plots which received 80-0-0 plus straw, 0-0-0, 80-0-0, and 40-40-40 plus soil conditioner. It was observed that the application of 80-0-0 plus straw while still resulting in lower yields than that received with the use of 80-0-0, had increased yields over several other plots. Yields from plots where 40-40-40 plus soil conditioner was applied were above those from plots which received only 40-40-40.

Yields for the first three pickings, which contributed about seventy-five per cent of the total, showed that applications of 40-40-0 caused berries to mature most rapidly. Applications of 40-0-40 and 80-80-80 also appeared to increase the rate of maturity. The slowest rate of maturity occurred in the check plots (0-0-0). Rate of maturity appeared to show a positive relationship with total yield only for those plots which received applications of 40-40-0, 80-80-0, 80-0-0, and 40-40-40 plus soil conditioner. There were no significant differences between the applications and the relationships.

Effect on Nutrient Content of Leaves

The nutrient-element analyses of the leaves in relation to the various fertilizer treatments are shown in Table 2. The leaves from plots receiving high levels of nitrogen (except 80-0-80) and the one plot on which 40-40-0 was used contained significantly greater amounts

TABLE 2. **Leaf Analysis of Black Raspberry Leaves in Relation to Fertiliser Treatments (per cent of dry weight)**

Treatment	Nutrient-element								
	N	P	K	Ca	Mg	B	Mn	Fe	Cu
0-0-0	3.32	.196	1.09	1.29	.669	.0028	.0204	.0171	.0020
40-0-0	3.39	.165	1.23	1.15	.524	.0022	.0248	.0128	.0017
40-40-0	3.52	.202	1.40	1.24	.560	.0024	.0317	.0189	.0018
40-0-40	3.36	.163	1.47	1.06	.530	.0021	.0307	.0152	.0021
40-40-40	3.40	.207	1.36	1.29	.567	.0024	.0504	.0219	.0019
0-40-40	3.21	.193	1.16	1.26	.659	.0026	.0271	.0156	.0022
40-40-40 plus Krilium	3.44	.238	1.46	1.38	.555	.0025	.0314	.0186	.0020
80-0-0	3.54	.185	1.12	1.24	.538	.0022	.0508	.0159	.0020
80-80-0	3.47	.192	1.35	1.16	.590	.0023	.0523	.0170	.0019
80-0-80	3.45	.209	1.51	1.34	.540	.0022	.0621	.0177	.0019
80-80-80	3.53	.223	1.60	1.16	.501	.0023	.0787	.0170	.0019
80-0-0 plus Straw	3.56	.170	1.37	1.23	.487	.0021	.0497	.0164	.0020
L.S.D. 5% =	0.14	N.S.[1]	0.22	N.S.	N.S.	N.S.	.0239	N.S.	N.S.
1% =	0.20		0.29				.0325		

(1) F value not significant.

of nitrogen than did leaves from plots which had applications of no fertilizer, low levels of nitrogen and potassium, or low levels of phosphorus and potassium. The leaves from plots that received nitrogen and potassium, or low levels of complete fertilizers contained significantly more nitrogen than did leaves from plots to which low levels of phosphorus and potassium had been added. The use of 80-0-0 plus straw resulted in the largest amount of leaf nitrogen and was significantly higher than those where nitrogen alone or low complete fertilizers were used. There were no relationships between nitrogen content in leaves and total yield.

No significant differences due to fertilizers were noted for the phosphorus content of leaves, but the following trends were found. The highest amount of phosphorus was found in the leaves from the application of 40-40-40 plus soil conditioner, while the plots which received 80-80-80, 80-0-80, and 40-40-40 were noted to have slightly less leaf phosphorus. The lowest amounts of phosphorus in the leaves resulted from the use of fertilizers which contained nitrogen only or low levels of nitrogen and potassium.

High levels of potassium in fertilizers significantly increased leaf potassium. The lowest level of potassium in the leaves, other than the check plot, was found for applications of high levels of nitrogen alone (80-0-0). It was observed that the addition of straw to a nitrogen application resulted in higher potassium content in leaves. This also occurred when a soil conditioner was added to an application of 40-40-40.

The application of 40-40-40 with soil conditioner resulted in highest calcium content in leaves, but no significant difference could be established between different fertilizer applications and the amount of this element in the foliage.

Highest contents of magnesium appeared to be in leaves from plots which received no nitrogen, although no significant difference between high and low amounts was shown.

The amounts of boron in leaves were very low with a range of .0021 per cent to .0028 per cent on a dry weight basis. Leaves from the plot which received no fertilizer appeared to have the largest quantity of this element, although no statistical significance could be found between the upper and lower limits as shown from the different applications.

Use of high levels of a complete fertilizer (80-80-80) significantly increased the manganese content of the leaves above that for other treatments, except the 80-0-80 application. The use of 40-40-40 fertilizer showed a significant increase for leaf manganese above that for the no-treatment and the 40-0-0 plots. Low levels of manganese in the leaves appeared to result from the use of 40-pound applications of one major element alone, a combination of two elements, or a complete fertilizer plus a soil conditioner. Although statistical differences were not present in all cases, the application of fertilizers high in nitrogen (except where straw was added) appeared to result in higher manganese content of leaves as compared to applications of no nitrogen or low levels of this element.

