VOL. 7 AUGUST, 1933 NO. 14

HILGARDIA

A Journal of Agricultural Science

PUBLISHED BY THE

California Agricultural Experiment Station

CONTENTS

UNIVERSITY OF CALIFORNIA, BERKELEY, CALIFORNIA

HILGARDIA
A JOURNAL OF AGRICULTURAL SCIENCE
PUBLISHED BY THE
CALIFORNIA AGRICULTURAL EXPERIMENT STATION

VOL. 7 AUGUST, 1933 NO. 14

EFFECT OF COVERCROPS ON THE SOIL SOLUTION AT DIFFERENT DEPTHS UNDER ORCHARD CONDITIONS[1]

E. L. PROEBSTING[2]

Two earlier papers[4, 5] have presented progress reports concerning changes in concentration of the more important ions in the soil solution under a variety of covercrop treatments and with different species of trees. These results were obtained from the orchard of the Pomology Division of the California Agricultural Experiment Station at Davis. The crop history has been given[4] in a former paper and is not essential for consideration of the data given here. The plot treatments were alfalfa sod (*Medicago sativa*); a summer covercrop of mat bean (*Phaseolus aconitifolius*), which was superseded by *Dolichos lablab* in the seasons 1931 and 1932; and winter covercrops of rye (*Secale cereale*) and of *Melilotus indica*. These were all compared with three clean-cultivated checks. The treatments were duplicated. They ran in strips across the species plantings of pears, prunes, apples, Japanese plums, cherries, apricots, and peaches as shown in figure 1. The method used in obtaining the soil solution has been described elsewhere[3], and is essentially a displacement rather than an extraction with an excess of water.

In the preceding reports, the data have been based on analyses from composite samples of the upper 4 feet of soil. Because many roots penetrate to greater depths, analyses have been made of the soil solution obtained to a depth of 8 feet. The present report shows the results of four composite samples of 2 feet each to a total depth of 8 feet. This changed procedure has reduced the number of plots that could be

1 Received for publication March 17, 1933.

2 Associate Professor of Pomology and Associate Pomologist in the Experiment Station.

sampled in a given period to one-fourth of the previous number. The time interval between samples of a given plot has therefore been markedly increased, and the number of points on the graph of a season's results correspondingly reduced. The seasonal sequences have been so

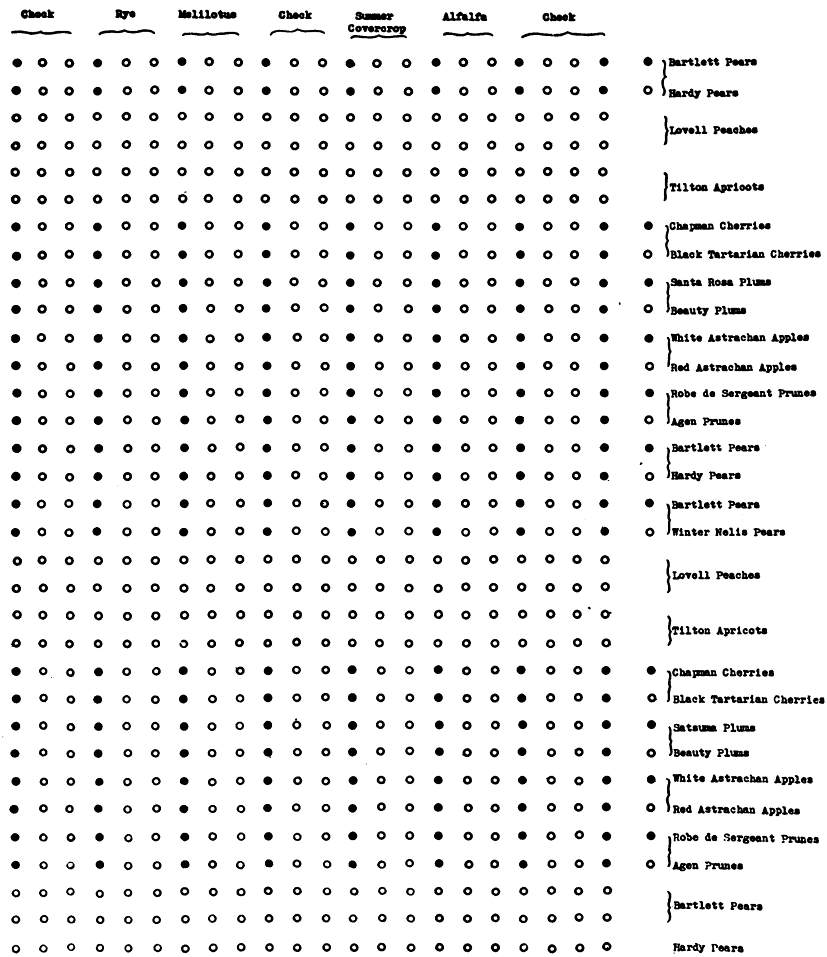

Fig. 1. Planting plan of covercrop experiment. Block A is the lower 17 rows; block B the upper 16. Numbering begins at the lower right-hand corner in each block. Symbols indicating the kinds of fruit trees in each row are given at the right.

regular, however, that there is probably no serious objection to the changed method of sampling. The first samples taken at the greater depth were secured in 1929 in four plots of block B, namely the north check and alfalfa plots of pears and peaches. These samples showed such striking differences that the method was extended to 28 plots for each of the past three seasons. Sampling of the peach and pear plots was continued until June, 1931, and then a change was made to the adjacent rows of apricots and prunes. The reason for this change was primarily that a very large number of holes had been made in limited areas, cutting many roots and thus causing an increasing heterogeneity in the plot. Areas tapped by roots lose moisture and solutes, and when the roots are cut a new situation develops. Until new roots grow into such a region, the area is not typical of the plot in question. The two fruits chosen, besides lying adjacent to the fruits already used, had the additional advantage of differing from each other in growth and fruiting habits as well as in handling. The apricot tree is much larger and, probably, deeper rooted than the prune. It matures its fruit early in the season, being harvested in June. It is pruned severely, and the fruit is thinned. The prune, in contrast, matures its fruit in September, is pruned very little, and is rarely thinned.

These differences in behavior were expected to influence somewhat the character of withdrawals made on the soil solution at various periods of the year. In the course of these investigations, it was found that there was a marked tendency for the soil solution under apricots to resemble that under peaches, and for that under prunes to approximate that under pears. Few data have been secured on the other three species, namely, apples, Japanese plums, and cherries, and these will not be considered in any of the discussion.

In order to conserve space in the presentation of data, the major results of only one season, 1930, will be reported. Important deviations from these typical cases will be noted where they occur. The large number of solutions analyzed (over 1,200 in the period under discussion) would seem to justify the withholding of a considerable portion of the data.

NITRATE

It has been pointed out[4, 5] that in the upper 4 feet of soil the nitrate concentration varies seasonally, usually showing its minimum in the spring and its maximum in the fall; that alfalfa reduces the NO_3 concentration, as do peaches to a lesser degree. The data presented here (tables 1 to 4, inclusive), support these conclusions. In addition, a number of interesting relationships can be seen. Perhaps the most striking is the contrast between alfalfa and check plots. The divergence in concentration between these two series of plots is greater below 4 feet than above that depth. The relation between nitrates under peaches and those under pears, however, is the reverse at the lower depths of that in the top 4 feet. That is, the concentration of nitrate is greater under peaches than under pears at the lower depth.

