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Maintaining Fertility of Grande Ronde Valley Soils

Agricultural Experiment Station
Oregon State Agricultural College
CORVALLIS

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SUMMARY

FERTILIZER experiments with Catherine silt loam at the Oregon State Livestock Branch Experiment Station at Union for the past twelve-year period are reported herein. Four crops have been grown in a combination rotation on a like number of ranges of thirteen plots each with nine different treatments and four untreated checks. The crops were grown without irrigation.

In these experiments significant and profitable crop response has been obtained from (1) land-plaster or sulfur in alfalfa growing, and (2) superphosphate in grain growing. Cooperative fertilizer trials and chemical analyses indicate that Grande Ronde soils are unfavorably low in sulfur and may be low in readily soluble phosphorus.

Preliminary results from nineteen crop rotations maintained for eight years indicate that rotating with legumes such as peas or the use of annual sweet clover with spring wheat will increase the yearly income.

A key to Grande Ronde Valley soil types is presented, then drainage and irrigation requirements, chemical analyses, management, and maintenance are discussed.

Maintaining Fertility of Grande Ronde Soils

By

W. L. Powers and D. E. Richards

INTRODUCTION

THE object of this report is to submit the results of fertilizer and soil-improvement trials conducted jointly by the Oregon State Agricultural Experiment Station at Corvallis and the Oregon State Livestock Branch Experiment Station at Union, the field trials having been conducted at the Union Station.* The Union Station fertility plots form an essential unit in a state-wide program for determining the fertilizer needs of Oregon soils in the development of an economic and permanent system of soil fertility.

FERTILIZER EXPERIMENTS

STATION FERTILIZER TRIALS

Fertilizer trials initiated at the Oregon State Livestock Experiment Station near Union in 1920 were planned to determine the soil needs for growing staple crops and the effect of various fertilizer applications on soil and crops, and to endeavor to conserve soil fertility by practicing a rotation system with a legume crop.

A plot of land with uniform soil was selected near the Station headquarters and divided into four sections. Each section was subdivided into thirteen tenth-acre plots, 2 by 8 rods in size and respectively numbered from north to south. The fertilizer applications are applied every third year to plots having the same serial number throughout each of the four sections.

One-foot alleys are maintained between plots and twenty-foot alleys between sections. Every fourth plot is a check.

The crops grown are Grimm alfalfa, peas and barley, corn, and winter wheat. These are rotated in the following manner: corn after peas and barley, and wheat after corn. Every fifth year alfalfa follows wheat and the silage crop of peas and barley follows alfalfa. The detailed data for the first twelve years of this experiment are given in Table I. The yields fluctuate with the seasons. Several check plots show some variation in yields in the untreated portions of the experimental tract, yet the yield of

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*The late Robert Withycombe, as superintendent, gave faithful attention to maintenance of the experiment and records thereof for a full decade.

TABLE I. FERTILIZER EXPERIMENT, OREGON STATE LIVESTOCK EXPERIMENT STATION, UNION, OREGON

Annual and Average Yield per Acre of Corn, Peas and Barley for Silage, Fortyfold Wheat, and Grimm Alfalfa. Plots 1/10 acre in size.