There appeared to be no relationship between the iron content in leaves and the different fertilizer applications and no significant differences resulted from the use of the various fertilizers.

The different applications of fertilizers showed no significant differences in the copper content of leaves, although the average amounts ranged from a low of .0017 per cent to a high of .0022 per cent based on the dry weight.

<u>Effect on Nutrient Content of Soil</u>

Soil tests for pH, "reserve" and "active" nutrients in relation to fertilizer treatments are shown in Table 3. The average pH values ranged from 4.7 in plots where 80-80-80 fertilizer was applied to 5.4 in the plots where no fertilizer was added. There were no significant differences in these pH values as affected by different fertilizers.

The two complete fertilizers, 40-40-40 and 80-80-80, gave the highest amounts of "reserve" phosphorus in soil and were significantly greater than all treatments which received applications containing no phosphorus, low levels of nitrogen and phosphorus, or a soil conditioner. The 40-40-40 fertilizer application significantly increased "reserve" phosphorus over the 40-40-40 plus soil conditioner. An application of 0-40-40 resulted in significantly higher quantity of "reserve" phosphorus than 40-0-0 or 40-0-40.

The "reserve" potassium in soil was not influenced significantly

TABLE 3. Soil Analysis of Black Raspberry Plots in Relation to Fertilizer Treatments (pounds per acre)

	Reserve					Active					
Treatment	pH	P	K	Mn	Fe	P	K	Ca	Mg	Mn	Fe
0-0-0	5.4	42.6	130.0	9.3	26.7	5.7	85.3	480.0	16.7	0.0	6.0
40-0-0	5.1	40.3	97.3	9.3	34.7	4.3	61.3	413.3	10.7	6.0	2.0
40-40-0	5.0	47.0	121.3	2.7	53.3	4.7	83.3	413.3	16.0	5.3	2.0
40-0-40	5.0	39.0	149.3	7.3	26.7	4.7	93.3	320.0	13.3	6.0	1.3
40-40-40	5.2	72.7	174.7	8.0	80.0	8.0	110.0	666.7	24.3	4.7	0.7
0-40-40	5.3	58.0	148.0	5.3	42.7	7.3	104.0	413.3	7.0	2.7	2.0
40-40-40 plus Krilium	5.0	45.3	138.7	0.0	30.7	5.3	84.7	380.0	21.3	7.3	1.3
80-0-0	4.8	38.0	121.3	1.3	28.0	5.0	70.0	380.0	8.7	12.0	2.7
80-80-0	4.8	51.3	114.7	4.0	35.3	6.3	86.0	506.7	10.7	14.3	1.3
80-0-80	4.8	41.7	154.7	8.0	33.3	3.7	113.3	320.0	15.3	15.3	0.0
80-80-80	4.7	66.7	182.7	6.7	64.0	6.3	134.7	320.0	16.0	16.0	0.7
80-0-0 plus Straw	4.8	38.0	126.7	7.3	44.7	4.7	86.7	506.7	16.0	12.7	0.7
L.S.D. 5%=	N.S.	15.8	N.S.	N.S.	N.S.	2.0	33.7	N.S.	N.S.	4.4	N.S.
1%=		21.5				2.8	45.9			6.0	

by the different fertilizer treatments, but the following trends were noticed. The complete fertilizer applications resulted in greatest amount of "reserve" potassium. The next largest amounts were noted for plots which received fertilizers containing potassium plus one other element or a soil conditioner plus 40-40-40. The lowest amounts of "reserve" potassium in soil were found for plots which received no potassium in the fertilizer application.

No significant differences were noted for "reserve" manganese in relation to the fertilizer treatments. Since many of the replicates resulted in blank readings no indication of a trend could be found.

There were no significant differences noted between amounts of "reserve" iron in soil and the different fertilizers applied to plots. There was an indication that complete fertilizers would increase the "reserve" iron in soil while application of nitrogen alone would depress the amount.

Low levels of complete fertilizer significantly increased "active" phosphorus in soil above that found for plots treated with fertilizers containing no phosphorus, nitrogen alone, low levels of nitrogen and phosphorus only, or 40-40-40 plus soil conditioner. Applications of fertilizers containing low levels of phosphorus and potassium resulted in significantly greater amount of "active" phosphorus than the use of low levels of nitrogen alone, high levels of nitrogen with straw, nitrogen and potassium or low levels of nitrogen and phosphorus. High levels of nitrogen and potassium, and the low level nitrogen fertilizers when applied to soil showed significant decreases of "active" phosphorus in soil as compared to results obtained from plots which had received high levels of complete fertilizer or high levels of nitrogen and phosphorus. The soil from the plot which received no fertilizer had significantly more "active" phosphorus than that from the plot which received 80-0-80 fertilizer.

The high level of complete fertilizer significantly increased "active" potassium above that for all treatments containing no potassium and also the two plots receiving 40-0-40 and 40-40-40 plus soil conditioner. The applications of nitrogen alone significantly depressed the amount of "active" potassium as compared to the use of 80-0-80 or 0-40-40.

Increasing the amount of nitrogen, phosphorus or potassium fertilizers (either alone or in combination) significantly increased "active" manganese above that found for similar combinations at the lower rates of applications. The soil from the check plot showed no "active" manganese and was significantly lower than all treatments.