TABLE 1

NITRATE CONTENT OF SOIL SOLUTION IN PEACH SERIES, BLOCK A,* IN PARTS PER MILLION OF NO_3 OF DISPLACED SOLUTION

Treatment	Date	Depth			
		0–2 feet	2–4 feet	4–6 feet	6–8 feet
Clean-cultivated check	May 23	230	270	1,490	2,240
	July 2	240	140	430	1,100
	September 12	380	430	1,950	1,720
	December 23	460	210	1,030	1,390
Alfalfa sod	May 26	570	220	100	160
	July 7	540	180	90	140
	September 18	120	200	70	60
Summer covercrop	May 27	170	130	210	1,040
	July 8	300	120	170	760
	September 14	210	100	210	230
Clean-cultivated check	May 28	160	130	660	1,800
	July 9	270	340	....	1,370
	September 19	240	80	1,100	1,960
Winter covercrop of melilotus	May 29	240	60	1,110	1,750
	July 10	......	70	730	1,570
	September 20	280	80	350	1,200
Winter covercrop of rye	May 30	220	60	270	510
	July 11	460	70	160	560
	September 25	420	80	170	450
Clean-cultivated check	June 2	200	130	930	1,840
	July 15	......	100	710	1,200
	September 27	430	160	1,100	2,040

* Block A consists of trees planted in 1922; block B of trees planted in 1923.

According to studies by Beckett and Huberty,[2] alfalfa roots may be fairly well distributed at depths to 8 feet under the conditions prevailing at Davis. Probably, therefore, the alfalfa plant has reduced the nitrate concentration to a depth of at least 8 feet by direct absorption.

The alfalfa was plowed up in the fall of 1929 because weeds had become established in these plots. In the top 2 feet, the NO_3 concentration rose steadily for a year, beginning within a month after plowing and reaching a maximum the following autumn. The lower depths showed progressively less effect than the surface, there being no significant increase at 6 to 8 feet. When the plots were reseeded in the fall of 1930, the NO_3 concentration dropped rapidly again; and it has since been maintained at a low level in all plots. The alfalfa seems to be the major

TABLE 2

NITRATE CONTENT OF SOIL SOLUTION IN PEACH SERIES, BLOCK B, IN PARTS PER MILLION OF NO_3 OF DISPLACED SOLUTION

Treatment	Date	Depth 0–2 feet	2–4 feet	4–6 feet	6–8 feet
Clean-cultivated check	March 21	260	170	510	900
	May 5	210	170	440	970
	June 10	200	150	450	970
	August 12	280	230	630	930
	November 7	470	270	670	620
Alfalfa	March 1	260	70	30	30
	May 6	590	150	50	30
	June 19	380	130	100	60
	August 13	190	150	240	40
	November 8	530	120	30	30
Summer covercrop	May 7	130	140	640	730
	June 18	270	100	310	1,000
	August 14	230	170	660	1,120
	November 14	350	180	900	1,040
Clean-cultivated check	May 8	150	200	640	870
	June 17	190	90	530	1,080
	August 15	120	110	590	730
	November 23	360	130	660	1,350
Winter covercrop of melilotus	May 9	130	70	320	630
	June 16	210	80	130	520
	August 16	100	50	100	360
	November 25	60	70	180	600
Winter covercrop of rye	May 12	150	80	70	90
	June 13	210	90	70	120
	August 21	280	80	90	200
	November 29	360	80	80	230
Clean-cultivated check	May 13	210	230	300	1,040
	June 12	160	80	280	1,100
	August 22	210	100	410	1,090
	December 2	460	70	340	600

factor affecting the level of NO_3 concentration in plots having this treatment. Differences between species of trees are obscured by the greater effect of the alfalfa.

The effect of the summer covercrop on nitrates has been slight. Though somewhat lower concentration appears in the summer covercrop plots than in the adjacent check, the differences are slight; those that do appear are greater in the lower than in the upper layers.

The plots on which *Melilotus indica* was grown as a winter covercrop have shown an anomalous behavior with respect to NO_3 concentration.

TABLE 3

NITRATE CONTENT OF SOIL SOLUTION IN PEAR SERIES, BLOCK A, IN PARTS PER MILLION OF NO_3 OF DISPLACED SOLUTION

Treatment	Date	Depth			
		0–2 feet	2–4 feet	4–6 feet	6–8 feet
Clean-cultivated check	June 3	350	310	650	910
	July 16	260	210	310	620
	September 30	520	330	560	980
Alfalfa	June 4	320	280	100	80
	July 17	750	280	150	100
	October 2	610	300	130	100
Summer covercrop	June 5	230	210	290	530
	July 18	410	230	140	400
	October 3	370	100	850	540
Clean-cultivated check	June 6	280	320	670	1,160
	July 21	330	310	440	630
	October 8	670	460	620	640
Winter covercrop of melilotus	June 9	230	80	40	110
	July 22	360	140	70	90
	October 10	590	130	100	210
Winter covercrop of rye	June 10	300	140	80	70
	July 23	450	160	60	90
	October 14	540	200	80	50
Clean-cultivated check	June 11	310	300	430	580
	July 24	340	290	480	570
	October 16	900	550	970	590

Although most plots show an increase in NO_3 over the check, in the top soil, the reverse is true in the lower depths. In the late fall and early winter after seeding there is usually a decrease of NO_3 in those plots as compared with the checks.

The plants were well nodulated and were plowed under while still succulent; but, despite this fact, the influence of melilotus, generally, has been to depress the NO_3 concentration in the lower depths of the soil.

The effect of a winter covercrop on NO_3 in the lower depths is carried still further in the case of rye. Although the top 2 feet often show an increase over the check, the lower depths show a greater depression of the NO_3 concentration. The concentration of NO_3 in the 6–8 foot layer of the check often is 20 to 30 times that occurring at the same depth in

TABLE 4

NITRATE CONTENT OF SOIL SOLUTION IN PEAR SERIES, BLOCK B, IN PARTS PER MILLION OF NO_3 OF DISPLACED SOLUTION

Treatment	Date	Depth			
		0–2 feet	2–4 feet	4–6 feet	6–8 feet
Clean-cultivated check	March 28	390	410	900	1,030
	May 14	420	410	560	570
	June 23	300	330	530	480
	August 23	510	......	200	750
	December 6	690	410	650	670
Alfalfa	March 22	300	280	80	60
	May 15	630	410	90	100
	June 24	590	230	130	70
	August 28	980	340	310	130
	December 13	860	510	390	160
Summer covercrop	May 16	340	330	510	800
	June 25	390	270	280	640
	August 29	400	270	440	920
	December 15	......	370	590	740
Clean-cultivated check	May 19	320	330	810	660
	June 25	290	390	760	710
	August 30	240	280	670	580
	December 17	......	360	770	750
Winter covercrop of melilotus	May 20	450	190	350	370
	June 27	460	170	250	350
	September 2	490	240	160	250
	December 18	370	330	310	260
Winter covercrop of rye	May 21	510	290	460	240
	June 30	520	190	190	220
	September 3	400	170	140	230
	December 19	760	210	250	200
Clean-cultivated check	May 22	320	490	690	780
	July 1	350	320	540	700
	September 11	420	270	260	310
	December 22	330	590	630	540

the rye plot. These high ratios were not found in the data for 1930 given here but were present in some of the data for other years. This result can be interpreted in several ways: there may be direct absorption by roots of the covercrop; the carbohydrate materials of the plant may be leached throughout the soil column examined, providing a source of energy for organisms which remove NO_3 from the solution to build protoplasm; or the decomposition of rye may produce substances which inhibit the activity of nitrifying organisms. A somewhat similar circumstance has been reported by Batchelor,[3] who found that straw added to the surface soil of citrus orchards reduced the NO_3 content of the top 4 feet of soil to a negligible amount. In that case the first possibility, that of removal of NO_3 by the roots of a covercrop, is eliminated, and depression of NO_3 must be ascribed to leached materials of one of the two kinds postulated above. This explanation will also account for the fact that the NO_3 concentration of the lower depths in the summer cover and the melilotus plots is less than that of the checks.

