SEASONAL VARIATION OF PLANT NUTRIENTS IN RASPBERRY PATCHES UNDER DIFFERENT CULTURAL TREATMENTS.

by

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INTRODUCTION.

During past years a considerable amount of experimental work has been done in regard to the value of fertilizers and cover crops for orchards. Numerous results have been reported showing the affect of different manurial treatments - in many instances the response, particularly to some nutrients, has been negative. On the other hand, in many fruit growing sections, certain fertilizing practices have proved beneficial and have been adopted by a large number of progressive orchardists. While work along such lines has progressed rapidly with tree fruits, a survey of the literature as regards small fruits indicates that there is very little concrete evidence as to the value of manurial treatments and a comparatively small amount of literature is available on the subject.

PURPOSE OF EXPERIMENT.

In the Mission Hatzic district of British Columbia there are upwards of 700 acres devoted to the production of raspberries. Growers

in this district are confronted with the problem as to the best method of maintaining or increasing fertility, particularly as barnyard manure is available in only limited amounts. The experimental plots which are discussed hereafter were planned to throw some light on this subject. They were brought into being by the writer at the Dominion Experimental Farm, Agassiz, B.C., and are laid out on the grounds of that institution.

REVIEW OF LITERATURE.

A review of literature on manurial treatments gives very little definite information on the subject, most authorities recommending heavy applications of barnyard manure.

Cover Cropping in Raspberries is not generally practiced and there is little definite experimental evidence as to its value and practicability. It offers considerably greater disadvantages in berry patches than in orchards,as to an appreciable extent it interfers with picking, particularly in that it holds the dew until late in the morning. Quite often also during the berry season showery weather prevails.

Chandler (6) quotes Pickering as having obtained marked response with barnyard manure at 30 tons to the acre and slight response with mineral fertilizers. Dyer and Shrivel according to Chandler (6) obtained better results with 12.5 tons of manure to the acre than with complete fertilizers. Chandler (7) reports in treating raspberries with nitrogen increased growth and vigor of plants but only a slight and not correspond-

ing increased yield. Wallace (20) reports raspberries growing in plots show a marked falling off where nitrogen, potassium and calcium are withheld. Hoblyn (10) more recently has reported that a proper balance between nitrogen and potash is the secret of successful manuring in raspberries. Nitrogen up to a point may produce more cane by itself but has never increased the crop except in the presence of potash, alone it has been depressing in two tests. Sulphate of potash which has always been beneficial is on the whole superior to kainit. Time and application of potash depends upon kind and season.

PLOT ARRANGEMENT.