There were no significant differences in amounts of "active" iron in soil as a result of the various fertilizer treatments. The levels of this element per acre ranged from zero for plots treated with 80-0-80 to six pounds for plots which received no fertilizer.

No significant differences were found between amounts of "active" magnesium in soil and the application of different fertilizers to plots. The greatest amount of magnesium was associated with the use of 40-40-40 while "active" magnesium was lowest where 0-40-40 was used. There was no significant affect of the fertilizer applications upon "active" calcium.

DISCUSSION

The 1952 yields showed that straw was a limiting factor during the first year while high levels of nitrogen increased fruit production. Nitrogen-fixation through decomposition of the mulch was undoubtedly the cause of these low yields. The importance of potassium fertilizers as compared to phosphorus application is in agreement with work done by Stene (1935). The reduction in yields with continued use of larger amounts of fertilizer application was also borne out by similar results obtained by Stene (1933) and Clark and Powers (1945).

In 1953, lower levels of nitrogen appeared to be associated with the higher yields. The differences between yields were statistically insignificant and it was believed that severe disease infestations limited yield more than did fertilizer applications. Work reported by Waldo (1935) indicated high yields could be maintained by adequate fertilizers even in presence of disease. The high yields in 1953 could have been attributed to the fact that the plantings had always received excellent care. In addition to disease infestation, yield differences may have been limited by a generally low level of boron and phosphorus. Work done by Askew, Chittenden, and Monk (1951), and Ramig and Vandecaveye (1950), indicates that the amount of both elements found in the leaves was insufficient for maximum yields. The rate of maturity tended to be accelerated by application of low levels of nitrogen in combination with one other element. This difference in rate of maturity probably was due more to an unbalanced nutrient condition than to lower levels of nitrogen reducing the normal growing period.

The nitrogen content in leaves was well above the critical point as shown by Ramig and Vandecaveye (1950) and was related to the amount of this element contained in the fertilizer applied. The presence of potassium appeared to lower the nitrogen content in leaves more than the presence of phosphorus. This seemed to coincide with the added production and growth obtained with potassium which, in turn, may have caused the nitrogen content, on a percentage basis, to be lower. The levels of leaf phosphorus showed a tendency to be higher from plots which received the complete fertilizers and was highest from the plot which received the soil conditioner. This agreed with work done on corn by Quastel (1954) which showed a similar influence upon phosphorus absorption. Ramig and Vandecaveye (1950) showed the critical point for phosphorus content in leaves to be 0.3 per cent which was greater than that obtained from any of the plots. However, no visible symptoms of phosphorus deficiency were evident.

Potassium content of leaves was favorably influenced by high amounts of this element in the fertilizer. Adequate amounts of this element, according to reports of Goodall and Gregory (1947) and Clark and Power (1945), were found in all treatments. Sufficient quantities of leaf calcium were noted for all treatments, (Ramig and Vandecaveye, 1950). Fertilizers containing nitrogen alone or with one other element appeared to show the lowest amounts of calcium in leaves. Nitrogen alone or in combination with potassium in the fertilizer tended to result in lowered amounts of magnesium and boron in the leaves. None of the fertilizers showed any significant difference in the boron content of the leaves, and all were low according to Askew, Chittenden, and Monk (1951). However, no boron deficiency symptoms were apparent.

The influence of high nitrogen or complete fertilizers upon manganese content of leaves was very pronounced, although no apparent affect on yields was noticed with the high quantities of this element in the leaves. The increase in leaf manganese may have been associated with slightly lower soil pH conditions which were, in turn, associated with applications of high levels of nitrogen. In addition, ammonium, potassium and other cations contained in the fertilizers may have displaced the manganese from the soil colloid.

The phosphorus in the soil, both reserve and active, seemed to show larger amounts from soils treated with the fertilizers high in phosphorus or where all three elements were included. Both reserve and active potassium showed tendencies to be high where soil was treated with complete fertilizers or those high in potassium.

Low levels of a complete fertilizer seemed to result in the highest amounts of "active" calcium and "active" magnesium in the soil. However, no positive trend could be established between the different fertilizer applications and the varying amounts of these two elements.

The fertilizer treatments showed no relationship to reserve manganese, which was predominantly low. There was a positive relationship, although rather erratic, between "active" manganese in soil and the manganese content in leaf. This was not evident in the plots which received high levels of nitrogen fertilizers and in the check plot which received no fertilizers.

The highest amounts of "reserve" iron seemed to be associated with plots which also had the highest amounts of "reserve" potassium in the soil. There was no related affect between the "reserve" and the "active" iron in the soil, nor did fertilizer treatment have any affect on the amount of the "active" iron in soil.

SUMMARY

In 1952 fertilizer field trials established for black raspberries showed that high levels of nitrogen would increase significantly the yield of this fruit when climatic conditions damaged the fruiting potential. When weather was conducive to good fruit production, as in 1953, and where the soil was above average in productivity, black raspberry yields benefitted very little by fertilizer applications. Under these favorable conditions, rates of fruit maturity were influenced very slightly by the various fertilizer treatments.

High levels of nitrogen and potassium in the fertilizer applications resulted in larger amounts of these two elements in the leaves. Use of high levels of complete fertilizers resulted in increases in the manganese content of leaves. Addition of the soil conditioner "Krilium" to complete fertilizer application resulted in higher phosphorus content in leaves. Different fertilizer treatments caused no significant differences in calcium, magnesium, boron, iron, and copper content of leaves.