Plot and treatment*	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	1930	1931	1932	Total	Average
Corn, 1920-1932 inclusive	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*
1 Check	11.15	6.48	11.83	11.25	5.18	12.5	8.9	7.6	12.3	12.4	11.0	4.9	6.2	121.64	9.4
2 Manure	10.52	6.23	10.75	11.12	5.95	15.0	9.3	6.3	12.1	13.7	10.3	5.1	6.7	123.07	9.5
3 P K N	11.75	7.43	10.40	10.05	6.30	17.2	9.1	7.0	12.4	14.5	9.6	6.6	6.5	128.78	9.9
4 K N	12.45	8.58	9.53	8.70	6.50	17.2	9.0	6.8	10.6	12.6	6.1	5.8	5.7	119.56	9.2
5 Check	10.85	8.40	9.85	9.67	6.93	16.1	8.6	6.6	10.5	10.6	8.1	4.2	4.9	115.30	8.9
6 N P	10.75	7.78	10.65	10.32	8.05	16.3	9.3	8.0	10.4	12.2	9.7	6.1	5.3	124.85	9.6
7 S	12.00	7.48	9.50	9.70	6.73	16.2	6.2	7.3	10.4	11.5	11.0	5.0	4.6	117.54	9.0
8 Ca So$_4$	12.80	7.83	8.08	8.25	6.13	15.9	6.2	6.7	10.3	10.1	13.6	3.7	4.6	114.19	8.8
9 Check	12.00	7.43	8.35	8.42	6.85	14.0	7.3	6.2	10.3	9.5	13.2	4.5	4.2	112.25	8.6
10 K	12.35	7.90	8.53	10.05	6.58	13.3	8.9	4.4	10.5	10.8	12.7	5.0	4.8	115.81	8.9
11 N	12.00	5.58	8.48	9.92	5.45	12.9	10.1	3.9	9.8	12.2	10.8	4.0	4.6	109.73	8.4
12 P	7.97	4.98	8.83	9.85	4.88	14.7	9.7	4.5	7.9	13.1	8.2	4.3	4.9	103.81	8.0
13 Check	8.00	4.65	11.03	10.40	4.20	13.9	8.1	4.8	9.6	12.8	8.3	5.2	4.8	105.78	8.1
Peas and barley for silage, 1922-1932 inclusive	*Tons* †	*Tons* †	*Tons*	*Tons* ‡	*Tons*	*Tons*	*Tons*	*Tons* ‡	*Tons*	*Tons*	*Tons*	*Tons* ‡	*Tons* §	*Tons*	*Tons*
1 Check	....	....	4.67	8.77	5.48	10.7	3.4	8.4	4.9	4.2	5.7	9.6	4.3	70.12	6.4
2 Manure	....	....	3.99	9.55	6.05	10.1	3.9	10.2	5.0	4.5	6.2	8.6	5.0	73.05	6.6
3 P K N	....	....	3.71	9.80	7.55	11.8	3.9	12.0	4.8	5.0	8.2	4.8	5.0	76.54	7.0
4 K N	....	....	3.28	9.57	6.55	10.1	5.3	10.8	4.3	4.9	8.5	7.9	4.9	76.10	6.9
5 Check	....	....	3.49	9.42	7.05	11.1	6.3	10.6	3.8	6.0	7.9	6.9	4.8	77.31	7.0
6 N P	....	....	4.45	10.07	8.05	10.9	7.6	11.5	4.0	9.5	8.4	8.1	5.2	87.72	8.0
7 S	....	....	3.29	9.15	7.20	8.1	5.9	9.4	4.2	6.3	6.2	6.4	4.7	70.84	6.4
8 Ca So$_4$	....	....	3.33	10.40	6.33	7.2	5.6	8.6	4.1	6.5	6.2	5.7	4.7	68.66	6.2
9 Check	....	....	3.54	10.55	5.25	7.1	6.1	7.5	4.4	7.7	5.4	6.3	4.1	67.94	6.2
10 K	....	....	3.04	10.82	4.73	7.5	4.9	7.4	4.8	6.3	4.9	6.6	3.9	64.89	5.9
11 N	....	....	3.19	9.92	4.50	8.0	4.4	6.4	4.4	5.5	4.6	8.0	3.5	62.36	5.7
12 P	....	....	3.41	8.97	5.75	9.3	4.7	8.6	5.1	5.2	5.4	8.7	3.7	68.83	6.3
13 Check	....	....	3.35	8.35	6.88	10.3	3.9	7.5	6.3	3.3	5.7	9.1	3.6	68.28	6.2