The contrast between peaches and pears is difficult to explain with the existing data. The differences in the top 4 feet are in accord with expectations, but the reversal of this relationship in the lower 4 feet is not. It cannot be explained on the basis of root distribution, there being many roots in this region, as shown by their extraction of moisture and by their presence in samples. It cannot be explained by leaching from the surface soil. The concentration is greater in the lower depth and, too, is higher under peaches, where the NO_3 concentration in the surface soil is lower than under pears. Apparently there may be nitrification at these depths at a rate greater than the rate of withdrawal, and the differential for peaches may excel that for pears. Further work on this point is necessary before definite conclusions can be drawn.

Certain observations that bear on interpretation of these phenomena should now be made. Because of the low annual rainfall (about 17 inches) and its distribution almost exclusively through the winter months, the soil is not leached by rain water below the depth of root penetration.

Irrigation is practiced in the summer, the water carrying an appreciable amount of salts. The concentrations in parts per million are as follows: totals solids at 105°C, approximately 500; Na, about 50; K, 1; Ca, 35; Mg, 60; Cl, 10; HCO_3, 400; NO_3, 4; SO_4, 25; and SiO_2, 40. This water is applied at a rate that does not always effect penetration to the full depth of sampling. In 1932, two irrigations at very short intervals were given in order to wet the entire 8-foot column. Moisture data indicate that during prolonged periods the soil below 6 feet, in several plots at least, has had no additions of water from the surface. This being the case, displacement of nitrates from higher levels into this region cannot have been a factor in causing the high concentration observed. The variations noted must result from biological factors.

[3] Personal correspondence.

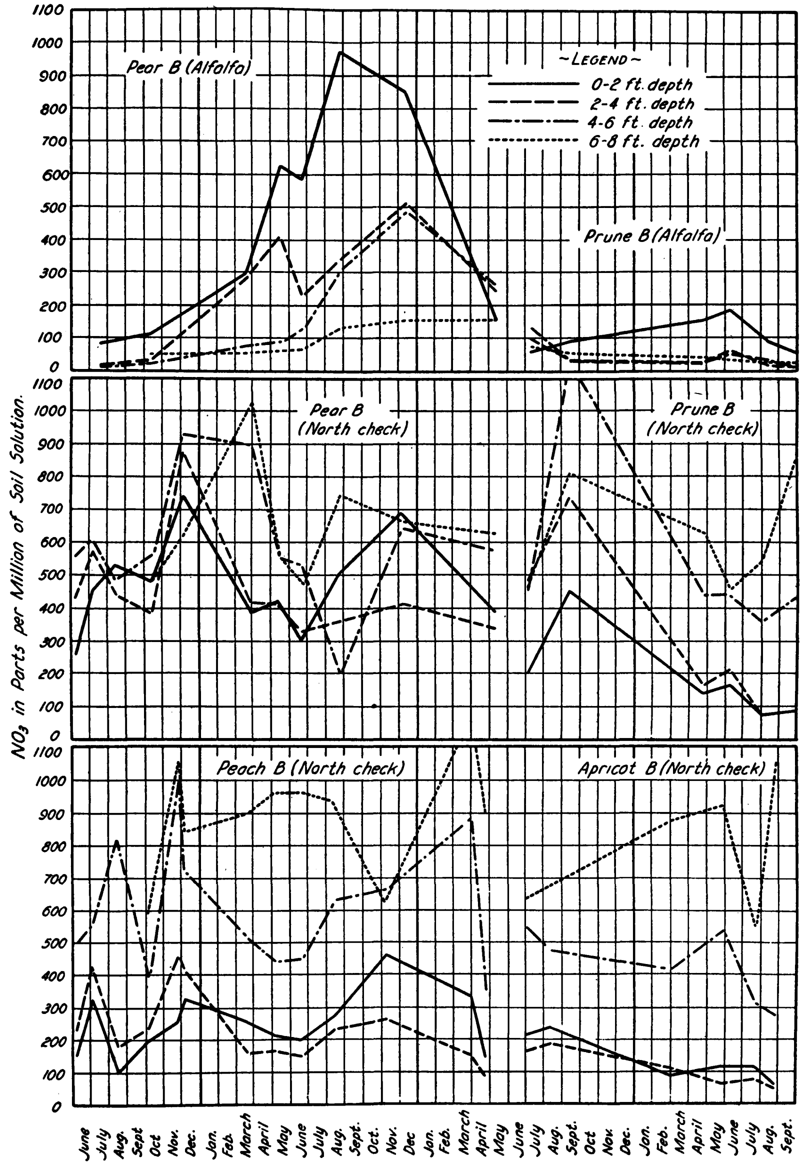

Fig. 2. Nitrate concentration of the soil solution from four depths in each of three plots, showing seasonal, species, and treatment differences.

On the other hand, the addition of water, whether by rain or by irrigation, must dilute the NO_3, at least temporarily. There must be some displacement of NO_3 into lower layers, also, even though it does not always proceed to the limit of sampling. The amount of displacement under field conditions is a matter of conjecture. It no doubt varies with the number of root channels and fissures, as indicated by Slater and Byers[6]. Such changes of concentration as may be ascribed to these causes are less than the changes actually observed, and do not affect the generalizations made concerning seasonal trends and differences between plots. In certain cases aberrant results may be ascribed to these factors, but they are not of first importance.

The changes in NO_3 concentration under apricots resemble those under peaches so closely as to permit these fruits to be discussed together. This fact is illustrated in figure 2. The general level of the curves is practically continuous for all layers except the surface. The surface 2 feet shows a lower concentration under apricots than under peaches, but this may be only a seasonal effect.

The prune plots yield NO_3 concentrations more like those of pear plots than of the other stone fruits. The fact that prune trees are smaller and less vigorous than the other stone fruits considered may be the explanation. The prune plot trends are exemplified in figure 2, where the data are plotted as continuations of the pear curves. These figures also show the contrast between check and alfalfa plots.

As the figures indicate, the surface soil appears to be more regular in the sequence of changes than the lower depths. This phenomenon does not, apparently, result from sampling errors, for duplicate determinations have usually given very similar concentrations. The fact that each sample is a composite of 30 cores from the soil tube, taken in an area roughly 20×50 feet, accounts for the small error in sampling. The data at hand do not explain all the deviations from smooth curves. Seemingly, however, these deviations do not occur often enough to invalidate the general conclusions.

The difference between the surface 2 feet and the second 2 feet might be tentatively explained as resulting from the higher organic content of the top soil and from the greater root distribution in the 2–4 foot layer. A more scattered root system might be postulated to account for the increased concentration below that depth; but, as indicated above, the data at hand are not deemed adequate for a satisfactory explanation of the facts observed.