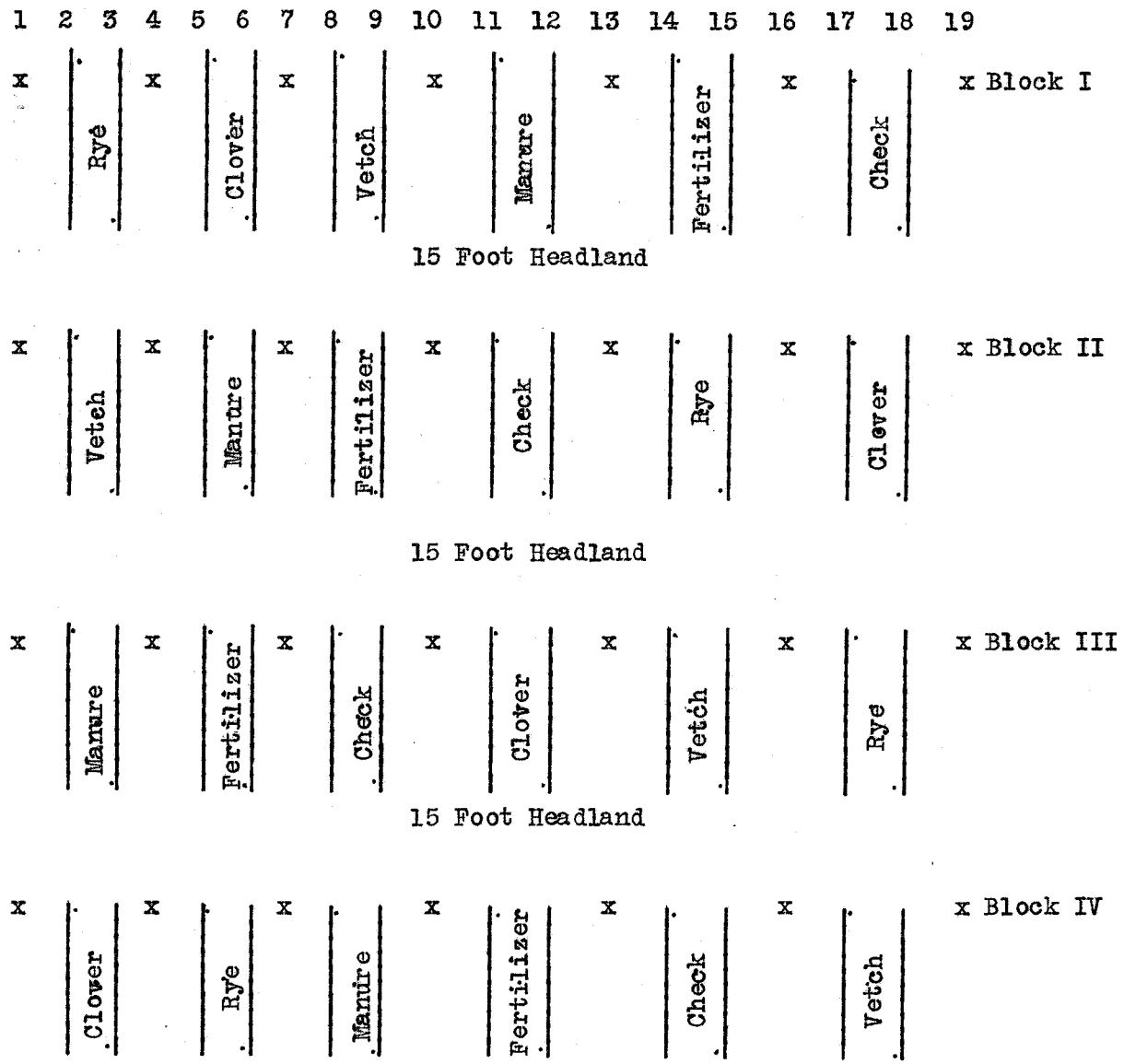
In the spring of 1930 an area 230 feet by 140 feet was laid out in twenty-four plots distributed uniformly over four blocks and planted to Cuthbert raspberries. Each plot consists of two adjacent 50' rows each containing 20 plants, with buffer rows planted on each side of each plot. Rows are spaced 7' 6" apart. The area was clean cultivated in 1930. In 1931 were commenced manurial treatments consisting of rye, vetch and clover cover crops, plots treated with manure and complete fertilizer the sixth plot receiving no manurial treatment and referred to hereafter as a check. These treatments are replicated once in each of four blocks and plots are allocated so that the maximum distribution is obtained over the whole area.

A seventh plot was treated with nitrogen only. A treatment

of this nature was not originally planned and is consequently not included in the main area, immediately adjacent however are additional rows of berries and from this location the soil samples referred to below were taken. The soil as far as a superficial examination is concerned is identical and the area is divided into four blocks as referred to above. These plots are not included in the following diagramatic sketch, they lie however to the right of each block as indicated and are one row removed from the first block, two, three and four respectively from the 2nd, 3rd and 4th blocks.

FIGURE I.

Diagramatic Sketch of Manurial Plots.



x Indicate buffer rows.
. Indicate position from which soil samples were taken.

PLOT TREATMENT.

