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CHANGES IN THE NITRATE AND SULFATE CONTENT OF THE SOIL SOLUTION UNDER ORCHARD CONDITIONS

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In 1922, the Division of Pomology of the California Agricultural Experiment Station began an investigation on the maintenance of soil fertility in deciduous orchards. For this purpose a field of approximately twelve acres was selected and half of it planted to deciduous fruit trees. This will hereafter be referred to as block *A*. The following year, 1923, the other half was set out. It will be designated block *B*. The soil in the field selected varied from a fine sandy loam to a loam of the Yolo series. The water table stood at approximately sixteen feet. The entire volume of soil above the water table was in horizon A. There were some slight modifications in texture before that depth was reached, but neither gravel nor clay was found.

CROP HISTORY OF THE FIELD USED

The crop history of this field before the planting of the orchard is of interest.† In the summer of 1908, this area was levelled for alfalfa irrigation. Previous to this time it had been in grain for an indefinite period, probably about fifty years. In the spring of 1909, it was planted to alfalfa. From 1909 to 1913, there is no available record as to yields or irrigation frequency, but it is supposed that the entire area had essentially the same treatment.

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† Professor S. H. Beckett of the Division of Irrigation Investigations and Practice has supplied the data for this section.

In 1914, 5.12 acre feet per acre of irrigation water were applied, distributed among three irrigations. Five crops of hay were cut, with an average yield of 6.45 tons per acre. In 1915, one irrigation of 1.7 acre feet per acre was given. The average yield was 5.04 tons per acre. In 1916, the field was plowed in the spring and seeded to barley, but not irrigated. The yield was about fifty bushels per acre. In June, after the grain had been harvested, the field was irrigated and planted to corn for ensilage. Because of late seeding, only three tons per acre were obtained. In 1917, the area was planted to corn (variety tests) and forage crops in small plots. Irrigation was uniform for the block, a total of 1.21 acre feet per acre being applied in two irrigations.

In 1918, alfalfa was again planted and irrigated once. In 1919, 2.3 acre feet per acre were applied in two irrigations. The yield of five cuttings was 9.71 tons of hay per acre. In 1920, only one scanty irrigation was applied, because of a shortage of water, and only 2.5 tons of hay per acre were harvested.

In 1921, the east half of the area was plowed and prepared for orchard planting. The west half remained in alfalfa until the following year, when it was treated in the same way.

ARRANGEMENT OF PLANTINGS

The accompanying diagram (fig. 1) shows the arrangement of the first planting (block *A*). The second half (block *B*) duplicated the first except that the guard row of hardy pears was not repeated, but Hardy pears were used as pollinizers, and Satsuma plums were planted instead of Santa Rosa. The trees were planted twenty-seven and one-half feet apart each way.

The varieties planted were as follows: almond, Ne Plus Ultra and I.X.L.; peach, Lovell; apricot, Tilton; cherry, Chapman and Black Tartarian; Japanese plum, Santa Rosa and Beauty in Block *A*, Satsuma and Beauty in block *B*; apple, White Astrachan and Red Astrachan; prune, Robe de Sergeant and Agen (French); pear, Bartlett and (guard row) Hardy.

The rootstocks used were as follows: For Ne Plus Ultra almond, almond; for I.X.L. almond, peach; for peach, peach; for apricot, apricot; for cherry, Mazzard; for Japanese plum, Myrobalan; for apple, apple; for prune, Myrobalan; and for pear, Japanese pear (*Pyrus serotina*). In 1928, the almonds were removed because of the death of several trees and the badly diseased condition of several more, and replanted with pears on French root.

Pruning has been uniform and moderately light throughout the life of the planting. One irrigation a year, in addition to the rainfall, was sufficient to keep the trees growing thriftily until cover crops were planted. The plots were necessarily of three rows each. The scheme of planting of sorts requiring cross pollination was two of one variety and one of another (see fig. 1). This arrangement limited the plots to three rows in order to eliminate varietal differences between plots. If the guard row on the north be disregarded, this scheme gives seven three-row plots, duplicated in block *B*. The cultural treatments

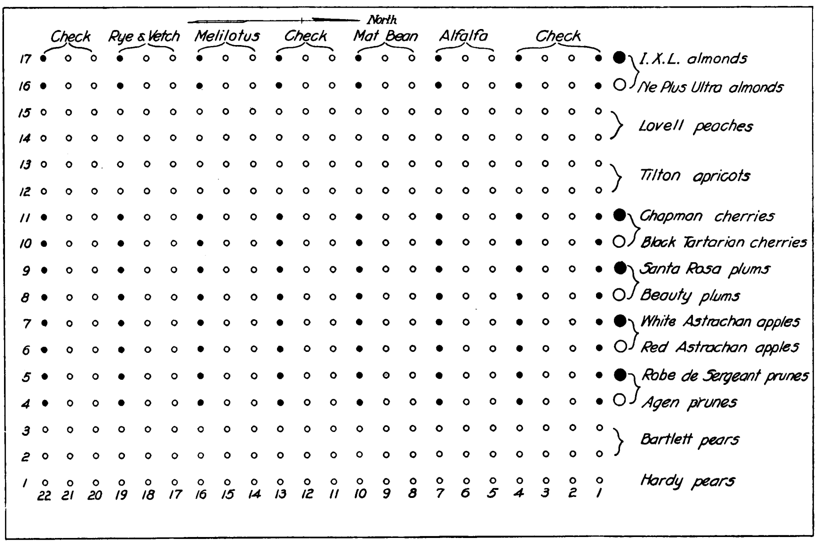

Fig. 1. Planting plan and arrangement of plots, block *A*. Block *B* duplicates block *A*, except as noted in the text.