SULFATE

The data for sulfate concentration are presented in tables 5 to 8. The relationships pointed out in earlier papers for the top 4 feet hold for this region. In the lower layers, a curious circumstance appears: the inverse

TABLE 5

SULFATE CONTENT OF SOIL SOLUTION IN PEACH SERIES, BLOCK A, IN PARTS PER MILLION OF SO_4 OF DISPLACED SOLUTION

Treatment	Date	Depth			
		0–2 feet	2–4 feet	4–6 feet	6–8 feet
Clean-cultivated check	May 23	160	260	280	180
	July 2	130	200	240	140
	September 12	290	420	260	140
	December 23	280	330	330	170
Alfalfa	May 25	100	180	230	320
	July 7	110	140	180	230
	September 18	80	170	180	200
Summer covercrop	May 27	140	190	290	270
	July 8	120	150	220	260
	September 14	260	230	420	350
Clean-cultivated check	May 28	120	270	280	170
	July 9	100	270	290	200
	September 19	200	360	480	240
Winter covercrop of melilotus	May 29	190	310	270	160
	July 10	......	310	300	140
	September 20	220	510	350	370
Winter covercrop of rye	May 30	170	260	260	160
	July 11	150	330	270	120
	September 25	180	240	360	190
Clean-cultivated check	May 31	150	280	310	150
	July 15	......	340	270	140
	September 27	220	390	340	140

relationship noted between SO_4 concentration and NO_3 concentration in the surface soil does not hold. That is, even though the NO_3 concentration is higher under peaches than under pears at these depths, the SO_4 concentration is also higher. The same phenomenon is seen in the comparison of apricots with prunes, the apricots exhibiting a condition analagous to that of peaches, the prunes to that of pears.

Another consistent relationship noted is that the maximum concentration of SO_4 occurs in the 4–6 foot layer. This condition obtains almost without exception except in alfalfa, where the concentration tends to be nearly the same in the two lower layers.

As in earlier years, more irregularity is apparent in the seasonal curves of SO_4 concentration than in those of NO_3.

TABLE 6

SULFATE CONTENT OF SOIL SOLUTION IN PEACH SERIES, BLOCK B, IN PARTS PER MILLION OF SO_4 OF DISPLACED SOLUTION

Treatment	Date	Depth			
		0–2 feet	2–4 feet	4–6 feet	6–8 feet
Clean-cultivated check	March 21	110	190	220	150
	May 5	200	210	230	200
	June 20	150	210	280	190
	August 12	160	240	300	220
	November 7	300	350	250	......
Alfalfa	March 1	80	100	90	80
	May 6	90	100	90	70
	June 19	100	100	110	90
	August 13	100	120	140	110
	November 8	220	230	90	130
Summer covercrop	May 7	170	220	270	300
	June 18	160	210	280	270
	August 14	100	290	350	270
	November 14	240	350	360	290
Clean-cultivated check	May 8	150	190	280	230
	June 17	120	190	280	260
	August 15	210	200	270	210
	November 23	60	280	360	290
Winter covercrop of melilotus	May 9	150	290	210	140
	June 16	160	160	210	320
	August 16	180	290	270	210
	November 25	50	310	320	190
Winter covercrop of rye	May 12	140	220	220	190
	June 13	130	180	240	220
	August 21	170	260	340	200
	November 29	230	......	......	280
Clean-cultivated check	May 13	140	210	280	170
	June 12	100	220	270	230
	August 22	220	290	370	150
	December 2	180	220	320	210

There have been significant additions of sulfate in the irrigation water (see concentrations, page 560). The annual increment would be approximately 100 pounds per acre, or about 30 p.p.m. for the 8 feet calculated on an average water content. This figure is no more than a rough estimate to give the order of magnitude of the additions made. On the basis of this estimate, enough sulfate has been added to give 250 to 300 p.p.m. of solution in the 8-foot column in the past ten years. That the solution has not been increasing notably in this period, certainly

TABLE 7

SULFATE CONTENT OF SOIL SOLUTION IN PEAR SERIES, BLOCK A, IN PARTS PER MILLION OF SO_4 OF DISPLACED SOLUTION

Treatment	Date	Depth			
		0–2 feet	2–4 feet	4–6 feet	6–8 feet
Clean-cultivated check	June 3	160	130	160	140
	July 16	100	130	190	170
	September 30	140	200	200	180
Alfalfa	June 4	70	200	180	270
	July 17	90	110	160	150
	October 2	80	110	170	190
Summer covercrop	June 5	110	180	230	150
	July 18	50	170	120	170
	October 3	170	230	360	160
Clean-cultivated check	June 6	180	170	180	110
	July 21	130	200	180	120
	October 8	230	290	250	180
Winter covercrop of melilotus	June 9	90	250	160	120
	July 22	120	210	160	60
	October 10	140	300	230	160
Winter covercrop of rye	June 10	70	150	150	110
	July 23	140	190	180	140
	October 14	110	140	190	160
Clean-cultivated check	June 11	110	160	210	130
	July 24	150	180	200	120
	October 16	210	250	220	110

not in any such amount, may indicate a biological control of SO_4 concentration within certain limits. Precipitation of $CaSO_4$ seems unlikely because the concentration of Ca and SO_4 are well below the solubility of this compound, and fluctuate from time to time. It would be expected that equilibrium with solid $CaSO_4$ would give a nearly constant concentration. The annual cycle of changes cannot be interpreted on the basis of increments added by irrigation water, although these increments may be a factor in the irregularity noted.

TABLE 8

SULFATE CONTENT OF SOIL SOLUTION IN PEAR SERIES, BLOCK B, IN PARTS PER MILLION OF SO_4 OF DISPLACED SOLUTION

Treatment	Date	Depth			
		0–2 feet	2–4 feet	4–6 feet	6–8 feet
Clean-cultivated check	March 28	150	140	170	140
	May 13	210	130	120	80
	June 23	100	140	130	90
	August 23	90	160	190	120
	December 6	210	170	180	110
Alfalfa	March 22	50	90	80	90
	May 14	80	100	90	90
	June 24	80	90	90	100
	August 28	110	90	120	130
	December 13	80	100	110	100
Summer covercrop	May 15	100	110	170	160
	June 25	160	160	160	160
	August 29	100	140	180	180
	December 15	150	190	200	190
Clean-cultivated check	May 19	120	120	150	100
	June 25	80	140	150	120
	August 30	160	170	120	80
	December 17	......	160	170	100
Winter covercrop of melilotus	May 20	150	190	90	100
	June 27	100	140	150	110
	September 2	130	110	190	80
	December 18	......	100	110	......
Winter covercrop of rye	May 21	120	220	180	100
	June 30	130	200	190	110
	September 3	90	120	160	90
	December 19	170	......	260	130
Clean-cultivated check	May 22	110	150	140	130
	July 1	50	140	150	110
	September 11	130	130	160	120
	December 22	100	200	190	110

BICARBONATE

The HCO_3 concentration also shows a tendency to fall off during the growing season in the surface 4 feet. This trend, as shown in tables 9 to 12, does not appear in some plots, and is of a low order in others. In the lower layers the falling off is likewise not entirely regular. The data obtained from the apricot and prune series in 1931 are still less consistent in the depths below 4 feet.

TABLE 9

BICARBONATE CONTENT OF SOIL SOLUTION IN PEACH SERIES, BLOCK A, IN PARTS PER MILLION OF HCO_3 OF DISPLACED SOLUTION

Treatment	Date	Depth			
		0–2 feet	2–4 feet	4–6 feet	6–8 feet
Clean-cultivated check	May 23	60	70	110	140
	July 2	60	70	180	170
	September 12	40	......	100	120
Alfalfa	May 26	80	100	210	220
	July 7	130	90	180	240
	September 18	110	100	180	250
Summer covercrop	May 27	90	80	160	200
	July 8	100	60	200	260
	September 14	......	......	130	250
Clean-cultivated check	May 28	70	70	160	200
	July 9	......	70	140	......
	September 19	60	50	120	220
Winter covercrop of melilotus	May 29	100	70	150	240
	July 10	......	80	180	290
	September 20	130	70	110	130
Winter covercrop of rye	May 30	80	80	160	270
	July 11	110	80	200	320
	September 25	150	130	200	360
Clean-cultivated check	June 2	60	60	140	140
	July 12	......	70	140	120
	September 27	170	50	140	150

One very regular relationship, however, is the much higher concentration of HCO_3 in the lower than in the upper layers, in all plots in all series in all years.