	Fortyfold wheat, 1922-1932 inclusive	Bushels ‖	Bushels ‖	Bushels	Bushels	Bushels ‖	Bushels	Bushels	Bushels	Bushels	Bushels	Bushels	Bushels	Bushels	Bushels	Bushels
1	Check	....	....	23.2	60.7	....	51.0	39.3	52.5	33.3	46.2	62.5	30.3	51.7	450.7	45.1
2	Manure	....	....	25.0	54.6	....	58.6	46.3	56.5	46.3	56.2	55.0	38.0	39.5	476.0	47.6
3	P K N	....	....	29.2	57.6	....	54.0	54.2	57.5	23.3	38.5	65.2	32.2	45.3	457.0	45.7
4	K N	....	....	31.2	58.2	....	53.0	53.3	60.0	33.5	50.3	63.7	40.3	38.7	482.2	48.2
5	Check	....	....	32.2	54.8	....	51.3	57.8	59.2	37.8	50.9	61.6	40.0	40.8	486.4	48.6
6	N P	....	....	35.8	58.8	....	56.8	51.7	63.8	37.2	55.4	68.8	40.5	47.2	516.0	51.6
7	S	....	....	30.8	52.5	....	48.1	60.2	56.8	32.2	51.8	64.5	32.8	51.0	480.7	48.1
8	Ca So$_4$	....	....	29.0	48.6	....	49.1	57.5	55.0	34.2	40.0	62.5	31.0	51.3	458.2	45.8
9	Check	....	....	28.8	52.3	....	51.1	57.7	54.0	36.3	41.8	61.5	36.2	43.3	463.0	46.3
10	K	....	....	31.2	52.1	....	52.1	53.8	56.8	35.7	42.9	68.0	33.7	47.7	474.0	47.4
11	N	....	....	20.0	56.1	....	45.5	58.2	55.0	35.5	47.3	62.8	31.0	46.7	458.1	45.8
12	P	....	....	19.3	57.0	....	54.3	58.7	71.8	41.7	53.5	77.8	30.8	48.3	513.2	51.3
13	Check	....	....	18.7	53.6	....	47.0	55.8	43.3	34.0	48.0	64.5	29.3	44.5	438.7	43.9
	Grimm alfalfa, 1921-1931 inclusive	Tons ¶	Tons	Tons	Tons	Tons ¶	Tons	Tons	Tons	Tons **	Tons	Tons	Tons	Tons ¶	Tons	Tons
1	Check	....	6.03	6.60	6.30	....	6.5	5.3	5.7	1.6	7.7	7.4	5.3	....	58.43	5.8
2	Manure	....	7.19	6.99	6.61	....	6.9	6.8	6.1	1.7	7.2	8.5	6.5	....	64.49	6.4
3	P K N	....	7.58	6.70	6.21	....	6.7	6.8	6.3	2.1	7.9	8.5	6.2	....	64.99	6.5
4	K N	....	7.50	7.32	6.77	....	5.6	5.9	5.5	1.7	6.7	7.6	7.1	....	61.69	6.2
5	Check	....	6.74	6.04	6.22	....	6.1	6.3	6.1	1.7	6.5	6.8	6.8	....	59.30	5.9
6	N P	....	7.46	7.03	6.92	....	6.1	6.7	6.0	1.8	6.9	8.0	6.4	....	63.31	6.3
7	S	....	7.22	6.88	6.86	....	6.0	6.7	6.2	1.8	7.0	8.1	7.0	....	63.76	6.4
8	Ca So$_4$	....	7.32	6.89	6.60	....	5.9	7.2	6.7	1.8	7.1	8.0	7.5	....	65.00	6.5
9	Check	....	6.20	6.50	6.66	....	5.9	7.4	6.2	1.7	7.5	8.5	6.6	....	63.16	6.3
10	K	....	6.22	6.49	6.26	....	6.6	7.0	6.1	1.6	6.9	8.1	6.5	....	61.77	6.2
11	N	....	6.21	7.16	6.56	....	6.1	7.6	6.4	1.4	7.0	7.3	5.9	....	61.63	6.2
12	P	....	6.74	6.70	6.62	....	6.4	6.4	6.4	2.0	7.3	7.3	6.4	....	62.26	6.2
13	Check	....	6.25	6.61	6.35	....	6.1	6.9	4.8	1.5	7.7	8.5	7.0	....	61.71	6.2

*N=Nitrogen. P=Phosphorus. K=Potassium. S=Sulfur. Ca So$_4$=Calcium Sulfate (Gypsum).

†In 1920 and 1921 oats used with peas instead of barley.

‡Alfalfa sod land.

§Peas and barley cut for hay instead of silage in 1932.

‖In 1920, 1921, and 1924 spring wheat used. In 1924 the plots were sown to Hard Federation.

¶No crop was harvested from the alfalfa plots in 1920, 1924, and 1932 owing to new seedings.

**Crop from new seeding.

alfalfa treated with calcium sulfate and that of wheat treated with phosphate is significantly higher than that of any untreated plot. Maximum yields and value of increase with wheat for the period of the experiment has been obtained where phosphorus was applied.

The net increase or decrease in value of crop resulting from various treatments is summarized in Table II. This table is arranged to show yield per acre, cost of fertilizer, and increased income. Current crop values were used in making computations; namely, wheat 35¢ a bushel, alfalfa hay $7.00 a ton, corn silage $3.00, and peas and barley silage $2.50 a ton. The fertilizers used, cost, and rate of application were as follows:

Acid phosphate (phosphorus)	200	pounds per acre	@ $20.00 per ton
Tankage (nitrogen)	100	pounds per acre	@ $50.00 per ton
Muriate of potash (potassium)	160	pounds per acre	@ $48.00 per ton
Land-plaster	200	pounds per acre	@ $10.00 per ton
Sulfur	100	pounds per acre	@ $45.00 per ton
Manure	8	tons per acre	@ 50¢ per ton

Fertilizers were applied once every three years.