The manurial treatments were as follows e.g. block one:-

Rye was seeded between rows 1 and 2, 2 and 3, 3 and 4.
Clover was " " " 4 and 5, 5 and 6, 6 and 7.
Vetch " " " " 7 and 8, 8 and 9, 9 and 10.
Manure was spread between rows 10 and 11, 11 and 12, 12 and 13.
Fertilizer was " " " 13 and 14, 14 and 15, 15 and 16.
Rows 16 - 19 received no treatment.

The treatments referred to were commenced in 1931. Well rotted manure was applied at the rate of 12 tons 891 lbs. per acre on March 28. Complete fertilizer (5-10-6) was applied at the rate of 750 lbs. per acre on April 3. Nitrogen plots were treated with an application of nitrogen equal to that given in the complete fertilizer. Rye, Vetch and Clover were seeded respectively at 112, 112 and 20 lbs. per acre on May 19. Plots which were not cover cropped were cultivated during the growing season to keep down weeds. The amount of such growth was not greater than that ordinarily found on well cared for plots. The area as a whole was ploughed on April 4, disced April 20, hoed May 13, cultivated May 20, hoed August 10, disced August 13. Rye was disced down July 21 at which time it had passed the most desirable period showing a tendency to become strong after discing. The remaining plots other than vetch and clovers were disced at the same time, these latter plots were

turned down August 13, at which time they were in ideal condition for green manuring.

A physical examination of the soil shows it to be a fine silt carrying with it a considerable amount of clay, a fact which is indicated both by the amount of moisture present under maximum and minimum moisture conditions and the somewhat sticky properties after rainfall. The surface soil is approximately six inches in depth, beneath this layer there is a somewhat coarser and lighter colored silt and from a depth of 18" to 24" there is a layer of sand and gravel. The previous cropping history of this area is as follows:-

The land was cleared in 1914-15. Thereafter there was practiced a four year field rotation in such a manner that in 1929 there was growing a field of corn, in 1928 the area was in pastureland, in 1927 in hay and in 1926 in oats. All hoed crops were fertilized with barnyard manure. The area is of a degree of fertility that corn, potatoes and root crops make a ready response to applications of complete fertilizers. Shutt (18) analyzed soil from the Experimental Farm in 1893 and reported as follows:-

Water	3.24%	Potash	.33 %
Organic Volatile Matter	6.96%	Soda	.17 %
Clay and Sand	75.14%	Phosphoric acid (undetermined)	.25 %
Oxide of Iron and Alumina	10.83%	Carbonic acid	.46 %
Lime	.94%	Nitrogen	.148%
Magnesia	1.48%		

He reports the soil as being rather light though possessing a fair amount of clay, in potash slightly above average, in nitrogen and phosphoric acid containing amounts equal to those of good average fertile soils and somewhat deficient in lime.

All plots were harvested during the summer of 1931. The following table gives the yields obtained.

TABLE I.

Plot Yield.

	Block I		Block II		Block III		Block IV		Total	
	Lbs.	ozs.	Lbs.	ozs.	Lbs.	ozs.	Lbs.	ozs.	Lbs.	ozs.
Rye	21	3	21	4	20	7	27	6	90	8
Clover	22	13	17	13	29	12	30	13	101	3
Vetch	19	8	27	11	21	8	25	0	93	11
Manure	21	13	28	11	24	10	17	15	93	1
Fertilizer	22	14	25	3	27	12	25	7	101	4
Check	24	0	16	8	33	1	24	15	98	8
Total	132	3	137	2	157	2	151	8		

The respective yields cannot be definitely taken as an indication of results of plot treatment. The results are only those of the first cropping year and there was some unevenness of stand of canes which leaves a margin of error for this factor. No cane counts or measurements have been taken, from observation however it is apparent that fertilized plots have given the most vigorous growth.

SOIL SAMPLES.