Another such relationship is the higher concentration in solutions from alfalfa plots. This difference is less than that between top and lower soils, but is nearly as consistent throughout the period dealt with. Very few exceptions occur in the many samples compared. The winter-covercrop plots show a generally increased HCO_3 concentration, com-

TABLE 10

BICARBONATE CONTENT OF SOIL SOLUTION IN PEACH SERIES, BLOCK B, IN PARTS PER MILLION OF HCO_3 OF DISPLACED SOLUTION

Treatment	Date	Depth			
		0–2 feet	2–4 feet	4–6 feet	6–8 feet
Clean-cultivated check	March 21	190	60	140	140
	May 5	110	100	180	160
	June 20	60	70	130	130
	August 12	90	70	150	120
	November 7	60	50	......	120
Alfalfa	March 1	280	150	200	320
	May 6	110	110	210	310
	June 19	100	110	170	270
	August 13	140	130	130	210
	November 9	70	70	110	170
Summer covercrop	May 7	120	100	210	310
	June 18	80	70	170	220
	August 14	60	30	100	110
	November 14	80	60	110	180
Clean-cultivated check	May 8	100	80	170	300
	June 17	80	60	140	190
	August 15	100	100	160	250
	November 23	40	20	50	60
Winter covercrop of melilotus	May 9	100	90	190	270
	June 16	130	90	180	180
	August 16	110	70	180	250
	November 25	50	50	90	100
Winter covercrop of rye	May 12	140	100	200	270
	June 13	150	130	180	230
	August 21	90	90	150	260
	November 29	150	60	110	150
Clean-cultivated check	May 13	70	70	150	130
	June 12	120	70	140	130
	August 22	80	60	120	140
	December 2	30	30	70	80

pared with the checks. Their values are sometimes greater than those for alfalfa, especially in the rye plots.

The amount of HCO_3 added by the irrigation water is of considerable magnitude. Apparently, however, only biological processes in the soil can account for the observed concentration.

Burd and Martin's[1] hypothesis, that anions may be absorbed more rapidly than cations, and HCO_3 excreted by the organism to preserve the electrical balance, seems the most acceptable one at the present time. If monovalent ions are more readily absorbed than divalent, then one

TABLE 11

BICARBONATE CONTENT OF SOIL SOLUTION IN PEAR SERIES, BLOCK A, IN PARTS PER MILLION OF HCO_3 OF DISPLACED SOLUTION

Treatment	Date	Depth			
		0–2 feet	2–4 feet	4–6 feet	6–8 feet
Clean-cultivated check	June 3	50	50	140	210
	July 16	50	50	180	270
	September 30	40	40	140	230
Alfalfa	June 4	60	70	200	220
	July 17	60	80	210	280
	October 2	50	60	180	170
Summer covercrop	June 5	70	50	200	230
	July 18	50	80	200	280
	October 3	50	40	130	190
Clean-cultivated check	June 6	40	30	140	120
	July 21	40	40	180	170
	October 8	70	30	130	140
Winter covercrop of melilotus	June 9	120	80	270	460
	July 22	60	40	220	300
	October 10	40	40	160	200
Winter covercrop of rye	June 10	150	90	250	380
	July 23	90	50	200	310
	October 14	40	40	190	300
Clean-cultivated check	June 11	80	90	170	240
	July 24	40	40	190	310
	October 16	90	40	140	260

might expect a greater absorption of cations in the surface soil, where K concentration is greatest (see below). In the deeper soil, the decreased K concentration and increased Ca and Mg concentration would tend to decrease cation absorption. The higher NO_3 concentration might tend to encourage a relatively increased absorption of anions. The HCO_3 concentration under these conditions would tend to be low in the surface layers and high in the lower ones, as is actually the case. Such a process would likewise tend to shift the pH toward the alkaline side in the lower layers; and this theory again fits the facts, the pH in the top 4 feet ranging about 7.6, while the 4–8 foot column is approximately 8.2.

TABLE 12

BICARBONATE CONTENT OF SOIL SOLUTION IN PEAR SERIES, BLOCK B, IN PARTS PER MILLION OF HCO_3 OF DISPLACED SOLUTION

Treatment	Date	Depth 0–2 feet	2–4 feet	4–6 feet	6–8 feet
Clean-cultivated check	March 28	70	60	170	160
	May 14	50	60	180	190
	June 23	40	60	190	170
	August 23	50	80	170	210
	December 6	20	20	120	150
Alfalfa	March 22	180	80	250	260
	May 15	80	70	220	240
	June 24	70	60	210	260
	August 28	....	60	160	250
	December 13	20	20	100	240
Summer covercrop	May 16	70	70	210	320
	June 25	80	70	170	250
	August 29	80	50	130	170
	December 15	20	10	80	110
Clean-cultivated check	May 19	60	50	170	290
	June 26	40	40	150	160
	August 30	70	170	200	100
	December 17	....	20	90	220
Winter covercrop of melilotus	May 20	70	60	190	330
	June 27	60	40	180	350
	September 2	80	50	130	190
	December 18	20	30	110	......
Winter covercrop of rye	May 21	60	50	170	310
	June 30	60	20	160	270
	September 3	50	40	170	340
	December 19	20	70	140	140
Clean-cultivated check	May 22	40	50	160	190
	July 1	30	30	140	130
	September 11	50	60	140	250
	December 22	10	20	100	120

There are no carbonates in this soil in the 8 feet used for these samples. As an alternative explanation, it has been suggested by Burd[4] that liberation of CO_2 from the soil in consequence of slight changes in the buffer system might adequately account for the differences in HCO_3 shown in these analyses.

[4] Personal correspondence.

CHLORIDE

For the years 1931 and 1932, chloride determinations were made on all solutions. The data for these solutions (numbering over 800) are not presented, because their significance does not seem to warrant the space. Chloride, not being considered an important nutrient, was not included in the analysis of earlier solutions; it was included for 1931 and 1932 primarily to enable a closer balance sheet of cations and anions to be prepared. There is some similarity between Cl concentration and SO_4 concentration. It is low in the surface, with a maximum in the 4–6 foot layer. It is higher under peaches than under pears, and higher under apricots than under prunes. It is low in alfalfa plots and intermediate in the winter-covercrop plots, as compared with the checks. The concentration in the 0–2 foot layer of pears averages about 60 parts per million; in the 2–4 foot layer, slightly more; in the 4–6 foot layer, 80 to 160 p.p.m.; and in the 6–8 foot layer, 60 to 120 p.p.m. In the peaches the averages range from 40 to 70 p.p.m. in the surface layer; 70 to 110 in the 2–4 foot layer; 120 to 300 in the 4–6 foot layer; and 150 to 260 in the 6–8 foot layer. The apricot plots give somewhat higher results than the peach; the prune little more than the pear. These results vary considerably in the two years, the 1931 levels being higher than those of 1932.

PHOSPHATE

Only one point brought out by the new data adds to those illustrated by the previous figures as respects phosphate content. The PO_4 concentration is greatest in the surface soil (about 0.3 p.p.m.), decreases to a minimum in the 4–6 foot layer, and rises slightly in the 6–8 foot depth. The level is low in all cases, with an average of less than 0.1 p.p.m. of PO_4 in the 4–6 foot zone. There seems to be an equilibrium condition without seasonal change. In spite of this low level, the trees show no indication whatever of phosphorous deficiency. Growth has been vigorous. The constant concentration, even though low, seems to supply an adequate total amount. As others have pointed out, however, these values are averages; and local zones at the interface between soil particle and absorbing surface of the root may be entirely different in magnitude.