included three plots in the nature of checks, which were given clean cultivation as ordinarily practiced in the Sacramento Valley: two plots with winter cover crops, one plot with summer crop, and one plot with a permanent cover crop of alfalfa. Another orchard served as a guard on the south. Starting at the north, the treatments of the seven plots were as follows: check (clean cultivation, with weed cover in winter); alfalfa; mat bean (*Phaseolus aconitifolius*) (a summer cover crop); check; *Melilotus indica*; rye and vetch; and check. The winter cover crops were planted September 22, 1924, for the first time, and in September of each year thereafter. The alfalfa was planted in the spring of 1925. The mat bean was first planted in May 1925, and in May of each succeeding year.

DATA OBTAINED FROM PLOTS

In order to determine the effect of these crops on tree growth and production, and to determine the way these effects are produced, observations of various sorts were made on the plots.

Records of the circumference of the trunk of each tree and of the yield of each tree have been kept. No differences have been seen in the behavior of the trees under these treatments up to the present time, except for a tendency for growth of the trunk to be slightly less in the apricots and peaches in block *B* in the alfalfa plot in 1927. Growth has been vigorous, and the early bearing sorts have given promise of good crops. The peach trees planted in block *B* averaged about twenty-five pounds of fruit per tree in 1927 and over fifty in 1928, while those in block *A* averaged nearly two hundred in 1927 and over two hundred in 1928. The apricot trees in block *B* averaged nearly fifty pounds per tree in 1927, though only twenty in 1928; while those in block *A* dropped from over one hundred in 1927 to forty in 1928.

Studies were made to determine seasonal changes in the soil solution, using the displacement method of Burd and Martin.[1] The only major modification made in their method was the use of the soil directly from the field at whatever moisture content it happened to have, rather than the adjustment of the moisture content to a standard percentage before displacement. It was thought that this modification would give a closer approximation to the relative proportion of the ions studied, than would a method which might dilute certain ions to a greater extent than others.

A series of samples was taken at weekly intervals from May to September 1926, in the north check plot of peaches in block *A*, in order to determine whether or not there were times during the summer when maxima or minima occurred which should be taken into account in further work. Two depths were studied: zero to three feet and three to six feet.

Considerable fluctuation was found in the concentration of all ions considered except hydrogen ion concentration, which was almost constant at pH 7.0 to 7.2 in the top three feet, and from 7.4 to 7.8 in the 3–6 foot samples; and phosphate concentration, which was almost without exception between the limits of 0.5 and 1.0 parts per million of total soluble phosphorus, expressed as PO_4. There were, however, no marked maxima or minima between those dates. Sulfate varied from 50 to 120 p.p.m., and nitrate from 130 to 500 p.p.m. of soil solution. The cations will be considered in a later paper. The differences existing between the top three feet and the second three feet were considered to be too small to warrant the extra labor involved in taking samples, so that all samples taken after 1926 are composites of the first four feet.

Field sampling was carried on with soil tubes of the type recommended by the Division of Irrigation. For all of the samples taken in 1927 and 1928, from twelve to eighteen four-foot samples were taken in the central area of a plot, and composited. Satisfactory duplicates could be obtained with this type of sampling.

In 1927, a series of plots was sampled once a month from March until August and thereafter at irregular intervals. Samples were taken from twenty-eight plots, which included all the peaches and the pears of both blocks. These two fruits were selected because they both do well under the climatic conditions found at Davis, and because they represented the stone and the pome fruits.

Specific resistance is given in tables 1 to 4. These data show a gradual drop throughout the summer, indicating an increase in the concentration of electrolytes. Less seasonal change occurs in the alfalfa plots than in the others. There seems to be some tendency for the resistance to be lower in the winter cover crop blocks, though this fact may have no significance. The moisture content of each sample is also given; no constant relation is apparent between resistance and moisture content.

The pH is fairly constant at about pH 7.0–7.6.

The data for phosphorus are not presented, for they followed the same level found in 1926. If one considers the values obtained by the colorimetric method from solutions which had not been evaporated and ignited, the level of inorganic PO_4 is much lower, being from about 0.5 parts per million to only a trace.

The data for nitrates in terms of parts per million of soil solution are presented in tables 5 to 8. There was a tendency to follow, in a general way, the trend of conductivity measurements, mentioned above. The drop in nitrates during the late winter period was also striking in most plots. The minimum concentration generally occurred about April in both 1927 and 1928, at which time specific resistance was highest. An interesting contrast is evident between peach series and pear series. In all six check plots in the pear series, the general level of nitrates was higher than that in the corresponding plot in the peach series. In the alfalfa plots, the differences were insignificant.