Use of complete fertilizers resulted in greater amounts of "reserve" phosphorus, potassium, and iron in the soil. Applications of low levels of complete fertilizers increased "active" phosphorus in soil, while high levels of complete fertilizers increased "active" potassium and manganese in the soil. "Active" calcium, magnesium, and iron in the soil were not significantly influenced by different fertilizer applications.

LITERATURE CITED

Askew, H. O., Chittenden, E. T., and Monk, R. J., 1951. "Die-Back" in Raspberries - A Boron Deficiency Ailment. Journal of Horticultural Science. 26: 268-284.

Bailey, John S., 1949. Winter Injury to Red Raspberries as Affected by Cultivation or Mulching. Proc. Amer. Soc. Hort. Sci. 54: 197-199.

Chandler, W. H., 1920. Some Responses of Bush Fruits to Fertilizers. Proc. Amer. Soc. Hort. Sci. 17: 201-204.

Cherry, W. F., 1931. Studies on the Effect of Chemical Fertilizers Upon Growth and Fruit Production of the Black Raspberry. Proc. Amer. Soc. Hort. Sci. 28: 176-179.

Childs, W. H., 1941. Production, Berry Size, and Growth of Red Raspberries as Influenced by Mulching. Proc. Amer. Soc. Hort. Sci. 38: 405-409.

Childs, W. H., and Hoffman, M. B., 1932. Nitrogen Fertilization of Latham Red Raspberries. Proc. Amer. Soc. Hort. Sci. 29: 302-305.

Clark, H. E., and Powers, W. L., 1945. Leaf Analysis as an Indicator of Potassium Requirement of Cane Fruits. Plant Physiol., 20: 51-61.

Clark, J. Harold, 1939. The Effects of Mulching Red Raspberries on Growth and Production. Proc. Amer. Soc. Hort. Sci. 37: 604-608.

Collison, R. C. and Slate, G. L., 1943. Fertilizer Responses of Black Raspberries in Western New York in Demonstrational and Experimental Layouts. Proc. Amer. Soc. Hort. Sci. 42: 463-466.

Darrow, George M., and Magness, J. R., 1938. Investigations on Mulching Red Raspberries. Proc. Amer. Soc. Hort. Sci. 36: 481-484.

Goodall, D. W., and Gregory, F. G., 1947. Chemical Composition of Plants as an Index of Their Nutritional Status. Imperial Bureau of Horticulture and Plantation Crops, East Malling, Kent, England. Tech. Comm. No. 17: 38.

Harris, G. Howell, 1944. The Effect of Micro-elements on the Red Raspberry in Coastal British Columbia. Proc. Amer. Soc. Hort. Sci. 45: 300-302.

Havis, Leon, 1939. Pointers on Cultural Practices with Strawberries and Raspberries. Proc. Ohio State Hort. Soc. 72: 63-67.

Judkins, Wesley P., 1945. Recent Developments in Cultural Practices for Raspberries and Strawberries. Proc. Ohio State Hort. Soc. 78: 139-143.

Marshall, R. E., 1930. Fertilizing the Black Raspberry. Mich. Agric. Exp. Station Quarterly Bul. Vol. 12, No. 4: 123-128.

Powers, W. L., and Wood, L. K., 1946. Some Causes of Malnutrition in Cane Fruits. Proc. Soil Sci. Soc. Amer. 10: 260-262.

Ramig, R. E., and Vandecaveye, S. C., 1950. Nutrient Levels for Raspberries Grown in Water Cultures. Plant Physiol. 25: 617-629.

Quastel, J. H., 1954. Soil Conditioners. Ann. Rev. Plant Physiol. 5: 75-92.

Stene, A. E., 1933. Preliminary Studies in the Fertilization of Red Raspberries. Proc. Amer. Soc. Hort. Sci. 30: 275-277.

Stene, A. E., 1934. Fertilization of Red Raspberries. Proc. Amer. Soc. Hort. Sci. 32: 400.

Stene, A. E., 1935. Fertilizer Treatments of Red Raspberries. Proc. Amer. Soc. Hort. Sci. 33: 411-414.

Waldo, George F., 1935. Fruit Bud Formation in Small Fruits and Its Relation to Cultural Practices. Proc. Oregon State Hort. Soc. 27: 75.81.

Wallace, T., and Hewitt, E. J., 1946. Studies in Iron Deficiency of Crops. I. Problems of Iron Deficiency and the Interrelationships of Mineral Elements in Iron Nutrition. Journal of Pomology and Hort. Sci. 22: 153-161.