It was originally planned to take soil samples over a period of one year at two monthly intervals, weather conditions however prevented taking the proposed sixth sample the third week in January 1932. The method used to obtain samples, was that outlined by Russell (15). Between each pair of rows in each block 9 two inch cores to a depth of six inches were taken, 3 cores at one end adjacent to one row, 3 cores midway between rows and the remainder at the opposite end diagonally across from the first. Reference to Figure 1 will illustrate the method. This system was repeated for each treatment in each block. A composite sample was mixed, air dried, sifted through a three millimeter sieve and stored away in paper bags. The first sample from each treatment was taken on March 14 before any manurial treatment was given and is referred to as sample one. The second was taken on May 20 and is referred to as sample two, the remainder were taken on July 23, September 23, November 24, March 13, 1932, and are referred to respectively as samples 3, 4, 5 and 6.

At each respective date as referred to above moisture determinations were made, the soil samples being taken from the same area each time, namely at a given point in the headland between blocks one and two.

Sample 1, March 14 contained 29.6% moisture.

" 2, May 20 " 25.1% "

" 3, July 23 " 22.4% "

" 4, Sept. 23 " 24.4% "

" 5, Nov. 24 " 27.5% "

" 6, Mar. 13 " 27.5% "

The maximum moisture content determined was 29.9% in January and the minimum 22.4% for uncropped land and for cropped land, vetch cover crop 17.7%.

The following figures supplied by the Experimental Farm, Agassiz, give the monthly precipitation in inches and the mean temperature in degrees Fahrenheit for the period January 1931 to March 13, 1932.

	Prec. inches	Mean Temp. F°		Prec. inches	Mean Temp. F°
Jan.	5.07	43.15	Sept.	4.80	57.79
Feb.	4.03	41.64	Oct.	2.05	51.69
Mar.	5.96	45.35	Nov.	8.40	39.35
Apr.	5.14	52.53	Dec.	7.70	36.47
May	3.44	58.04	Jan.	9.42	33.61
June	4.48	60.43	Feb.	14.69	36.41
July	.64	64.44	Mar.	2.38	41.81
Aug.	.13	63.55			

SOIL ANALYSIS.

The data which follow were obtained to get information on the available plant nutrients during the first year of manurial treatment, to show the affect of such treatment and to show under what degree of natural fertility the various applications might bring about a response to growth and yield of raspberries. All the analyses were made in the horticultural laboratory of plant nutrition, University of British Columbia between

January 4 and March 30, 1932.

The method of obtaining the soil solution is that outlined by Burd and Martin (2) which shows that using the methods adopted "compacted soils tend to become completely saturated during displacement and that the mechanism of displacement consists in an actual translocation of successive layers of liquid." Further reference is also given by Burd and Martin (3) in 1924.

It is of some interest to note here that the average time required to displace the soil solution was from three to six hours and that in the seven displacements made using six tubes at a time samples taken in March 1931 and March 1932 were without exception the slowest by an average of 1½ hours to be displaced, and that samples taken July 23 were without exception the fastest. It might appear that lack of nutrients in March were responsible for this circumstance, when however it is considered that nutrients were also low in July this theory cannot be accepted. No efforts were made to determine the cause of this condition. All displacements were made at a moisture content of 27%.

The determinations made on the soil solution were:-

Electrical Conductivity.

pH, electrically, using a pH indicator with a quinhydrone electrode.

The following ions were determined colorimetrically with a Klett Top Reader colorimeter:-

Nitrates by the phenoldisulphonic method (1), Potassium as outlined by Cameron and Failyer (5), Phosphates by the ammonium molybdenum blue method (12), and magnesium as outlined by Hubbard (8). Chlorine and bicarbonates volumetrically (1). Calcium and sulphates as outlined by Richard and Wells (14).

PRESENTATION OF DATA.

CONDUCTIVITY - TABLE 2.

Specific Resistance (ohms)
~~Conductivity~~ of Soil Solutions under Different Treatments.