TABLE 1

SPECIFIC RESISTANCE OF DISPLACED SOLUTIONS IN OHMS AND MOISTURE CONTENT OF SAMPLES IN PER CENT OF DRY WEIGHT; PEACH SERIES, BLOCK *A*

Date	Check		Alfalfa		Mat bean		Check		Melilotus		Rye-vetch		Check	
	Resistance	Water	Resistance	Water	Resistance	Water	Resistance	Water	Resistance	Water	Resistance	Water	Resistance	Water
	Ohms	*Per cent*	*Ohms*	*Per cent*	*Ohms*	*Per cent*	*Ohms*	*Per cent*	*Ohms*	*Per cent*	*Ohms*	*Per cent*	*Ohms*	*Per cent*
April 11, 1927	590	24	680	24	400	23	630	23	410	21	410	24	500	24
May 9, 1927	380	21	400	21	330	20	450	21	360	19	300	20	380	22
June 13, 1927	270	23	270		380	20	300	22	290	22	200		270	21
July 11, 1927	210	18	230	18	230	17	270	15	180	14	180	15	260	16
August 17, 1927	360	23		15		14	260	22	270	20	320	21	370	15
October 5, 1927	230	13	230	15	270	13	270	15	250	12	220	15	230	13
December 2, 1927	270	18	270	16	290	15	340	18	230	17	320	18	270	19
January 19, 1928	150	18	230	22	260	22	230	19	270	22	200	19	230	22
April 24, 1928	270	21	270	18	320	18	380	21	320	19	230	18	420	20
May 21, 1928	320	17	320	22		16	270	19	200	17	240	17	250	17
June 18, 1928	290	16		22	360	17		20	260	16	260	15	360	17
July 9, 1928	240	13		12	290	16	280	12	220	13	190	14	240	13
August 8, 1928	230	13	230	13	230	11	220	12	190	10	200	12	200	13
September 15, 1928	200	17	350	18	220	12	210	17	160	18	150	14	190	14

TABLE 2

SPECIFIC RESISTANCE OF DISPLACED SOLUTIONS IN OHMS AND MOISTURE CONTENT OF SAMPLES IN PER CENT OF DRY WEIGHT; PEACH SERIES, BLOCK *B*

Date	Check		Alfalfa		Mat bean		Check		Melilotus		Rye-vetch		Check	
	Resistance	Water	Resistance	Water	Resistance	Water	Resistance	Water	Resistance	Water	Resistance	Water	Resistance	Water
	Ohms	*Per cent*	*Ohms*	*Per cent*	*Ohms*	*Per cent*	*Ohms*	*Per cent*	*Ohms*	*Per cent*	*Ohms*	*Per cent*	*Ohms*	*Per cent*
April 25, 1927	410	24	410	24	470	23	500	23	360	21	410	24	580	24
May 23, 1927	300	17	340	13	230	21	300	16	370	15	210	14	370	16
June 27, 1927	370	22	270	17	260	14	290	16	230	20	230	19	230	18
July 25, 1927	190	16	310	23	160	12	270	14	210	16	170	15	240	15
October 11, 1927	320	13	320	11	220	12	320	12	230	14	200	15	200	10
January 16, 1928	310	22	320	21	180	18	260	20	200	22	180	22	200	20
March 13, 1928	180	...	320	...	180	...	220	...	320	...	230	...	230	...
April 12, 1928	320	21	330	20	360	21	450	19	360	21	250	19	450	19
May 14, 1928	270	16	...	22	...	21	280	16	230	16	300	15	260	15
June 11, 1928	250	14	380	14	260	14	260	14	280	19	280	13	260	13
July 12, 1928	340	15	410	15	230	12	230	17	250	12	290	14	320	13
August 12, 1928	180	13	270	13	140	11	190	12	190	11	180	11	240	15
September 5, 1928	240	12	500	15	200	12	230	14	200	13	180	12	180	10

TABLE 3

SPECIFIC RESISTANCE OF DISPLACED SOLUTIONS IN OHMS AND MOISTURE CONTENT OF SAMPLES IN PER CENT OF DRY WEIGHT; PEAR SERIES, BLOCK *A*