APPENDIX TABLE 1. Total Yield of Black Raspberry Fruit in 1953 by Dates of Harvest[1/] - (ounces)

Treatment	Repl.	Ft. per Plot	Plants per Plot	July 3	July 6	July 10	July 13	July 17	July 20	Total
0-0-0	A	24.5	9.0	30.0	92.5	109.5	60.5	41.0	33.0	366.5
	B	23.5	9.0	48.0	115.5	101.5	50.5	19.0	21.5	356.0
	C	25.5	10.0	56.0*	110.5*	98.5	62.5	41.5	25.0	394.0
40-0-0	A	24.5	8.0	44.0	92.5	94.0	25.0	22.5	8.0	286.0
	B	25.0	9.0	87.0*	106.5*	73.0	46.5	28.5	12.5	354.0
	C	23.0	9.0	91.0*	100.5*	78.0	34.0	28.5	13.0	345.0
40-40-0	A	19.5	9.0	45.0	91.5	87.5	28.0	19.0	16.5	287.5
	B	21.0	9.0	78.0*	123.5*	86.5	40.5	28.0	16.0	372.5
	C	21.5	9.0	76.5*	113.0*	83.0	35.0	19.0	14.0	340.5
40-0-40	A	24.5	9.0	89.0*	113.5*	80.0	49.5	25.0	13.5	370.5
	B	20.0	9.0	51.5	108.0	83.0	33.0	18.5	10.0	304.0
	C	23.5	9.0	77.5	125.0	96.5	51.0	16.0	23.0	389.0
40-40-40	A	20.0	9.0	54.0*	66.5*	54.0	47.5	16.0	16.5	254.5
	B	22.0	9.5	39.0	105.5	91.5	44.5	16.5	16.0	313.0
	C	20.0	9.0	77.5*	92.0*	73.5	41.0	22.0	14.0	320.0
0-40-40	A	21.5	9.0	20.0	63.5	86.5	58.5	31.5	26.5	286.5
	B	22.0	9.0	54.5*	118.0*	90.5	56.0	38.5	22.5	379.5
	C	24.0	9.0	49.5*	129.0*	123.0	56.0	19.0	26.0	402.5
40-40-40 plus Krilium	A	27.0	9.5	47.0	121.0	120.0	36.5	28.0	16.5	369.5
	B	20.0	9.0	54.5	100.5	83.0	41.0	20.0	13.0	312.0
	C	25.5	10.0	115.5*	137.5*	74.0	61.0	38.0	16.5	442.5

Appendix Table 1. Cont'd.

Treatment	Repl.	Ft. per Plot	Plants Per Plot	July 3	July 6	July 10	July 13	July 17	July 20	Total
80-0-0	A	20.0	8.5	56.5	85.5	74.0	26.0	21.5	9.0	272.5
	B	25.0	9.0	88.5*	103.0*	78.5	51.0	29.0	17.0	367.0
	C	22.5	7.5	34.5	96.5	79.5	39.0	13.0	19.0	281.5
80-80-0	A	22.0	9.0	43.5	77.0	80.0	38.0	22.5	13.0	274.0
	B	24.5	9.0	63.0	131.0	110.5	40.0	22.5	22.5	389.5
	C	24.5	9.0	105.0*	99.0*	45.0	59.0	26.5	15.0	349.5
80-0-80	A	27.0	9.0	76.0*	105.5*	83.5	30.5	24.0	10.0	329.5
	B	23.5	8.0	49.5	106.5	98.5	40.0	28.0	17.5	340.0
	C	23.5	9.0	88.5*	104.0*	79.5	32.0	26.0	12.0	342.0
80-80-80	A	30.0	9.0	93.5*	124.0*	88.5	72.0	27.5	24.0	429.5
	B	19.5	9.0	84.0*	103.0*	74.5	39.0	23.0	14.0	337.5
	C	22.0	9.0	76.0	97.5	84.5	46.0	13.5	15.0	332.5
80-0-0	A	23.5	9.0	42.0	108.0	87.0	29.0	29.0	15.0	310.0
plus	B	23.5	8.5	73.0*	90.0*	54.0	38.0	22.0	10.5	287.5
2½ T. Straw	C	21.5	9.0	108.5*	110.0*	72.0	43.5	25.0	14.5	373.5

[1] No correction made for length of plot or number of plants in plot.

* Picked one day later.

APPENDIX TABLE 2. Yield of Black Raspberry Fruit. - 1952 - (ounces)

Replicate	Fertiliser Treatment											
	0-0-0	40-0-0	40-40-0	40-0-40	40-40-40	0-40-40	40-40-40 + Krilium	80-0-0	80-80-0	80-0-80	80-80-80	80-0-0 + Straw
A	52.3	78.4	93.7	67.5	46.8	58.6	62.3	100.8	66.2	54.7	52.3	47.9
B	83.8	86.2	80.8	84.9	89.1	81.0	113.3	70.6	67.5	106.7	102.4	53.4
C	62.1	88.9	82.8	76.2	112.2	96.9	56.8	101.1	76.2	102.4	93.0	81.9
Total	197.2	253.5	257.3	228.6	248.1	236.5	232.4	272.5	209.9	263.8	247.7	183.2
Average	65.7	84.5	85.8	76.2	82.7	78.8	77.5	90.8	70.0	87.9	82.6	61.1

APPENDIX TABLE 3. Yield of Black Raspberry Fruit. - First Three Pickings - 1953 - (ounces)

A	206.4	230.6	250.2	251.1	190.0	172.2	220.0	249.0	198.5	213.7	222.1	219.6
B	245.7	232.1	298.7	264.0	221.3	260.3	259.2	235.2	270.7	265.3	292.1	212.9
C	203.0	255.2	276.0	277.1	264.6	273.6	251.4	244.5	221.3	252.1	257.0	294.3
Total	655.1	717.9	824.9	792.2	675.9	706.1	730.6	728.7	690.5	731.1	771.2	726.8
Average	218.4	239.3	275.0	265.1	225.3	235.4	243.5	243.0	230.2	243.7	257.1	242.3