The highest twelve-year average yield for Fortyfold wheat has resulted from the phosphate treatment. The twelve-year average increase in yield amounted to 6.1 bushels, representing a net crop value of $1.47 an acre even at current prices. There is evidence from cooperative trials on other soil types of the Valley that on the worn wheat lands phosphorus will become of increasing importance in maintaining yields.

Grimm alfalfa treated with land-plaster gave an average increase in net income of $1.56. Continued application of sulfur on this soil type appears to increase acidity. However, on soils of the Valley having a neutral or slightly alkaline reaction, it is believed that sulfur may prove a more profitable fertilizer than land-plaster. An average increase in net crop value of 98¢ an acre was realized from use of barnyard manure at the rate of eight tons each three years. A net increase of 51¢ an acre from use of a complete fertilizer—one supplying phosphorus, potassium, and nitrogen—was realized.

Peas and barley grown for silage have given a maximum yield when treated with phosphorus and nitrogen. The gain has been 1.73 tons and the net increase $2.83 an acre. At present prices, the increase from complete fertilizer and from other treatments was not sufficient to return the fertilizer cost.

When treated with complete fertilizer, corn gave a maximum yield of 9.8 tons an acre. This was a gain of 1.2 tons over the untreated plot. Nitrogen and phosphorus gave nearly as large an increase. With this treatment, the maximum net increase in crop value was realized, amounting to $1.20 an acre.

The two most significant results of this trial are (1) the value of phosphorus, especially on grain crops and (2) the value of sulfur carriers on alfalfa. These experiments should be maintained for they will continue to yield fundamental information for developing a permanent system of agriculture for this and similar soils of the region.

TABLE II. RESULTS OF FERTILIZER TRIALS
Oregon State Livestock Experiment Station, Union, Oregon.
Twelve-year Average

Treatment	Average yield per acre	Cost of fertilizer	Net increase or decrease in value of crop
WINTER WHEAT (FORTYFOLD)	*Bushels*		
No fertilizer	43.8	-------	-------
Manure	46.1	$1.33	-$0.52
Phosphorus–Potassium–Nitrogen	42.9	2.78	-3.10
Potassium–Nitrogen	45.0	2.11	-1.69
Nitrogen–Phosphorus	48.2	1.50	.04
Sulfur	45.1	.75	-.29
Land-plaster	43.5	.33	-.44
Potassium	44.9	1.28	-.89
Nitrogen	44.2	.83	-.69
Phosphorus	49.9	.67	1.47
GRIMM ALFALFA	*Tons*		
No fertilizer	5.99	-------	-------
Manure	6.32	$1.33	$0.98
Phosphorus–Potassium–Nitrogen	6.46	2.78	.51
Potassium–Nitrogen	5.80	2.11	-3.44
Nitrogen–Phosphorus	6.12	1.50	-.59
Sulfur	6.15	.75	.37
Land-plaster	6.26	.33	1.56
Potassium	6.10	1.28	-.51
Nitrogen	6.07	.83	-.27
Phosphorus	6.08	.67	-.04
PEAS AND BARLEY (SILAGE)	*Tons*		
No fertilizer	6.77	-------	-------
Manure	6.9	$1.33	$1.00
Phosphorus–Potassium–Nitrogen	7.4	2.78	-1.20
Potassium–Nitrogen	7.3	2.11	-.78
Nitrogen–Phosphorus	8.5	1.50	2.83
Sulfur	6.78	.75	-.72
Land-plaster	6.4	.33	-1.26
Potassium	6.0	1.28	-3.21
Nitrogen	5.9	.83	-3.01
Phosphorus	6.7	.67	-.85
CORN (SILAGE)	*Tons*		
No fertilizer	8.6	-------	-------
Manure	9.3	$1.33	$0.77
Phosphorus–Potassium–Nitrogen	9.8	2.78	.82
Potassium–Nitrogen	8.97	2.11	-1.00
Nitrogen–Phosphorus	9.5	1.50	1.20
Sulfur	8.9	.75	.15
Land-plaster	8.7	.33	-.03
Potassium	8.8	1.28	-.68
Nitrogen	8.3	.83	-1.73
Phosphorus	8.1	.67	-2.17