Date	Check		Alfalfa		Mat bean		Check		Melilotus		Rye-vetch		Check	
	Resistance	Water	Resistance	Water	Resistance	Water	Resistance	Water	Resistance	Water	Resistance	Water	Resistance	Water
	Ohms	*Per cent*	*Ohms*	*Per cent*	*Ohms*	*Per cent*	*Ohms*	*Per cent*	*Ohms*	*Per cent*	*Ohms*	*Per cent*	*Ohms*	*Per cent*
April 18, 1927	350	24	500	24	500	22	510	21	360	21	350	22	500	21
May 16, 1927	320	21	330	19	330	21	340	19	270	17	330	18	400	23
June 20, 1927	270	22	380	24	360	19	300	22	290	21	250	18	340	24
July 18, 1927	250	19	310	15	250	20	250	17	190	17	140	14	290	20
September 19, 1927	270	18	410	14	270	15	200	17	230	22	260	17	410	13
October 24, 1927	180	18	230	13	170	13	150	14	200	17	150	17	160	18
January 11, 1928	180	20	140	22	180	21	180	23	...	...	...	...	...	...
February 13, 1928	200	24	320	22	270	23	230	24	320	23	340	22	230	22
April 10, 1928	360	...	410	...	410	...	360	...	320	...	270	...	310	...
May 2, 1928	300	21	...	17	270	23	320	22	190	...	240	...	450	...
May 23, 1928	270	20	270	17	180	...	210	...	270	...	300	16	240	19
June 20, 1928	240	22	320	17	270	18	270	19	260	18	240	20	230	20
July 11, 1928	200	20	360	15	230	20	280	17	230	18	230	15	250	18
August 10, 1928	210	17	...	17	230	13	180	13	180	13	210	13	190	12
September 19, 1928	...	17	270	15	...	...	180	16	...	...	...	...	...	14

TABLE 4

SPECIFIC RESISTANCE OF DISPLACED SOLUTIONS IN OHMS AND MOISTURE CONTENT OF SAMPLES IN PER CENT OF DRY WEIGHT; PEAR SERIES, BLOCK *B*

Date	Check		Alfalfa		Mat bean		Check		Melilotus		Rye-vetch		Check	
	Resist-ance	Water	Resist-ance	Water	Resist-ance	Water	Resist-ance	Water	Resist-ance	Water	Resist-ance	Water	Resist-ance	Water
	Ohms	*Per cent*	*Ohms*	*Per cent*	*Ohms*	*Per cent*	*Ohms*	*Per cent*	*Ohms*	*Per cent*	*Ohms*	*Per cent*	*Ohms*	*Per cent*
May 2, 1927	410	21	450	19	590	21	680	23	630	21	250	21	540	21
May 31, 1927	450	19	...	13	330	21	410	18	240	21	230	21	340	21
July 5, 1927	240	21	270	21	230	22	240	21	200	20	180	20	230	20
August 1, 1927	250	19	290	17	180	19	170	19	170	17	170	20	280	19
November 1, 1927	190	16	250	14	150	15	300	18	150	14	120	15	210	14
January 18, 1928	290	19	320	19	270	20	270	21	160	20	270	22	180	19
March 16, 1928	250	...	390	...	300	...	320	...	260	18	400	19	230	20
April 18, 1928	350	...	320	...	450	...	450	...	270	...	230	...	320	...
May 16, 1928	250	18	320	18	160	23	230	21	240	20	230	17	270	18
June 13, 1928	...	11	...	...	...	19	220	13	210	14	...	14	220	13
June 16, 1928	190	17	340	15	270	16	220	15	140	17	220	15	220	15
August 14, 1928	180	14	320	15	210	15	140	13	170	14	160	14	190	15
September 12, 1928	180	13	360	11	290	10	180	14	180	11	190	12	190	12

TABLE 5

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

Date	Check	Alfalfa	Mat bean	Check	Melilotus	Rye-vetch	Check
March 10, 1927	117	157	157	109	176	....	101
April 11, 1927	101	78	112	67	135	140	78
May 9, 1927	73	176	111	157	140	211	148
June 13, 1927	185	127	149	132	121	254	168
July 11, 1927	288	104	157	199	317	322	314
August 17, 1927	75	....	....	125	200	225	150
October 5, 1927	193	175	88	156	142	293	160
December 2, 1927	136	434	360	322	322	341	347
January 18, 1928	353	75	136	174	124	155	244
March 20, 1928	200	34	47	87	45	58	77
April 24, 1928	145	67	102	62	100	110	93
May 21, 1928	113	65	....	113	120	122	157
June 18, 1928	145	....	100	....	163	165	93
July 9, 1928	162	....	100	106	139	160	125
August 8, 1928	165	84	142	230	131	195	187
September 15, 1928	205	82	175	195	269	324	271

TABLE 6

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

Date	Check	Alfalfa	Mat bean	Check	Melilotus	Rye-vetch	Check
March 28, 1927	146	152	168	157	135	146	101
April 25, 1927	101	62	101	101	152	135	112
May 23, 1927	243	234	211	152	165	355	224
June 27, 1927	132	188	213	137	112	241	286
July 25, 1927	250	176	373	174	247	380	228
October 11, 1927	125	138	256	125	175	188	225
January 16, 1928	150	100	372	211	211	204	242
February 23, 1928	174	87	310	....	....	....	....
March 13, 1928	262	50	306	177	75	56	188
April 12, 1928	81	35	90	97	91	122	90
May 14, 1928	133	....	....	131	165	98	120
June 11, 1928	206	111	245	206	160	162	157
July 12, 1928	177	55	222	210	200	104	181
August 12, 1928	225	146	250	215	200	219	229
September 5, 1928	205	82	175	195	269	324	271