APPENDIX TABLE 4. Yield of Black Raspberry Fruit. - 1953 - (ounces)

Replicate	Fertilizer Treatment											
	0-0-0	40-0-0	40-40-0	40-0-40	40-40-40	0-40-40	40-40-40 + Krilium	80-0-0	80-80-0	80-0-80	80-80-80	80-0-0 + Straw
A	325.8	286.1	321.1	329.4	277.2	290.2	282.3	314.2	271.3	265.8	311.8	287.3
B	330.0	308.4	386.3	331.0	293.5	375.7	339.8	319.7	346.3	354.5	377.0	282.1
C	302.8	326.7	344.9	360.5	348.5	365.3	340.2	327.0	310.7	317.0	329.2	378.4
Total	958.6	921.2	1052.3	1020.9	919.2	1031.2	962.3	960.9	928.3	937.3	1018.0	947.8
Average	319.5	307.1	350.8	340.3	306.4	343.7	320.8	320.3	309.4	312.4	339.3	315.9

APPENDIX TABLE 5. Nitrogen Content of Black Raspberry Leaves. - (per cent of dry weight)

A	3.43	3.38	3.54	3.29	3.27	3.24	3.50	3.60	3.45	3.38	3.56	3.70
B	3.33	3.33	3.55	3.45	3.42	3.18	3.46	3.44	3.48	3.58	3.56	3.43
C	3.19	3.45	3.48	3.35	3.50	3.21	3.36	3.58	3.48	3.40	3.48	3.55
Total	9.95	10.16	10.57	10.09	10.19	9.63	10.32	10.62	10.41	10.36	10.60	10.68
Average	3.32	3.39	3.52	3.36	3.40	3.21	3.44	3.54	3.47	3.45	3.53	3.56

APPENDIX TABLE 6. Phosphorus Content of Black Raspberry Leaves. - (per cent of dry weight)

Replicate	Fertilizer Treatment 0-0-0	40-0-0	40-40-0	40-0-40	40-40-40	0-40-40	40-40-40 + Krilium	80-0-0	80-80-0	80-0-80	80-80-80	80-0-0 + Straw
A	.136	.170	.166	.139	.194	.177	.199	.276	.138	.201	.270	.161
B	.224	.193	.175	.235	.178	.253	.271	.118	.212	.185	.237	.132
C	.227	.133	.264	.115	.249	.149	.243	.160	.225	.240	.161	.217
Total	.587	.496	.605	.489	.621	.579	.713	.554	.575	.626	.668	.510
Average	.196	.165	.202	.163	.207	.193	.238	.185	.192	.209	.223	.170

APPENDIX TABLE 7. Potassium Content of Black Raspberry Leaves. - (per cent of dry weight)

A	.98	1.32	1.19	1.18	1.16	.98	1.32	1.00	1.19	1.39	1.50	1.53
B	1.28	1.17	1.50	1.61	1.36	1.24	1.59	1.28	1.56	1.54	1.75	1.26
C	1.01	1.21	1.52	1.63	1.55	1.27	1.48	1.08	1.31	1.59	1.55	1.33
Total	3.27	3.70	4.21	4.42	4.07	3.49	4.39	3.36	4.06	4.52	4.80	4.12
Average	1.09	1.23	1.40	1.47	1.36	1.16	1.46	1.12	1.35	1.51	1.60	1.37

APPENDIX TABLE 8. Calcium Content of Black Raspberry Leaves. - (per cent of dry weight)

Replicate	Fertilizer Treatment 0-0-0	40-0-0	40-40-0	40-0-40	40-40-40	0-40-40	40-40-40 + Krilium	80-0-0	80-80-0	80-0-80	80-80-80	80-0-0 + Straw
A	1.17	1.09	1.09	1.22	1.28	1.20	1.30	1.55	0.90	1.36	1.33	1.18
B	1.25	1.36	1.17	1.19	1.14	1.47	1.36	1.03	1.16	1.13	1.23	1.19
C	1.44	1.00	1.45	0.77	1.45	1.11	1.49	1.15	1.41	1.53	0.91	1.32
Total	3.86	3.45	3.71	3.18	3.87	3.78	4.15	3.73	3.47	4.02	3.47	3.69
Average	1.29	1.15	1.24	1.06	1.29	1.26	1.38	1.24	1.16	1.34	1.16	1.23

APPLENDIX TABLE 9. Magnesium Content of Black Raspberry Leaves. - (per cent of dry weight)

A	.715	.617	.635	.550	.533	.730	.592	.597	.592	.520	.517	.503
B	.642	.533	.483	.470	.642	.586	.527	.387	.600	.602	.410	.477
C	.650	.423	.561	.570	.527	.660	.545	.630	.577	.498	.577	.481
Total	2.007	1.573	1.679	1.590	1.702	1.976	1.664	1.614	1.769	1.620	1.504	1.461
Average	.669	.524	.560	.530	.567	.659	.555	.538	.590	.540	.501	.487

APPENDIX TABLE 10. Boron Content of Black Raspberry Leaves. - (per cent of dry weight)