COOPERATIVE FERTILIZER TRIALS

Seven cooperative demonstration trials were initiated by the former Union County Agent, Paul Spillman, in 1917, using sulfur carriers applied to alfalfa at different rates. Gypsum was used in 50-, 100-, 200- and 300-pound applications per acre. Sulfur was applied at the rates of 100 and 200 pounds per acre. Farms on which trials were conducted were those of R. W. Ledbetter, Alicel; Bernal Hug, Elgin; Organ Brothers, Cove; Robert Clark, Island City; E. D. Whiting, LaGrande; Fred Zaugg, LaGrande;

and Homer Carnes, North Powder. Three fields were on clay loam, two were dark silt loam, and two were classed as sandy loam. The season was dry and only one irrigated field gave results the first year. The following year all the trials gave substantial increases from applications of sulfur or calcium sulfate. Accurate results were not obtained after the second year. Gypsum gave quickest results. The effect of sulfur endured longer and appeared to be the more economical and durable treatment. The economic rate of application was found to be 200 pounds of calcium sulfate or gypsum and 100 pounds of sulfur an acre. Increases of 100 to 154 per cent were obtained. At the prices then current, gypsum and alfalfa being worth one cent per pound each, the net profit was $30.17 an acre from 200 pounds of gypsum and $31.48 from the sulfur treatment.

A fertilizer trial on the cherry orchard of T. C. Hefty on LaGrande gravelly silt loam, fan phase, near Cove has been maintained for three years. The results the past season indicated that fertilized trees returned approximately $1.00 each above the cost of the increased yield of Royal Anns. With black cherries, according to County Agent H. G. Avery, the increased yield would be worth approximately $1.50 per tree above cost. Fruit from each tree has been weighed by the owner each of the past four years. Mr. Avery supplied information on results obtained, which have been summarized in Table III.

TABLE III. FERTILIZER TRIAL ON CHERRIES

Plot and treatment	Rate per tree	Yield			Relative yield per cent			Cost per tree 1932	Value increase per tree
		1931	1932	1933	1931	1932	1933		
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	%	%	%		
1 Sulfate of ammonia Superphosphate Sulfate of potash	4 7 2	154.3	75.1	112.4	125.7	128.5	203.2	$0.38	$1.71
2 Superphosphate Sulfate of potash	7 2	150.1	69.9	92.6	122.3	119.6	167.4	.20	1.11
3 Untreated	--	112.7	58.4	55.3	100.0	100.0	100.0	-------	-------
4 Sulfate of ammonia	4	106.3	54.8	85.6	88.1	93.9	154.8	.18	.91

CHEMICAL ANALYSES OF FERTILITY PLOT SOILS

A chemical invoice has been completed from samples recently collected from one range of the old fertility plots at Union and the results of determinations for surface soils to plow depth are presented in Table IV. The analyses reflect a considerable uniformity in the soils even after twelve years of treatment. The soil is well supplied with organic matter and has good base exchange capacity—that is, capacity to absorb and retain basic nutrients such as calcium and potassium in nearly available form. The supply of exchange calcium is especially good. A laboratory study was made of the effect of sulfur on part of the uniformly mixed lot of soil from an untreated plot of this experiment field. The results are reported in Table V. This study indicates a large increase in sulfate and calcium and some increase in soluble potassium, resulting from a sulfur treatment. A tendency to increase acidity or lower the reaction value (pH) is also noted. On slightly alkaline soils this acidifying effect would be beneficial and the sulfur is a more concentrated source of sulfate than is gypsum. Sulfur also has a greater solubility effect.

TABLE IV. CHEMICAL ANALYSES OF SOIL SAMPLES. SURFACE 0-8"—OREGON STATE LIVESTOCK EXPERIMENT STATION, FERTILITY AND SOILS DEPARTMENT, OREGON AGRICULTURAL EXPERIMENT STATION