Soil Treatment	Dates Soil Samples Taken						Total for Treatment
	Mar.14	May 20	July 23	Sept.23	Nov.24	Mar. 13	
	1931	1931	1931	1931	1931	1932	
Rye	7200	1350	2100	3525	5100	7800	27075
Clover	7800	1950	5700	2100	4500	6700	28750
Vetch	7200	2325	4950	3000	3550	7350	27875
Fertilizer	4950	1125	2250	2100	3150	7950	21525
Manure	5250	1650	2175	1875	2175	6450	19575
Nitrogen	4650	1420	2250	2175	3000	7500	20995
Check	4125	1875	2625	1875	2850	6450	19800
Mean Average	5311	1671	3150	2379	3475	7171	

In the above table the figures indicate a close relationship between the total concentration of ions as determined in the different analyses which follow:-

REACTION OF SOIL SOLUTION - TABLE 3.

pH Values of Soil Solution under Different Treatments.

Soil Treatment	Dates Soil Samples Taken						Mean Ave. for Treatments
	Mar.14	May 20	July 23	Sept.23	Nov.24	Mar. 13	
	1931	1931	1931	1931	1931	1932	
Rye	5.4	5.3	5.8	5.9	6.0	5.5	5.65
Clover	5.5	5.5	6.3	6.0	5.8	5.5	5.77
Vetch	5.8	5.7	5.8	5.7	5.8	5.5	5.72
Fertilizer	6.0	5.9	6.1	5.9	5.9	5.8	5.93
Manure	5.9	5.7	5.7	5.8	5.8	5.9	5.80
Nitrogen	5.9	5.8	5.9	5.7	5.8	6.0	5.85
Check	5.8	5.7	5.7	5.6	5.6	5.8	5.70
Mean Average	5.76	5.66	5.90	5.80	5.80	5.70	

The mean average figures give some indication that the higher pH values prevail during summer and that higher values are obtained from plots growing no cover crops.

NITRATES - TABLE 4.

Nitrates in Soil Solution in Parts per Million.

Soil Treatment	Dates Soil Samples Taken						Total for Treatment
	Mar.14	May 20	July 23	Sept.23	Nov.24	Mar.13	
	1931	1931	1931	1931	1931	1932	
Rye	4	428	62	155	89	15	753
Clover	3	169	23	272	105	23	595
Vetch	6	197	117	202	133	15	670
Fertilizer	43	346	151	295	172	18	1025
Manure	84	557	238	346	216	19	1460
Nitrogen	93	415	254	295	177	17	1251
Check	91	399	221	399	199	51	1360
Mean Average	46	359	152	281	156	23	

The above table indicates a definite trend in seasonal fluctuation of nitrate content with maximum values in the spring and fall. Rapid spring and summer growth of plants is considered as being responsible for the low July concentration. There is also evidenced a lower nitrate content in those plots treated with cover crops than those receiving other cultural treatments. There is less nitrate under clover than in any other plot.

PHOSPHATES - TABLE 5.

Phosphates in Soil Solution in Parts per Million.

Soil Treatment	Dates Soil Samples Taken						Total for Treatment.
	Mar.14	May 20	July 23	Sept.23	Nov.24	Mar. 13	
	1931	1931	1931	1931	1931	1932	
Rye	7.80	5.90	6.76	6.66	6.76	7.15	41.03
Clover	6.82	7.32	6.99	6.99	6.82	8.84	43.78
Vetch	6.48	7.00	7.70	7.76	8.15	8.97	46.06
Fertilizer	8.89	9.25	9.62	9.81	10.00	9.42	56.99
Manure	5.74	6.36	7.15	6.61	6.73	7.00	39.59
Nitrogen	7.84	7.84	8.86	6.92	7.84	8.71	48.01
Check	5.47	7.62	7.62	7.62	7.62	7.62	43.57
Mean Average	7.01	7.33	7.81	7.48	7.70	8.24	

The high value for phosphates is not presumed to be due entirely to the presence of this ion, it being reasonable to assume that a certain amount of silicate is present as no efforts were made to remove such material. The seasonal concentration does not fluctuate in any definite way, neither is there conclusive evidence that any one treatment is superior to another. Application of complete fertilizer has given the highest total value, these plots however gave the highest concentration before any treatment was applied which tends to nullify this affect. The same may be said of nitrogen plots. A further examination of the table shows that the concentration in the check plots has remained more stable than that of any other treatment indicating that there has been less interference in ionic re-

lationship than where manurial applications have been made.