TABLE 7

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

Date	Check	Alfalfa	Mat bean	Check	Meli-lotus	Rye-vetch	Check
March 21, 1927	236	146	162	130	121	225	247
April 18, 1927	112	180	185	146	258	202	118
May 16, 1927	161	110	213	198	198	190	189
June 20, 1927	280	130	211	243	217	285	204
July 18, 1927	274	173	263	242	496	606	244
September 19, 1927	238	75	160	240	288	400	156
October 24, 1927	262	81	256	431	312	427	500
January 11, 1928	372	....	347	250	....	174	211
February 13, 1928	329	87	236	409	124	124	360
April 10, 1928	221	43	61	130	93	92	215
April 26, 1928	142	37	200	83	....	....	....
May 2, 1928	168	....	202	166	315	150	125
May 23, 1928	218	93	397	285	225	137	345
June 20, 1928	283	263	250	237	217	237	325
July 11, 1928	356	87	288	225	238	375	278
August 10, 1928	300	....	224	387	311	268	387
September 19, 1928	....	89	....	394	....	....	516

TABLE 8

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

Date	Check	Alfalfa	Mat bean	Check	Meli-lotus	Rye-vetch	Check
April 4, 1927	123	112	152	202	225	191	169
May 2, 1927	202	73	135	101	112	270	123
May 31, 1927	239	238	173	173	306	587	248
July 5, 1927	328	223	308	299	326	418	370
August 1, 1927	305	150	487	238	547	490	306
November 1, 1927	387	121	485	325	385	435	304
January 18, 1928	223	98	223	273	422	236	422
March 16, 1928	172	40	190	171	177	107	287
April 18, 1928	140	46	75	101	138	160	178
May 16, 1928	261	....	....	267	280	250	261
June 13, 1928	....	....	....	382	377	....	391
July 16, 1928	410	95	150	359	620	331	363
August 14, 1928	437	131	330	562	418	434	525
September 12, 1928	594	79	262	600	600	462	500

In the mat bean plots the differences were small, but both the plots of the pear series were higher than the corresponding plots of the peach series. The differences in the winter cover crop plots were even more pronounced than those in the check plots. This difference between species may be explained, possibly, by the fact that the growth and yield of the peach trees was much greater than that of the pear trees. Another plausible explanation is the fact that peaches are considered by the grower to be "heavy nitrogen feeders." The plots of the peach series were less variable than the pears, all of the plots tending to change in the same direction and to show smaller differences between the highest and lowest ones.

The alfalfa plots had a tendency to be low in nitrates, especially under the pear trees. In the peach series the alfalfa plots are the lowest in over half of the samples; while in the plots of the pear series they are lowest on twenty-two out of twenty six dates. This phenomenon is more striking in 1928 than in 1927.

In the mat bean plots, the general behavior was similar to that of the checks.

The Melilotus plots showed a high degree of variability. Only in the pears of Block *B* is there a marked increase in nitrates over the check plots in 1927, the other three series having shown, in general, little tendency to rise above the checks. The curves in 1928 closely approximate those of the checks.

The rye and vetch plots had the highest general level of nitrates through most of the year in 1927. After about November they fell very rapidly, to a low point in the spring. In 1928, the curves were close to those of the checks, often falling below them, as may be seen from inspection of tables 5 to 8. Figure 2 shows the average of the nitrate concentration of the north and center checks from tables 5 to 8. The seasonal variation and difference between peach and pear plots is illustrated. Figure 3 shows the data for alfalfa plots from the same tables. The two sharp maxima are probably due to local nitrate accumulations.

The data for nitrates, expressed in terms of parts per million of dry soil, are presented in tables 9 to 12. These data give an approximation to the concentrations that might be expected from "one to one" extracts. They indicate that the seasonal changes mentioned above are not the result of dilution or concentration due to changes in moisture content of the soil alone.

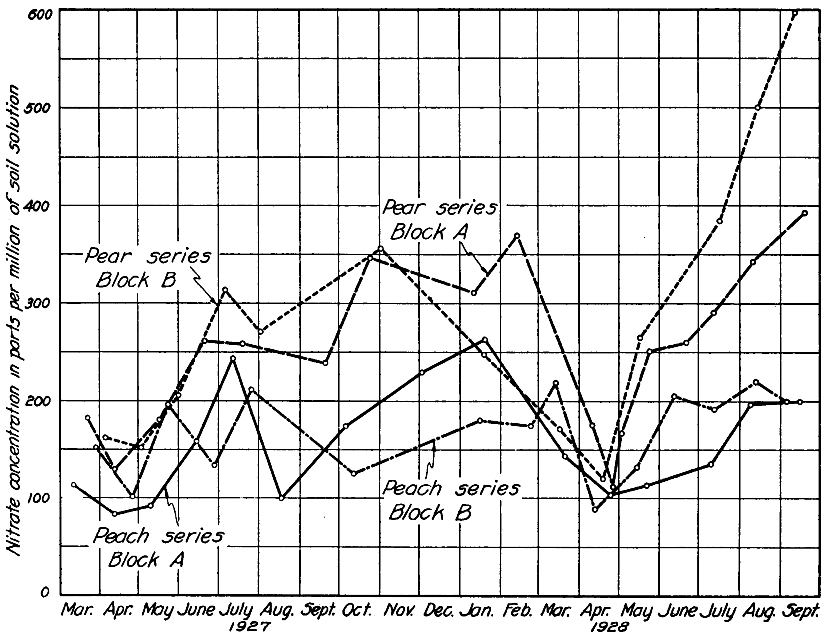

Fig. 2. Average nitrate content of north and center check plots, in parts per million of displaced solution.