Plot and treatment	Reaction value (pH)	Ill. Phos. test	Nitric nitrogen	Total nitrogen	Base exchange capacity M.E.‡ per 100 grams	Exchange			Soluble calcium per 100 grams soil	Soluble magnesium per 100 grams soil	Soluble potassium	Organic matter
						Calcium M.E. per 100 grams	Magnesium M.E. per 100 grams	Potassium M.E. per 100 grams				
			P.p.m.	%					*Grams*	*Grams*	*P.p.m.*	%
1 Check	6.8	Med.	14	0.228	30.7	36.82	6.97	1.42	.0076	.0012	66	4.40
2 P	7.0	Med.	12	0.201	35.0	36.80	6.97	1.47	.0080	.0012	48	4.26
3 N	6.7	High	17	0.229	35.6	39.84	6.24	1.42	.0112	.0018	65	4.28
4 K	6.6	Med.	13	0.218	30.0	33.98	8.49	0.33	.0084	.0026	98	5.12
5 Check	6.7	High	18	0.217	32.6	32.98	6.49	0.88	.0044	.0012	65	4.72
6 Gypsum	6.7	High	20	0.206	25.4	33.04	6.50	1.60	.0112	.0010	54	4.79
7 S	6.7	Doubt	15	0.229	34.8	33.00	9.66	1.31	.0120	.0026	58	4.71
8 PN	6.7	Med.	16	0.221	34.2	32.28	6.89	0.42	.0104	.0022	66	4.49
9 Check	7.1	Doubt	18	0.203	40.6	32.50	13.93	0.18	.0060	.0008	49	4.72
10 NK	7.0	Doubt	20	0.224	40.4	33.90	13.00	1.13	.0100	.0020	71	4.87
11 NPK	7.1	Med.	17	0.224	37.5	34.86	14.70	0.95	.0068	.0014	78	4.58
12 Manure	7.1	Med.	23	0.221	33.7	38.14	14.61	3.48	.0132	.0014	58	4.91

*P=Phosphorus. N=Nitrogen. S=Sulfur. K=Potassium.

†M.E.=Milliequivalents per 100 grams.

‡Clarence Burnham, Graduate Fellow in Soils, assisted in these determinations.

TABLE V. EFFECT OF SULFUR ON SOIL SOLUTION DISPLACED FROM CATHERINE LOAM*

Samples from Union plots. Displaced May 25, 1925, after standing at optimum moisture 48 hours.

Treatment	Moisture	Reaction	Nutrients, parts per million				
			N	Sulfate (SO_4)	Phosphate (PO_4)	Calcium	Potassium
	%	*pH*	*P.p.m.*	*P.p.m.*	*P.p.m.*	*P.p.m.*	*P.p.m.*
Sulfur, 100 pounds per acre	30	5.47	22	555	3.0	328	318
Untreated	30	6.57	18	114	2.0	142	256

*Powers, W. L. *Sulfur in Relation to the Soil Solution*, Univ. of Calif. Pub. in Agricultural Sciences, 5:131, 1927.

ROTATION EXPERIMENTS

Nineteen crop rotations were included in an experiment initiated at the Union Station in 1924 by Robert Withycombe, G. R. Hyslop, and D. E. Stephens. While quack-grass has interfered somewhat with cropping to

TABLE VI. BEST OF 19 ROTATIONS, 1924-1932—UNION STATION

Rotation	Per acre (1932 prices)		
	Average yield	Value	Yearly income
17 *Winter Wheat–Peas–Potatoes*			
Winter wheat after potatoes	44.4 bushels	$15.54	
Peas after winter wheat	28.8 bushels	34.56	
Potatoes after peas	151.4 bushels	68.13	$39.41
3 *Corn continuous (silage)*			
Corn after corn continuous	5.4 tons	16.20	16.20
6 *Winter Wheat–Peas*			
Winter wheat after peas (8 years)	29.5 bushels	10.33	
Peas after winter wheat (6 years)	19.2 bushels	23.04	16.69
5 *Spring Wheat–Peas and Barley (check)*			
Spring wheat after peas and barley	23.8 bushels	8.33	
Peas and barley after spring wheat	6.3 tons	15.75	12.04
16 *Winter Wheat–Peas–Fallow*			
Winter wheat after fallow	36.8 bushels	12.88	
Peas after winter wheat	24.7 bushels	29.64	14.17
15 *Spring Wheat–Corn–Barley*			
Barley after corn	52.2 bushels	18.79	
Corn after spring wheat	5.4 tons	16.20	
Spring wheat after barley	21.4 bushels	7.49	14.16
1 *Spring Wheat Continuous*			
Spring wheat after spring wheat (6 years)	23.5 bushels	8.23	8.23
2 *Spring Wheat and Annual Sweet Clover* (5 years)	26.1 bushels	9.14	9.14
4 *Winter Wheat after Fallow (check)*			
Winter wheat after fallow	37.1 bushels	12.99	6.50

Prices:
Wheat @ 35¢ per bushel.
Barley @ 36¢ per bushel.
Peas @ $1.20 per bushel.
Peas and barley silage @ $2.50 per ton.
Corn silage @ $3.00 per ton.
Potatoes @ 45¢ per bushel.

date, the value of legumes for maintaining productiveness is clearly indicated by preliminary results. Table III. A three-year rotation; namely, wheat–peas–potatoes, has yielded the highest annual income. A two-year rotation, wheat–potatoes, has given promising returns. Annual sweet clover with spring wheat gives indications of yielding larger yearly returns than spring wheat alone yearly. According to results so far obtained, a rotation of wheat–peas–fallow appears to give larger annual returns than the common wheat–fallow system.