POTASSIUM - TABLE 6.

Potassium in Soil Solution in Parts per Million.

Soil Treatment	Dates Soil Samples Taken						Total for Treatment
	Mar.14	May 20	July 23	Sept.23	Nov.24	Mar. 13	
	1931	1931	1931	1931	1931	1932	
Rye	7	16	6	10	9	7	55
Clover	3	14	6	12	10	9	54
Vetch	7	12	10	12	7	8	56
Fertilizer	7	17	12	12	9	8	65
Manure	7	22	10	20	11	5	75
Nitrogen	9	25	11	19	11	9	84
Check	10	15	12	15	11	8	71
Mean Average	7.1	17.1	9.5	14.3	9.7	7.7	

Concentration of potassium has shown definite seasonal fluctuations similar to that indicated by nitrogen with highest values for May and September. Plots cover cropped have shown a lower concentration than those otherwise treated and though the difference is small clover shows a lesser amount than any other treatment. It is also to be noted that the nitrogen treated area has given the highest potassic value.

CALCIUM - TABLE 7.

Calcium in Soil Solution in Parts per Million.

Soil Treatment	Dates Soil Samples Taken						Total for Treatment
	Mar.14 1931	May 20 1931	July 23 1931	Sept.23 1931	Nov.24 1931	Mar.13 1932	
Rye	70	302	89	86	82	21	650
Clover	37	117	50	87	52	24	367
Vetch	44	103	82	80	74	22	405
Fertilizer	60	151	122	80	106	31	550
Manure	85	250	107	136	118	20	716
Nitrogen	88	138	88	88	78	32	512
Check	74	173	132	76	97	26	578
Mean Average	65	176	96	90	87	25	

Calcium has not shown a seasonal trend like nitrogen, the highest concentration being present in May with a gradual decline progressing with the season. There is some indication that the concentration under cover crops is less than under plots without such treatment. The exception to this condition in the above table is from the rye plot which appears somewhat abnormal in calcium concentration for the May period. Clover again shows the minimum value for this ion.

MAGNESIUM - TABLE 8.

Magnesium in Soil Solution in Parts per Million.

Soil Treatment	Dates Soil Samples Taken						Total for Treatment
	Mar.14	May 20	July 23	Sept.23	Nov. 24	Mar.13	
	1931	1931	1931	1931	1931	1932	
Rye	7	23	9	7	6	4	56
Clover	5	7	6	8	5	4	35
Vetch	14	32	14	21	19	3	103
Fertilizer	11	29	13	7	9	5	64
Manure	7	20	16	13	11	6	73
Nitrogen	25	21	27	31	21	19	144
Check	4	14	14	8	13	4	57
Mean Average	10.4	20.9	14.1	13.6	12.0	6.4	

Magnesium shows the same general behavior as calcium as regards seasonal trend, values becoming less as the growth period advances from May. Individual treatments taken by themselves show some variation in this respect from period to period, the trend however is as mentioned. Clover again shows the tendency to either suppress or utilize larger quantities of this ion than any other treatment. The high value for March 1931 appears abnormal. Nitrogen plots show a higher total value for magnesium than any other treatment.

SULPHATES - TABLE 9.

Sulphates in Soil Solution in Parts per Million.

Soil Treatment	Dates Soil Samples Taken						Total for Treatment
	Mar.14	May 20	July 23	Sept.23	Nov.24	Mar. 13	
	1931	1931	1931	1931	1931	1932	
Rye	11	22	9	17	11	8	78
Clover	9	8	8	8	5	6	44
Vetch	17	10	8	8	8	6	57
Fertilizer	15	36	36	32	12	7	138
Manure	14	13	8	10	7	6	58
Nitrogen	10	8	11	11	10	7	57
Check	10	10	10	33	11	4	78
Mean Average	12	15	13	17	9	6	

When all plots are considered there is a higher concentration of sulphates for May and September than for the July, November and March 1932 periods. When plots are taken individually no definite conclusions can reliably be drawn due to inconsistent fluctuations. Quite opposed to what has preceded, in four of the seven treatments, March 1931 concentration has exceeded that of May for which no adequate explanation is offered. Plots treated with clover show the lowest concentration.