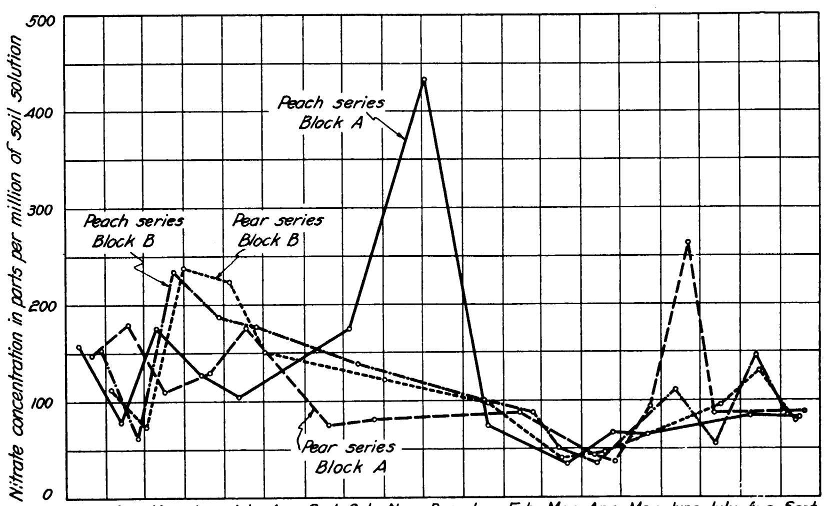

Fig. 3. Nitrate content of alfalfa plots, in parts per million of displaced solution.

TABLE 9

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

(Calculated from table 5)

Date	Check	Alfalfa	Mat bean	Check	Meli-lotus	Rye-vetch	Check
March 10, 1927	29	39	39	27	44	......	25
April 11, 1927	24	21	26	16	28	31	19
May 9, 1927	15	37	22	33	27	43	33
June 13, 1927	43	25	29	29	27	69	35
July 11, 1927	52	19	27	30	44	48	50
August 17, 1927	17	......	......	18	40	47	23
October 6, 1927	25	26	11	23	17	44	21
December 2, 1927	24	69	54	58	55	61	66
January 19, 1928	64	12	20	31	23	28	46
March 20, 1928	42	7	10	18	9	12	15
April 24, 1928	30	12	18	7	19	20	19
May 21, 1928	19	12	......	18	23	20	27
June 18, 1928	23	......	17	......	26	25	16
July 9, 1928	21	......	16	12	18	22	16
August 8, 1928	21	11	16	28	13	23	24
September 14, 1928	35	15	19	33	48	45	38

TABLE 10

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

(Calculated from table 6)

Date	Check	Alfalfa	Mat bean	Check	Meli-lotus	Rye-vetch	Check
March 28, 1927	37	38	42	39	34	38	25
April 25, 1927	23	11	20	18	31	27	22
May 23, 1927	41	30	44	24	25	50	38
June 27, 1927	28	30	47	27	22	48	52
July 25, 1927	40	40	45	24	40	57	34
October 11, 1927	16	15	31	15	25	28	23
January 16, 1928	33	21	67	42	......	45	48
February 23, 1928	38	20	66	......	......	......	......
March 13, 1928	52	10	60	35	14	11	38
April 12, 1928	17	7	19	18	19	23	17
May 14, 1928	21	......	......	21	26	15	18
June 11, 1928	29	15	34	28	31	21	20
July 12, 1928	27	8	27	36	24	15	24
August 12, 1928	29	19	28	26	23	24	34
September 5, 1928	23	11	45	36	36	27	35

TABLE 11

NITRATE CONTENT OF SOIL SOLUTION IN PEAR SERIES, BLOCK *A*, IN PARTS PER MILLION OF DRY SOIL

(Calculated from table 7)

Date	Check	Alfalfa	Mat bean	Check	Meli-lotus	Rye-vetch	Check
March 21, 1927	59	37	41	33	30	56	62
April 18, 1927	27	43	41	31	54	44	25
May 16, 1927	34	21	45	38	34	34	44
June 20, 1927	62	31	40	52	46	51	49
July 18, 1927	52	26	26	64	84	85	49
September 19, 1927	43	11	24	41	63	68	20
October 24, 1927	47	11	33	60	53	60	90
January 11, 1928	74	....	73	58	....	36	46
February 13, 1928	79	19	54	98	29	27	79
April 10, 1928 (estimated)*	44	8	12	26	19	18	43
April 26, 1928	....	6	42	17	....	....	....
May 2, 1928	35	....	46	36	63	30	25
May 23, 1928	43	16	83	57	45	22	66
June 20, 1928	62	43	45	45	39	47	64
July 11, 1928	71	13	58	38	42	55	50
August 10, 1928	51	....	29	50	40	35	46
September 19, 1928	....	13	....	63	....	....	72

* This set of figures calculated on an estimated moisture content of 20 per cent.