MANAGEMENT OF GRANDE RONDE VALLEY SOILS

CLASSIFICATION KEY FOR GRANDE RONDE VALLEY SOILS (TABLE VII)

According to the soil survey report* the Grande Ronde Valley as mapped comprises 289 square miles or 184,960 acres situated in a basin-like area ranging from 2,700 to 3,000 feet above sea-level. The climate is semi-arid. The average annual precipitation is 19.37 inches, partly in the form of snow. The annual snowfall is 45.3 inches at LaGrande. The average date of last killing frost is April 24 and that of the first, October 2. Heavy frosts have occurred as late as May 28 and as early as August 30.

The Valley is traversed by the Grande Ronde River, which is an extremely crooked stream with sluggish current. The alluvial stream valley in the south and east of the basin is flat and poorly drained. The sand-ridge in the north central part has a gently undulating and wind-modified surface with drainage well developed. Foot-hill and alluvial fans smooth enough for cultivation are included in the surveyed area. The Valley was originally treeless except in the foot-slopes, where there is tamarack, pine and fir. The soils were developed mainly under grass cover and belong therefore to the great soil groups of the world known as the black earths and chestnut-brown earths with perhaps some that would correlate with the groups designated meadow soils. These dark, semi-arid grass-land soils are deep, well supplied with organic matter and lime of granular structure, durable, and well suited to the production of grain and hardy forage plants.

The distinguishing characteristics of different soil series of the Valley are shown in Table VII. The soils of the valley area fall into four groups, eleven series, including twenty-eight types and nine subordinate phases. The four groups are foot-hill soils, wind-blown soils of the sand-ridge, soils of the old terraces and fans, and the fine alluvial and lake-laid material of the valley floor.

The soil groups are divided into series which include soils similar in respect to (1) common origin, (2) range of culture, (3) subsoil conditions, structure and color, (4) topography, (5) drainage, and (6) agricultural values.

The hill soils include members of Tolo and Waha series. The Tolo series includes light-colored timbered soils. The Waha soils are dark and developed under grass cover.

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*Soil Survey Report of the Grande Ronde Valley Area, A. E. Kocher, U. S. Department of Agriculture, in charge, and W. L. Powers and A. O. Albin, Oregon Agricultural Experiment Station; No. 16, Series of 1926.

Terraces and fans include Hyrum, LaGrande, and Springdale series. LaGrande series is extensive in the southern part of the Valley. Hyrum series includes old terraces. Springdale soils occupy timbered fans on the west side of the Valley.

The sand-ridge group includes soils of Palouse and Alicel series. The distinguishing characteristic is that the soils of Palouse series have calcareous subsoils.

On the valley floor Gooch, Klamath, Conley, and Catherine series occur. These soils are nearly level and are imperfectly drained. The first has calcareous, the second silicious compact subsoil. Conley series is non-calcareous. Catherine series includes fairly recent alluvium.

The soil type is the unit of classification. A series may include soils of various textural types such as Alicel sandy loam and Alicel silt loam. The type indicates the series and also the texture. Its full description includes all that may be seen in a fresh vertical cut through the layers of a soil profile from the surface into the underlying soil material like a piece of

TABLE VII. KEY TO GRANDE RONDE VALLEY SOILS

Group number and series name	Soil	Subsoil	Parent material
1. *Foot-hill residuals from consolidated rock*			
Waha	Dark dull-brown soil	On brown mottled columnar	Non-calcareous subsoil on basalt
Tolo	Light grayish-brown soil	On yellowish-brown mottled subsoil	From loess and basalt
2. *Weathered wind-laid materials*			
Alicel	Very dark dull-brown soil	On dark yellowish-brown non-calcareous	From loess
Palouse	Very dark dull-brown soil	On brown columnar calcareous	From loess
3. *Old terrace of coarse alluvium*			
Hyrum	Black adobe	On light yellowish-gray cemented gravelly calcareous	From old alluvium
LaGrande	Very dull dark-brown soil	On grayish-brown compact slightly calcareous	Alluvium
Springdale	Medium brown soil	On lighter brown gravelly	On basaltic material
4. *Valley floor fine alluvial and lake-laid material*			
Gooch	Dark grayish-brown poorly drained	Alkaline soil on light gray-brown compact, calcareous subsoil	On light-brown sandy alluvial material
Klamath	Dull dark-gray poorly drained soil	On gray diatomaceous pan on heavy alluvium	....
Conley	Dark-gray brown poorly drained soil	On lighter blue-gray non-calcareous alluvium	....
Catherine	Very dark friable imperfectly drained soil	On brown or mottled subsoil	On more recent alluvium

layer cake. The profile distribution of organic matter, clay, slightly soluble salts, color, reaction, and structure, which are type characteristics, is acquired according to the climatic and related conditions under which the soil has developed or aged.