BICARBONATES - TABLE 10.

Bicarbonates in Soil Solution in Parts per Million.

Soil Treatment	Dates Soil Samples Taken						Total for Treatment
	Mar.14 1931	May 20 1931	July 23 1931	Sept.23 1931	Nov.24 1931	Mar. 13 1932	
Rye	29	22	37	27	27	29	171
Clover	51	27	37	24	24	17	180
Vetch	29	17	27	20	22	17	132
Fertilizer	39	29	41	24	24	24	181
Manure	34	27	27	27	27	29	171
Nitrogen	46	44	44	34	37	37	242
Check	34	27	29	29	54	24	197
Mean Average	37	28	35	26	31	25	

From the above table it may be deduced that when ions previously mentioned are low bicarbonates are high and vice versa, March 1932 being excepted. This ionic relation pertains more particularly to nitrates and potassium. It is again to be noted that plots treated with cover crops have a lower concentration than plots not so treated and that nitrogen treated areas show increased bicarbonate value over that of any plot.

CHLORINE - TABLE 11.

Chlorine in Soil Solution in Parts per Million.

Soil Treatment	Dates Soil Samples Taken						Total for Treatment
	Mar.14	May 20	July 23	Sept.23	Nov.24	Mar.13	
	1931	1931	1931	1931	1931	1932	
Rye	32	14	16	14	10	30	116
Clover	24	36	12	16	12	34	134
Vetch	26	24	14	10	20	28	122
Fertilizer	22	48	42	16	12	28	168
Manure	20	28	22	18	14	32	134
Nitrogen	20	22	16	10	18	26	112
Check	24	18	22	12	12	24	112
Mean Average	24	27	21	14	14	29	

No satisfactory explanation presents itself in regard to the data on chlorine when all ion periods are compared. If this ion is a product of precipitation climatic conditions would demand that concentration of this ion be higher in September and November than in July. On the other hand if the periods from May to March 1932 are used as a basis of comparison it may be concluded that concentration declined during the period of growth due to penetration of ions and that accumulation did not take place again until after November. During the season of 1931 Cuthbert raspberries increased cane growth both as regards length and diameter until the beginning of December.

DISCUSSION.

In the foregoing pages data have been presented on the concentration of ions of nitrates, phosphates, potassium, calcium, magnesium, sulphates, bicarbonates and chlorine under different methods of manurial treatment. There has been with all ions excepting bicarbonates March 1931 a lower value during the winter months November to March than at other seasons of the year. The conductivity, table 2, indicates a seasonal rise and fall of ions particularly nitrates, sulphates and potassium. The soil type and climatical conditions lead to the belief that a very considerable amount of leaching takes place during this winter period. Due however to the satisfactory growth conditions that prevail the soil is considered to be one of a high "come-back power." This condition manifests itself sometime between the middle of March and the middle of May and meteorological data would indicate that increased temperature and decreased precipitation accompanied by increased activities of soil organisms would bring about such a condition. The time of most rapid growth is from May 24 to June 30 and nitrates in particular are taken more rapidly from the soil solution than they are formed, concentration again rising in the September period. To a lesser extent the same condition is applicable to potassium and sulphates.

Calcium, magnesium and chlorine show a tendency to decline in concentration from a high point in May as the season progresses. Russell (16) states that nitrogen, phosphorous and potassium are absorbed rapidly in the early stages of plant life, falling off thereafter, calcium absorp-

tion on the other hand increases as plant growth continues. Phosphates have indicated no seasonal trend, tending to remain constant more especially so when there has been no other cropping or fertilizing. Bicarbonates tend to exhibit high values at periods when other ions are low and vice versa, particularly as regards nitrates, bicarbonates having formed to maintain the soil solution in equilibrium.