CALCIUM

The results of the analyses for calcium appear in tables 13 to 16. These data have confirmed those presented before on the Ca concentration in the upper 4 feet. The general relationships for Ca concentration agree

TABLE 13

CALCIUM CONTENT OF SOIL SOLUTION IN PEACH SERIES, BLOCK A, IN PARTS PER MILLION OF DISPLACED SOLUTION

Treatment	Date	Depth			
		0–2 feet	2–4 feet	4–6 feet	6–8 feet
Clean-cultivated check	June 23	60	83	196	199
	July 2	55	55	107	118
	September 12	103	151	......	173
	December 23	115	100	193	140
Alfalfa	May 26	83	75	70	100
	July 7	97	50	60	72
	September 18	50	73	60	60
Summer covercrop	May 27	50	52	89	145
	July 8	68	45	80	135
	September 14	78	55	135	314
Clean-cultivated check	May 28	41	62	132	143
	July 9	53	56	134	269
	September 19	73	79	223	150
Winter covercrop of melilotus	May 29	61	74	186	142
	July 10	....	76	135	131
	September 20	85	106	152	231
Winter covercrop of rye	May 30	60	72	103	65
	July 11	94	91	100	59
	September 25	88	82	128	78
Clean-cultivated check	June 2	59	70	162	203
	July 15	....	78	150	235
	September 27	83	112	205	220

nicely with those recorded for NO_3 above. There is, however, less contrast between surface and deeper layers than in the case of NO_3. In some of the pears, in fact, the deeper layers are actually lower in the Ca ion, notably in some of the rye-plot samples. The high nitrate content of the deeper layers under peaches is reflected in the high Ca content of the same regions. The apricot and prune plots also show the contrasts indicated in the discussion of NO_3 above.

TABLE 14

CALCIUM CONTENT OF SOIL SOLUTION IN PEACH SERIES, BLOCK B, IN PARTS PER MILLION OF DISPLACED SOLUTION

Treatment	Date	Depth			
		0–2 feet	2–4 feet	4–6 feet	6–8 feet
Clean-cultivated check	March 21	64	56	108	170
	May 5	67	60	110	196
	June 20	52	61	123	280
	August 12	57	80	141	180
	November 7	110	111	143	120
Alfalfa	March 1	67	43	40	53
	May 6	80	46	40	45
	June 19	65	48	43	48
	August 13	66	46	44	51
	November 8	120	69	30	58
Summer covercrop	May 7	53	71	137	180
	June 18	62	57	96	235
	August 14	42	84	153	246
	November 14	98	94	197	208
Clean-cultivated check	May 8	50	65	149	143
	June 17	46	47	131	184
	August 15	78	59	126	128
	November 23	33	71	157	238
Winter covercrop of melilotus	May 9	50	58	111	113
	June 16	60	47	77	114
	August 16	64	73	93	97
	November 25	30	81	100	99
Winter covercrop of rye	May 12	52	70	85	70
	June 13	57	57	81	79
	August 21	75	75	131	87
	November 29	88	88	130	105
Clean-cultivated check	May 13	56	76	132	179
	June 12	42	54	103	202
	August 22	90	87	131	184
	December 2	90	60	120	115

In a considerable number of samples, the Ca content has its maximum in the 4–6 foot layer, the 6–8 foot zone showing some decrease. This is a point of divergence from the behavior of nitrate.

A notable reduction of Ca appears in the lower layers of alfalfa and the rye plots and to a less extent in the melilotus plots.

TABLE 15

CALCIUM CONTENT OF SOIL SOLUTION IN PEAR SERIES, BLOCK A, IN PARTS PER MILLION OF DISPLACED SOLUTION

Treatment	Date	Depth			
		0–2 feet	2–4 feet	4–6 feet	6–8 feet
Clean-cultivated check	June 3	68	60	106	99
	July 16	50	50	79	81
	September 30	91	90	122	142
Alfalfa	June 4	42	81	71	51
	July 17	90	51	57	47
	October 2	80	56	58	47
Summer covercrop	June 5	50	62	89	70
	July 18	57	62	62	84
	October 3	76	63	111	41
Clean-cultivated check	June 6	69	70	119	113
	July 19	61	75	101	84
	October 8	127	113	156	100
Winter covercrop of melilotus	June 9	58	58	63	55
	July 22	70	60	65	42
	October 10	96	77	80	52
Winter covercrop of rye	June 10	65	51	61	43
	July 23	80	58	60	44
	October 14	85	57	64	43
Clean-cultivated check	June 11	60	75	88	62
	July 24	67	71	90	53
	October 16	159	133	162	66

TABLE 16

CALCIUM CONTENT OF SOIL SOLUTION IN PEAR SERIES, BLOCK B, IN PARTS PER MILLION OF DISPLACED SOLUTION

Treatment	Date	Depth			
		0–2 feet	2–4 feet	4–6 feet	6–8 feet
Clean-cultivated check	March 28	76	82	146	132
	May 14	94	78	107	75
	June 23	56	70	95	68
	August 23	73	76	114	98
	December 6	124	93	111	89
Alfalfa	March 22	56	52	51	43
	May 15	97	69	52	48
	June 24	73	47	54	48
	August 28	124	54	74	58
	December 13	105	72	67	42
Summer covercrop	May 16	59	56	93	110
	June 25	75	60	73	96
	August 29	47	57	85	109
	December 15	105	68	96	100
Clean-cultivated check	May 19	56	59	118	75
	June 26	54	73	123	82
	August 30	53	72	70	82
	December 17	....	73	110	77
Winter covercrop of melilotus	May 20	93	55	71	51
	June 27	83	53	66	58
	September 2	85	56	62	51
	December 18	60	63	67	....
Winter covercrop of rye	May 21	96	78	93	45
	June 30	93	69	66	45
	September 3	68	55	62	50
	December 19	112	73	85	37
Clean-cultivated check	May 2	58	78	110	104
	July 1	62	62	103	84
	September 11	87	62	76	68
	December 22	57	101	109	56

MAGNESIUM

The magnesium content (given in tables 17–20) follows that of Ca with extraordinary fidelity in the top 4 feet. Though it is generally somewhat lower in the surface 2 feet than is Ca, the divergence is not great. In the 6–8 foot zone, however, appears a marked divergence, Mg being much higher in many plots. In the alfalfa, rye, and melilotus plots, both Ca and Mg are reduced to a low level in the region below 4 feet; but in the check plots and in the summer covercrop plots the relationship indicated is rather consistent for all fruits studied. Possibly Mg is more easily leached through a soil than is Ca, and has accumulated in the lower depths as a result of such leaching over the period of soil

TABLE 17

MAGNESIUM CONTENT OF SOIL SOLUTION IN PEACH SERIES, BLOCK A, IN PARTS PER MILLION OF DISPLACED SOLUTION

Treatment	Date	Depth			
		0–2 feet	2–4 feet	4–6 feet	6–8 feet
Clean-cultivated check	May 23	53	95	286	346
	July 2	48	32	162	216
	September 12	88	155	212	265
	December 3	103	102	266	265
Alfalfa	May 26	72	61	91	149
	July 7	87	45	72	95
	September 18	41	61	66	82
Summer covercrop	May 27	45	56	108	249
	July 8	63	41	95	235
	September 14	80	67	147	261
Clean-cultivated check	May 28	37	75	179	343
	July 9	47	64	179	353
	September 19	79	96	222	295
Winter covercrop of melilotus	May 29	59	75	233	303
	July 10	....	71	196	291
	September 20	78	84	125	144
Winter covercrop of rye	May 30	53	72	128	141
	July 11	83	86	117	146
	September 25	81	82	137	171
Clean-cultivated check	June 2	57	74	189	315
	July 15	....	88	168	204
	September 27	79	117	245	297