TABLE 12

NITRATE CONTENT OF SOIL SOLUTION IN PEAR SERIES, BLOCK *B*, IN PARTS PER MILLION OF DRY SOIL

(Calculated from table 8)

Date	Check	Alfalfa	Mat bean	Check	Meli-lotus	Rye-vetch	Check
April 4, 1927	31	28	38	51	56	48	42
May 2, 1927	42	14	28	23	23	57	26
May 31, 1927	45	31	36	31	58	100	46
July 5, 1927	69	46	68	63	64	84	74
August 1, 1927	58	26	90	45	93	98	57
November 1, 1927	62	17	70	59	54	65	43
January 18, 1928	42	19	45	57	84	62	80
March 16, 1928	34	8	38	34	34	21	57
April 18, 1928 (estimated)*	28	9	15	20	27	32	34
May 16, 1928	47	....	....	56	56	43	47
June 13, 1928	....	....	....	50	53	....	51
July 16, 1928	70	14	24	54	105	50	54
August 14, 1928	61	20	50	72	59	59	79
September 12, 1928	77	9	26	84	66	55	60

* This set of figures calculated on an estimated moisture content of 20 per cent.

Among the most striking differences thus far observed were those in the sulfate content, given in tables 13 to 16, between the peach series and the pear series. In the great majority of cases throughout this period, the sulfate content of the solution from the peach series was higher than that of the corresponding pear plot. The differences were greater and more consistent than were those of the nitrates pointed

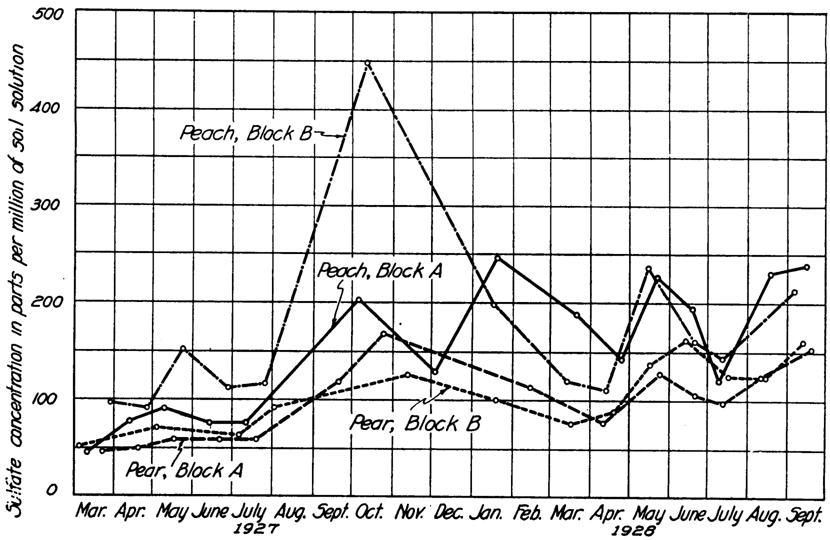

Fig. 4. Average sulfate content of the three check plots, in parts per million of displaced solution.

out above. The variability of the peach series with regard to sulfate was likewise greater than that of the pear plots. Differences between treatments were not consistent enough to be considered significant. It should be noted that the tendency of the maxima to appear in the fall and the minima in spring corresponded to the tendencies noted for nitrate, though by no means in so clear a manner. The data expressed on the dry weight basis showed the same features. The average of the three check plots is shown graphically in figure 4.

TABLE 13

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

Date	Check	Alfalfa	Mat bean	Check	Meli-lotus	Rye-vetch	Check
March 10, 1927	79	160	54	21	46	42	38
April 11, 1927	52	73	92	45	102	104	135
May 9, 1927	81	104	102	83	120	75	108
June 13, 1927	85	99	64	113	121	75	29
July 11, 1927	83	143	124	62	156	89	82
October 5, 1927	......	250	228	202	194	......	......
December 2, 1927	130	164	......	......	146	92	127
January 19, 1928	317	......	189	......	193	125	174
March 30, 1928	320	135	168	92	205	155	151
April 24, 1928	215	169	147	119	89	142	91
May 21, 1928	284	153	......	231	258	182	227
June 18, 1928	247	......	109	149	93	142	187
July 9, 1928	162	......	98	169	185	226	179
August 8, 1928	250	......	203	210	295	......	......
September 15, 1928	310	191	197	201	193	238	237