Replicate	Fertilizer Treatment 0-0-0	40-0-0	40-40-0	40-0-40	40-40-40	0-40-40	40-40-40 + Krilium	80-0-0	80-80-0	80-0-80	80-80-80	80-0-0 + Straw
A	.0029	.0020	.0021	.0021	.0029	.0025	.0022	.0025	.0016	.0020	.0024	.0018
B	.0023	.0026	.0023	.0023	.0022	.0029	.0025	.0020	.0024	.0023	.0022	.0020
C	.0031	.0019	.0027	.0020	.0022	.0023	.0027	.0021	.0028	.0023	.0022	.0026
Total	.0083	.0065	.0071	.0064	.0073	.0077	.0074	.0066	.0068	.0066	.0068	.0064
Average	.0028	.0022	.0024	.0021	.0024	.0026	.0025	.0022	.0023	.0022	.0023	.0021

APPENDIX TABLE 11. Manganese Content of Black Raspberry Leaves. - (per cent of dry weight)

A	.0131	.0242	.0302	.0440	.0660	.0203	.0214	.0820	.0540	.0680	.0890	.0420
B	.0132	.0293	.0315	.0340	.0292	.0357	.0463	.0385	.0450	.0412	.0860	.0510
C	.0350	.0208	.0335	.0141	.0560	.0253	.0264	.0318	.0580	.0770	.0610	.0560
Total	.0613	.0743	.0952	.0921	.1512	.0813	.0941	.1523	.1570	.1862	.2360	.1490
Average	.0204	.0248	.0317	.0307	.0504	.0271	.0314	.0508	.0523	.0621	.0787	.0497

APPENDIX TABLE 12. Iron Content of Black Raspberry Leaves. - (per cent of dry weight)

Replicate	0-0-0	40-0-0	40-40-0	40-0-40	40-40-40	0-40-40	40-40-40 + Krilium	80-0-0	80-80-0	80-0-80	80-80-80	80-0-0 + Straw
	Fertilizer Treatment											
A	.0153	.0139	.0146	.0136	.0327	.0138	.0148	.0243	.0101	.0157	.0178	.0175
B	.0157	.0132	.0214	.0200	.0152	.0183	.0212	.0107	.0218	.0190	.0180	.0083
C	.0204	.0112	.0207	.0121	.0178	.0147	.0197	.0126	.0190	.0185	.0153	.0234
Total	.0514	.0383	.0567	.0457	.0657	.0468	.0557	.0476	.0509	.0532	.0511	.0492
Average	.0171	.0128	.0189	.0152	.0219	.0156	.0186	.0159	.0170	.0177	.0170	.0164

APPENDIX TABLE 13. Copper Content of Black Raspberry Leaves. - (per cent of dry weight)

A	.0022	.0022	.0018	.0021	.0020	.0022	.0021	.0020	.0019	.0015	.0019	.0019
B	.0020	.0015	.0018	.0022	.0019	.0018	.0019	.0017	.0023	.0021	.0017	.0020
C	.0018	.0015	.0019	.0019	.0018	.0026	.0021	.0022	.0016	.0020	.0020	.0021
Total	.0060	.0052	.0055	.0062	.0057	.0066	.0061	.0059	.0058	.0056	.0056	.0060
Average	.0020	.0017	.0018	.0021	.0019	.0022	.0020	.0020	.0019	.0019	.0019	.0020

APPENDIX TABLE 14. Soil pH in Relation to Fertilizer Treatments. - Black Raspberry - 1953

Replicate	Fertilizer Treatment											
	0-0-0	40-0-0	40-40-0	40-0-40	40-40-40	0-40-40	40-40-40 + Krilium	80-0-0	80-80-0	80-0-80	80-80-80	80-0-0 + Straw
A	5.4	4.9	4.8	5.0	5.2	5.4	4.9	4.6	4.7	4.9	4.8	4.7
B	5.4	5.1	5.0	5.0	5.2	5.3	5.0	4.8	4.9	4.7	4.6	5.0
C	5.5	5.8	5.3	5.1	5.2	5.3	5.3	4.9	5.0	4.8	4.8	4.8
Average	5.4	5.1	5.0	5.0	5.2	5.3	5.0	4.8	4.8	4.8	4.7	4.8

APPENDIX TABLE 15. "Reserve" Phosphorus in Soil in Relation to Fertilizer Treatments.- Black Raspberry (pounds per acre)

Replicate	Fertilizer Treatment 0-0-0	40-0-0	40-40-0	40-0-40	40-40-40	0-40-40	40-40-40 + Krilium	80-0-0	80-80-0	80-0-80	80-80-80	80-0-0 + Straw
A	48	40	48	34	100	60	38	38	56	38	72	40
B	42	45	48	38	72	50	48	38	42	45	60	36
C	38	36	45	45	46	64	50	38	56	42	68	38
Total	128	121	141	117	218	174	136	114	154	125	200	114
Average	42.6	40.3	47.0	39.0	72.7	58.0	45.3	38.0	51.3	41.7	66.7	38.0

APPENDIX TABLE 16. "Active" Phosphorus in Soil in Relation to Fertilizer Treatments. - Black Raspberry (pounds per acre)

A	6	4	4	4	10	7	4	4	6	4	7	5
B	5	5	5	5	9	7	7	7	6	3	5	4
C	6	4	5	5	5	8	5	4	7	4	7	5
Total	17	13	14	14	24	22	16	15	19	11	19	14
Average	5.7	4.3	4.7	4.7	8.0	7.3	5.3	5.0	6.3	3.7	6.3	4.7