Lyon, Heinicke and Wilson (11) at Cornell have shown a low spring and a high fall concentration of nitrates under orchard conditions and lower under sod than under clean cultivation. Proebsting (13) at Davis, California, has shown a similar seasonal trend with values lower under alfalfa than in check plots; calcium, magnesium and sulphates showed comparable behavior while potassium concentration remained practically unchanged. Burd and Martin (4) analyzed soil solutions before and after growing an oat crop and one year later. They found the potassium content lowered immediately after cropping. Sears (17) in Illinois states that unproductive soils are due to two main factors low available potassium and an excess of nitrates, straw improving plant growth by adding potassium and decomposition increasing denitrifying soil organisms.

In dividing the treatments into two groups, plots growing cover crops and plots receiving other methods of treatment data are presented which show that green manuring lowers the concentration of ions. Smith and Humfeldt (19) found the concentration of nitrates much lower under growing crops than under fallow and lower under vetch than under rye. It is evident from the results obtained that under cover cropping there

are fewer available plant nutrients in the soil solution, consequently when fertility is low green manuring is not desirable and that clover exerts a greater drain than does either vetch or rye. It is not however reasonable to conclude that green manuring is entirely detrimental. In the various plots so treated there was no indication of a starved condition and eventually those ions which are absorbed from the soil solution are returned, partly to be leached out during winter months, part to be utilized the following year. Late summer and winter cover crops would appear to be of greater value when there is a possibility that such growth would deplete the soil solution to the detriment of the companion crop, or under conditions when there is already an apparent condition of starvation of which there are many indications in the main berry growing sections of British Columbia. Where moisture supply is low cover crops will also absorb amounts injurious to berry plants.

The application of manure, complete fertilizer and nitrogen has not significantly changed the total amounts of plant nutrients present nor the seasonal fluctuation. There is evidence however that application of nitrogen has appreciably increased potassium, magnesium and bicarbonates in the soil solution. This increased amount would appear to be due to the fact that nitric acid has been formed thus bringing into solution greater amounts of potassium and magnesium. Hoblyn (10) has referred to the necessary balance between nitrogen and potash to obtain satisfactory growth. The additional nitrates added would also appear to have increased root growth or root activity, thus bringing about a greater discharge of

carbon dioxide which has formed the bicarbonate. It may also be assumed that on soils which have been cropped for a long period without any fertilizer that applications of such materials would be of greater value than under the conditions of this experiment when growth at the outset has proved satisfactory. Furthermore applications of phosphates and potassium would tend to maintain quantities of these ions in their original state while green manuring would maintain or increase the organic matter and so induce the growth and activity of soil organisms.

The soil reaction has shown a lower pH value under cover crops which may be explained by reference to table 7 where it has been shown that calcium content is also lower under such treatments. Hoagland (9) states "it is doubtful whether the activities of the plant in the absorption of ions ordinarily bring about directly an increase of acidity in the soil," concluding that the bicarbonate ion is proportionately increased and tends to maintain the reaction near the neutral point.

Finally it is anticipated that similar laboratory tests will be repeated at a later date, that the foregoing data will be a basis of comparison for future analyses and that yields from plots may be correlated to the concentration of available plant nutrients.

SUMMARY.

1. Data have been presented showing the concentration and fluctuation of eight different ions.

2. Results indicate a high spring value for these ions:

3. That there is a definite seasonal rise and fall in concentration of nitrates, potassium, sulphates and bicarbonates:

4. That calcium,magnesium and chlorates tend to diminish as the season progresses:

5. That under cover crops there are a smaller amount of plant nutrients present and fewer under clover than under vetch or rye:

6. That addition of complete chemical fertilizer has not apparently increased the total amount of ions present but that the addition of nitrogen has increased the concentration of potassium, magnesium and carbonates in the soil solution.

7. That the pH values of the soil solution are higher in summer than at other seasons and higher in plots where no cover crops have been grown.

A C K N O W L E D G M E N T S.

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