TABLE 14

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

Date	Check	Alfalfa	Mat bean	Check	Meli-lotus	Rye-vetch	Check
March 28, 1927	92	78	39	52	......	31	146
April 25, 1927	120	146	104	104	80	115	49
May 23, 1927	146	193	177	196	68	68	113
June 27, 1927	61	125	63	159	97	144	114
July 25, 1927	196	86	188	109	79	128	42
October 11, 1927	332	169	372	652	......	283	362
January 16, 1928	178	160	207	201	83	226	216
February 23, 1928	103	193	164	......	......	......	......
March 13, 1928	185	114	188	115	107	182	209
April 12, 1928	187	141	127	76	102	135	68
May 14, 1928	240	......	......	231	235	233	238
June 11, 1928	190	139	110	168	198	67	121
July 12, 1928	144	64	146	154	170	101	131
August 12, 1928	229	......	190	......	......	......	......
September 5, 1928	203	81	193	225	211	277	211

TABLE 15

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

Date	Check	Alfalfa	Mat bean	Check	Meli-lotus	Rye-vetch	Check
March 21, 1927	75	29	22	29	22	15	38
April 18, 1927	66	14	34	45	26	41	38
May 16, 1927	40	47	57	65	60	38	71
June 20, 1927	63	63	40	56	40	38	59
July 18, 1927	46	68	62	89	43	65	41
September 19, 1927	105	89	101	131	103	81	....
October 24, 1927	168	....	354	....	205	351	....
February 13, 1928	117	91	94	119	123	87	103
April 10, 1928	58	120	84	84	151	102	88
May 23, 1928	102	134	113	153	120	....	....
June 20, 1928	102	69	100	....	128	98	109
July 11, 1928	106	103	116	90	94	106	96
August 10, 1928	125	....	128	109	100	97	138
September 19, 1928	....	219	....	152	....	....	....

TABLE 16

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

Date	Check	Alfalfa	Mat bean	Check	Meli-lotus	Rye-vetch	Check
March 4, 1927	42	20	27	52	46	62	60
May 2, 1927	85	32	25	62	26	92	67
July 5, 1927	58	51	59	40	51	52	95
August 1, 1927	123	106	92	92	114	63	59
November 11, 1927	193	....	86	59	....	175	....
January 18, 1928	98	....	82	81	133	75	121
March 16, 1928	83	66	82	70	97	76	....
April 18, 1928	77	55	76	86	103	141	98
May 16, 1928	140	....	....	168	118	138	101
May 13, 1928	....	....	....	155	105	....	167
July 16, 1928	158	89	95	125	138	111	88
August 14, 1928	....	113	....	....	....	....	123
September 12, 1928	179	115	102	152	107	160	150

DISCUSSION AND CONCLUSIONS

As a result of these studies, which are in the nature of a progress report, it is possible to point out certain points of difference between the changes induced in the soil solution by trees and by cereals. Burd and Martin[2] showed a marked drop in nitrate content at the end of the growing season for cereals. The data presented here do not show this for trees under Davis conditions, but show a tendency for a rise to occur during the growing season. It might be thought that the cover crops, whether planted or natural, as in the check plots, show the same tendency as do cereals. The alfalfa plots, however, have their minima at the same time as do the winter cover crop plots, although the growing season of alfalfa corresponds more nearly to that of the trees. The mat bean plots, which are nearly bare in winter, show a similar drop in the spring. It appears that, with the exception of alfalfa, nitrification exceeds utilization throughout the summer months. This is in fairly good agreement with the data of Lyon, Heinicke and Wilson,[4] who find nitrates to be at their maximum in June to August and to decrease in October. They report no data for the winter months. The minimum in the spring may be due to withdrawal by roots, which are growing at that period.

Burd[3] has pointed out that soils depleted in chloride and nitrate ions are high in sulfates. A similar phenomenon is seen in the comparison of the peach and pear series, the plots of the peach series being higher in sulfates and lower in nitrates than the plots of the pear series. The coefficient of correlation between the concentrations of these two ions is, however, very low, and the seasonal fluctuations of the two ions do not show a reciprocal relationship. It is possible that the bicarbonate relationship may offer at least a partial explanation of these discrepancies, though adequate data on this point are not available at the present time. The fact that nitrates are generally somewhat higher and sulfates lower than in most of the cropped soils reported on by Burd and Martin suggests that with more intensive cropping the differences between species noted here might be more striking, and certain anomalies in the figures might disappear.

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1. The Removal of Sodium Carbonate from Soils, by Walter P. Kelley and Edward E. Thomas. January, 1923.

4. Effect of Sodium Chlorid and Calcium Chlorid upon the Growth and Composition of Young Orange Trees, by H. S. Reed and A. R. C. Haas. April, 1923.

5. Citrus Blast and Black Pit, by H. S. Fawcett, W. T. Horne, and A. F. Camp. May, 1923.

6. A Study of Deciduous Fruit Tree Rootstocks with Special Reference to Their Identification, by Myer J. Heppner. June, 1923.

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8. Effect of Salts on the Intake of Inorganic Elements and on the Buffer System of the Plant, by D. R. Hoagland and J. C. Martin. July, 1923.

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