TABLE 18

MAGNESIUM CONTENT OF SOIL SOLUTION IN PEACH SERIES, BLOCK B, IN PARTS PER MILLION OF DISPLACED SOLUTION

Treatment	Date	Depth 0–2 feet	2–4 feet	4–6 feet	6–8 feet
Clean-cultivated check	March 21	52	66	119	155
	May 5	62	69	118	198
	June 20	42	53	133	143
	August 12	49	83	161	188
	November 7	103	110	160	122
Alfalfa	March 1	60	41	42	57
	May 6	71	46	46	47
	June 19	60	42	45	51
	August 13	57	44	48	55
	November 8	118	77	29	66
Summer covercrop	May 7	47	78	166	247
	June 18	59	56	107	196
	August 14	38	91	170	297
	November 14	90	101	237	310
Clean-cultivated check	May 8	40	66	165	227
	June 17	40	50	137	208
	August 15	74	62	136	234
	November 23	29	84	232	316
Winter covercrop of melilotus	May 9	46	65	121	154
	June 16	44	42	83	132
	August 16	63	72	97	147
	November 25	18	91	105	147
Winter covercrop of rye	May 12	47	70	88	87
	June 13	45	55	72	89
	August 21	68	73	131	107
	November 29	84	94	133	129
Clean-cultivated check	May 13	46	76	134	200
	June 12	37	48	110	191
	August 22	80	90	140	198
	December 2	84	57	126	134

formation. No points noted in these data would indicate that the concentration of Ca and Mg at any depth at any time is not primarily a function of biological activity and, in particular, of organisms affecting the nitrogen cycle.

TABLE 19

MAGNESIUM CONTENT OF SOIL SOLUTION IN PEAR SERIES, BLOCK A, IN PARTS PER MILLION OF DISPLACED SOLUTION

Treatment	Date	Depth			
		0–2 feet	2–4 feet	4–6 feet	6–8 feet
Clean-cultivated check	June 3	67	68	151	210
	July 16	46	55	114	203
	September 30	87	94	165	232
Alfalfa	June 4	42	97	108	121
	July 17	97	55	80	104
	October 2	83	59	79	107
Summer covercrop	June 5	47	64	119	146
	July 18	51	64	66	136
	October 3	67	61	212	96
Clean-cultivated check	June 6	99	82	146	217
	July 21	48	80	122	146
	October 8	122	126	162	153
Winter covercrop of melilotus	June 9	59	69	89	96
	July 22	71	71	89	74
	October 10	97	92	97	91
Winter covercrop of rye	June 10	59	47	64	91
	July 23	70	61	82	91
	October 14	83	58	85	88
Clean-cultivated check	June 11	46	59	116	144
	July 24	55	65	128	144
	October 16	136	121	217	142

TABLE 20

MAGNESIUM CONTENT OF SOIL SOLUTION IN PEAR SERIES, BLOCK B, IN PARTS PER MILLION OF DISPLACED SOLUTION

Treatment	Date	Depth 0–2 feet	Depth 2–4 feet	Depth 4–6 feet	Depth 6-8 feet
Clean-cultivated check	March 28	60	73	153	158
	May 14	79	77	120	106
	June 23	46	65	114	99
	August 23	54	58	141	125
	December 6	106	82	127	130
Alfalfa	March 22	52	59	56	55
	May 15	97	80	58	61
	June 24	74	53	64	70
	August 28	119	49	92	79
	December 13	105	56	81	58
Summer covercrop	May 16	58	67	122	177
	June 25	70	69	92	160
	August 29	31	60	107	186
	December 15	90	86	120	145
Clean-cultivated check	May 19	53	61	147	148
	June 26	46	78	141	169
	August 30	46	76	154	87
	December 17	....	80	135	166
Winter covercrop of melilotus	May 20	90	62	94	104
	June 27	78	55	84	108
	September 2	75	59	61	79
	December 18	53	66	81	......
Winter covercrop of rye	May 21	90	89	117	93
	June 30	91	71	87	91
	September 3	47	41	34	66
	December 19	113	82	110	78
Clean-cultivated check	May 22	53	92	129	144
	July 1	57	72	19	77
	September 11	78	66	83	93
	December 22	54	113	135	112

POTASSIUM

The data concerning K concentration of the solutions studied bring out nothing new; they are therefore omitted. The K concentration decreases with depth. It is constant throughout the year, with minor fluctuations, indicating an equilibrium with the solid phase. Differences between fruits or between treatments are too slight and irregular to be given any importance. The concentration is rather low, averaging about 6 p.p.m. in the top 2 feet, less than 2 p.p.m. at 2–4 feet, and less than 1 p.p.m. below 4 feet; but it seems entirely adequate for normal growth of the trees. The point noted in the discussion of phosphate—that these are average values which may not represent the concentration at the absorbing surface—should be noted in this connection also.

HYDROGEN ION CONCENTRATION

The pH of the displaced solutions has seemed not to vary enough to be significant. Of course, the changes effected by sampling, packing, and displacing might, by releasing CO_2, shift the pH slightly. Any shift from this cause is probably small, however, the solutions being alkaline. Perhaps the approximations reached by our methods are not accurate enough to justify the conclusion that changes in pH are of little importance. All the solutions are slightly alkaline. The surface soil generally has a pH of about 7.4 to 7.6. The alkalinity increases with depth to a pH of about 8.2 at 6–8 feet. As stated above, the hypothesis used to account for the HCO_3 changes fits the facts of H ion concentration. In addition, organic matter decomposing in the upper soil might supply acids which would tend to give a more acid condition in that region.

GROWTH AND FRUITING

The circumference of the trunk of the tree has been taken as a convenient measure of growth. The complete records are not presented; but table 21 gives the present circumference, representing growth for 11 years in the case of block A, and 10 years in that of block B. These figures show that in the first eight years of differential covercrop treatment, no important differences have developed in size of trees. Nor, apparently, is there any indication that the rate of growth of any group of trees is being affected.

The time of leaf fall in the autumn of 1932 has not been affected by any treatment. Differences that appeared in the cherry and apricot