APPENDIX TABLE 17. "Reserve" Potassium in Soil in Relation to Fertiliser Treatments. - Black Raspberry (pounds per acre)

Replicate	Fertiliser Treatment											
	0-0-0	40-0-0	40-40-0	40-0-40	40-40-40	0-40-40	40-40-40 + Krilium	80-0-0	80-80-0	80-0-80	80-80-80	80-0-0 + Straw
A	168	84	112	112	224	168	144	112	120	90	156	132
B	132	104	132	168	156	144	168	132	120	224	224	144
C	90	104	120	168	144	132	104	120	104	150	168	104
Total	390	292	364	448	524	444	416	364	344	464	548	380
Average	130.0	97.3	121.3	149.3	174.7	148.0	138.7	121.3	114.7	154.7	182.7	126.7

APPENDIX TABLE 18. "Active" Potassium in Soil in Relation to Fertiliser Treatments. - Black Raspberry (pounds per acre)

A	112	64	90	56	120	104	84	56	84	84	104	104
B	80	80	80	112	120	104	90	90	90	144	132	84
C	64	40	80	112	90	104	80	64	84	112	168	72
Total	256	184	250	280	330	312	254	210	258	340	404	260
Average	85.3	61.3	83.3	93.3	110.0	104.0	84.7	70.0	86.0	113.3	134.7	86.7

APPENDIX TABLE 19. "Reserve" Manganese in Soil in Relation to Fertilizer Treatments. - Black Raspberry (pounds per acre)

Replicate	Fertilizer Treatment 0-0-0	40-0-0	40-40-0	40-0-40	40-40-40	0-40-40	40-40-40 + Krilium	80-0-0	80-80-0	80-0-80	80-80-80	80-0-0 + Straw
A	12	-	-	12	20	16	-	4	4	16	20	-
B	16	16	-	10	-	-	-	-	8	8	-	12
C	0	12	8	-	4	-	0	-	0	-	-	10
Total	28	28	8	22	24	16	0	4	12	24	20	22
Average	9.3	9.3	2.7	7.3	8.0	5.3	0	1.3	4.0	8.0	6.7	7.3

APPENDIX TABLE 20. "Active" Manganese in Soil in Relation to Fertilizer Treatments. - Black Raspberry (pounds per acre)

A	0	6	8	8	8	0	10	16	11	16	16	16
B	0	8	6	6	3	8	8	12	16	16	16	16
C	0	4	2	4	3	0	4	8	16	14	16	6
Total	0	18	16	18	14	8	22	36	43	46	48	38
Average	0	6.0	5.3	6.0	4.7	2.7	7.3	12.0	14.3	15.3	16.0	12.7

APPENDIX TABLE 21. "Reserve" Iron in Soil in Relation to Fertilizer Treatments. - Black Raspberry (pounds per acre)

Replicate	Fertilizer Treatment											
	0-0-0	40-0-0	40-40-0	40-0-40	40-40-40	0-40-40	40-40-40 + Krilium	80-0-0	80-80-0	80-0-80	80-80-80	80-0-0 + Straw
A	32	24	32	16	80	64	40	48	48	20	80	24
B	32	48	80	32	80	16	20	16	40	32	32	30
C	16	32	48	32	80	48	32	20	18	48	80	80
Total	80	104	160	80	240	128	92	84	106	100	192	134
Average	26.7	34.7	53.3	26.7	80.0	42.7	30.7	28.0	35.3	33.3	64.0	44.7

APPENDIX TABLE 22. "Active" Iron in Soil in Relation to Fertilizer Treatments. - Black Raspberry (pounds per acre)

A	2	2	2	2	0	2	2	2	2	0	2	0
B	16	2	2	2	2	2	0	2	0	0	0	2
C	0	2	2	0	0	2	2	4	2	0	0	0
Total	18	6	6	4	2	6	4	8	4	0	2	2
Average	6.0	2.0	2.0	1.3	0.7	2.0	1.3	2.7	1.3	0.0	0.7	0.7

APPENDIX TABLE 23. "Active" Calcium in Soil in Relation to Fertilizer Treatments. - Black Raspberry
(pounds per acre)

Replicate	Fertilizer Treatment 0-0-0	40-0-0	40-40-0	40-0-40	40-40-40	0-40-40	40-40-40 + Krilium	80-0-0	80-80-0	80-0-80	80-80-80	80-0-0 + Straw
A	320	320	320	320	600	320	320	320	320	320	320	320
B	800	600	600	320	800	600	320	500	600	320	320	600
C	320	320	320	320	600	320	500	320	600	320	320	600
Total	1440	1240	1240	960	2000	1240	1140	1140	1520	960	960	1520
Average	480.0	413.3	413.3	320.0	666.7	413.3	380.0	380.0	506.7	320.0	320.0	506.7

APPENDIX TABLE 24. "Active" Magnesium in Soil in Relation to Fertilizer Treatments. - Black Raspberry
(pounds per acre)

A	18	-	16	-	32	-	16	-	-	14	16	16
B	16	16	16	16	16	5	16	10	16	16	16	16
C	16	16	16	24	25	16	32	16	16	16	16	16
Total	50	32	48	40	73	21	64	26	32	46	48	48
Average	16.7	10.7	16.0	13.3	24.3	7.0	21.3	8.7	10.7	15.3	16.0	16.0