TABLE 21

TRUNK CIRCUMFERENCES OF INDIVIDUAL TREES ON COVERCROP PLOTS, IN CENTIMETERS; NOVEMBER, 1932

Plot	Pear, *A*†		Prune, *A*		Apricot, *A*		Peach, *A*		Pear, *B*		Prune, *B*		Apricot, *B*		Peach, *B*	
	Row 2	Row 3	Row 4	Row 5	Row 12	Row 13	Row 14	Row 15	Row 1	Row 2	Row 3	Row 4	Row 11	Row 12	Row 13	Row 14
Guard row	58.8	65.5	24.9	46.2	79 8	81.8	82.4	82.5	62.6	37.1	51.8	21.3	94.3	82.0	84.7	91.3
Check	68.0	51.2	70.2	58.1	89.8	83.9	72.5	69.7	56.6	54.3	66.5	59.8	58.3	108.5	75.5	91.8
	76.0	59.9	64.7	63.1	75.2	80.4	82.8	90.2	57.6	51.4	43.3	57.6	85.6	85.6	63.2	96.5
	65.9	66.2	60.7	65.4	93.0	66.6	79.2	81.0	64.6	66.5	50.1	45.4	89.6	55.5	94.0	95.4
Alfalfa	60.4	57.7	54.8	51.4	out	90.1	80.6	99.7	52.5	4.6*	64.0	62.7	out	80.4	90.8	94.5
	58.7	42.2	59.0	67.2	84.8	90.5	90.1	91.2	54.1	43.6	59.0	56.3	75.5	84.5	94.7	83.4
	64.7	47.8	38.2	54.4	91.5	83.2	94.1	70.6	64.2	66.9	47.5	38.4	81.0	76.5	90.3	93.2
Summer covercrop	49.5	60.9	57.3	58.1	78.3	77.8	87.4	80.4	56.2	43.4	60.5	63.8	81.9	72.3	97.3	88.7
	55.2	50.8	65.2	65.2	86.7	82.2	104.0	96.7	48.1	54.1	62.1	68.8	68.7	75.2	91.6	94.6
	60.1	76.1	69.0	55.7	75.2	93.9	92.2	89.2	59.0	64.3	51.0	49.6	63.1	60.0	100.7	94.8
Check	79.6	69.3	40.5	63.6	70.4	82.7	69.5	90.4	54.5	60.4	74.3	66.7	79.4	67.5	82.5	91.2
	60.3	65.2	56.0	51.2	92.5	88.0	88.3	85.5	61.4	51.1	65.1	67.4	83.7	73.5	97.7	93.1
	58.0	70.7	35.1	67.4	84.1	83.0	76.2	82.6	62.7	67.3	56.9	46.1	87.9	83.6	98.5	92.5
Melilotus	44.1	63.2	51.8	69.9	88.2	80.8	89.3	96.4	53.9	22.8*	65.3	64.1	84.4	65.7	98.8	78.4
	52.9	58.3	63.2	67.3	92.8	84.5	89.8	94.7	57.8	50.9	61.4	64.5	82.8	73.4	103.6	97.3
	54.9	72.0	27.0	31.8	87.6	79.2	88.8	88.7	63.6	60.2	51.0	59.8	92.6	84.8	84.9	104.1
Rye	50.5	58.0	61.8	77.3	93.3	84.4	68.2	94.0	52.4	52.7	58.4	60.1	85.5	75.2	88.0	92.5
	60.8	66.3	58.3	62.6	84.4	83.7	95.0	89.0	67.5	54.9	77.6	60.4	81.0	93.0	71.0	90.6
	57.5	62.0	55.5	65.9	84.9	83.4	72.9	100.5	72.5	60.3	49.5	51.5	84.2	74.4	83.1	93.9
Check	63.2	57.6	65.1	56.5	85.5	76.2	83.5	86.4	54.4	5.0*	51.8	60.6	79.7	55.0	94.4	81.9
	65.2	64.6	63.0	46.7	90.7	83.3	84.1	89.9	64.0	40.7	68.1	58.5	75.3	75.6	81.8	80.9
	50.9	67.0	66.1	56.8	78.1	80.8	80.8	89.5	52.6	54.4	62.9	56.4	91.7	71.0	88.9	96.4

† Block A, 1922 planting; block B, 1923 planting.
* Sprouts from trunk killed by blight.

series in 1930 seem to have been associated with moisture conditions rather than with nutrition. So far, therefore, one must conclude that treatments which profoundly modify the soil solution have not affected the growth of the trees. It remains to be seen how long a differential NO_3 concentration can be maintained in the soil solution without affecting the growth of the tree.

TABLE 22

TOTAL KILOGRAMS OF FRUIT BORNE BY TREES IN COVERCROP EXPERIMENT

Plot	Pear, *A* (1932)	Prune, *A* (1930-32)		Apricot, *A* (1926-32)	Peach, *A* (1926-32)	Pear, *B** (1932)	Prune, *B* (1930-32)		Apricot, *B* (1926-32)	Peach, *B* (1926-32)
		French (Agen)	Robe de Sergeant				French (Agen)	Robe de Sergeant		
Check	355	1,098	747	2,265	4,445	177	572	575	1,141	1,210
Alfalfa	382	1,009	440	1,943	4,017	218	649	391	936†	901
Summer cover-crop	350	1,218	683	2,138	3,830	236	685	703	868	1,581
Check	586	839	700	2,101	4,488	373	797	677	1,714	975
Melilotus	345	1,214	131	2,159	6,484	205	504	690	1,481	1,124
Rye	568	1,183	811	2,012	4,388	327	785	713	1,730	1,790
Check	377	688	333	2,017	4,362	218	494	611	1,354	2,690

* Four trees of Bartlett per plot, the other two being Hardy, which have not as yet produced fruit.
† Five trees.

Fruit production records add little to the interpretation of the data at present. A summary giving the production per plot to date appears in table 22; it shows that the yields of some fruit are much more uniform than those of others. No treatment has resulted in consistently high yields. The trees commonly believed to use most NO_3 seem not to have had their yields depressed more than those needing relatively little.

It may be stated in a sentence that after eight years' treatment no certain differences have developed in either growth or fruiting.

SUMMARY

The data obtained from analyses of soil solutions displaced from 0–2, 2–4, 4–6, and 6–8 foot samples in peach, pear, apricot, and prune plots given differential covercrop treatments have shown that:

The average of the 0–2 and 2–4 foot samples confirms previously reported results.

The NO_3 concentration in the 4–6 and 6–8 foot depths under peaches and apricots is higher than that under pears and prunes, in contrast to the opposite situation in the surface of 4 feet.

The NO_3 concentration in the 4–6 and 6–8 foot samples is greatly reduced under alfalfa and winter covercrops as compared with clean-cultivated check plots.

Plowing under alfalfa increased the NO_3 concentration strikingly in the surface 4 feet, but had little effect below that depth. Reseeding alfalfa caused a reduction of NO_3 to about the former level.

The SO_4 concentration under peaches and apricots is higher in the 4–6 and 6–8 foot samples than that under pears and prunes. The maximum SO_4 concentration is usually in the 4–6 foot layer.

In spite of additions of SO_4 by irrigation water, there has been little change in its concentration in the soil solution over the period studied.

The HCO_3 concentration is higher in the 4–6 and 6–8 foot samples than in the 0–2 and 2–4 foot samples.

The HCO_3 concentration is higher in the alfalfa and winter covercrop plots than in the checks.

The chloride concentration is higher in the lower than the upper layers, with a maximum at 4–6 feet.

The chloride concentration is higher under peaches and apricots than under pears and prunes, and lower under alfalfa than under clean cultivation.

The PO_4 concentration is higher in surface than in deeper samples, with a minimum at 4–6 feet. There are no other significant differences, seasonal or from plot to plot.

The calcium concentration varies in the same manner as that of NO_3.

The magnesium concentration parallels that of calcium except that it is lower in the 0–2 foot and higher in the 6–8 foot samples than that of calcium.

The potassium concentration decreases with depth, but otherwise does not vary significantly.

ACKNOWLEDGMENTS

Acknowledgment is made to O. C. Compton and C. O. Hesse, who secured the soil samples and aided in the laboratory; and to E. A. Wilkins, who made the potassium determinations referred to in this paper. The Division of Chemistry has supplied the analysis of the irrigation water.

LITERATURE CITED

[1] BURD, J. S., and J. C. MARTIN.
1924. Secular and seasonal changes in the soil solution. Soil Sci. **18**:151–167.

[2] BECKETT, S. H., and M. R. HUBERTY.
1928. Irrigation investigations with field crops at Davis and at Delhi, California, 1909–1925. California Agr. Exp. Sta. Bul. **450**:1–24.

[3] CONRAD, J. P., E. L. PROEBSTING, and L. R. MCKINNON.
1930. Equipment and procedure for obtaining the displaced soil solution. Soil Sci. **29**:323–328.

[4] PROEBSTING, E. L.
1929. Changes in the nitrate and sulfate content of the soil solution under orchard conditions. Hilgardia **4**:57–76.

[5] PROEBSTING, E. L.
1930. Concentration of certain constituents of the soil solution under orchard conditions. Hilgardia **5**:35–59.

[6] SLATER, C. S., and H. G. BYERS.
1931. A laboratory method of the field percolation rate of soils. U. S. D. A. Tech. Bul. **232**:1–23.