REACTION AND RECLAMATION REQUIREMENTS (TABLE VIII)

Drainage needs. Soils of Klamath and Gooch series have compact subsoils and poor drainage. As indicated in Table VIII there are 48,576 acres of wet soils in the area. The soils of Klamath series tend to be saline—that is, to show an accumulation of "white alkali" or neutral salts like brine—while much of the soil in the Gooch series is not only saline but moderately alkaline, containing objectionable amounts of sodium carbonate or lye, called black alkali. With extension of irrigation, further attention to drainage would be required, after which land not excessively alkalied could be laundered out.

The drainage study by Doctor Adams* reveals three problems; namely, (1) protection from overflow lands, (2) underdrainage of considerable areas of valley bottom-lands, and (3) relief from high water-table required for improvement of certain cultivated bench lands.

TABLE VIII. ALKALINITY AND RECLAMATION REQUIREMENTS OF GRANDE RONDE SOILS

	Reaction pH	Acres
Soils best suited to irrigation:		
Alicel sandy loam		5,824
Alicel loam		6,424
Palouse sandy loam		1,000
Palouse fine sandy loam		2,560
Palouse loam		6,912
Palouse silt loam		6,912
LaGrande loam		1,792
LaGrande gravelly loam		1,408
Total acres		32,830
Soils suited to supplemental irrigation:		
LaGrande silt loam		2,176
LaGrande silty clay loam		6,528
Catherine silt loam	6.4	8,064
Catherine clay	6.3	8,960
Total acres		25,730
Soils needing drainage:		
Klamath silt loam	8.5	10,752
Klamath silty clay loam	6.1	6,208
Conley silty clay loam	6.2	4,992
Gooch fine sandy loam (saline)	10.2 Alkali	3,072
Gooch loam (saline)	10.7	2,688
Gooch silt loam	10.4	14,400
Gooch silty clay loam	10.5	6,464
Total acres		48,576

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*Adams, T. C.; A Drainage Reconnaissance of the Grande Ronde Valley, 1926, Unpublished data collected through cooperative investigations of the Soils Department, Oregon Agricultural Experiment Station, and the Division of Irrigation, Bureau of Agricultural Engineering, U. S. Department of Agriculture.

The wet foot slope near Cove has a sloping yet concave surface or tends to flatten toward the valley floor, where seepage appears during the high-water period in early season and results in damage to orchards. Deep intercepting underdrains six feet or more in depth are needed. Outlets can be obtained for individual holdings in most cases.

Flooding may be checked by (1) cut-off channels to straighten, shorten, or increase fall and capacity, (2) levying, (3) storage of flood water in reservoirs situated in the mountains, and (4) deepening the rocky outlet of the Valley. Further surveys are needed to determine which of these would be most economical. The rocky outlet channel is about two miles long with a little fall, however; and its improvement would be a costly undertaking. Reservoiring is contingent upon irrigation development and has its limits as a flood-control provision. Levies should be located and constructed so as to avoid seepage under them and would require community or district effort.

Studies of elevation, alkali subsoil, and water-table conditions indicate that a large part of the flat area in the southern portion of the Valley would be greatly benefited by drainage. Parts of the area northeast of Lone Tree, showing a reaction value above 9.5 pH (relative to pure water which is 7.0 pH or neutral) are so alkaline that reclamation would be uneconomic at present. Lands reported most amenable to drainage are (1) those northwest of Union, (2) overflowed land northeast of Hot Lake, and (3) swamped lands southwest of Lone Tree. Outlet systems are needed for the southern part of the Valley leading to the river channel at some point approximately west of Cove. For good drainage and alkali control, a minimum effective depth of six feet is needed.

Supplemental irrigation. Soil types listed in Table VIII which seem well suited to irrigation total 32,830 acres. Soils suited to supplemental irrigation total 25,730 additional acres. Soils most desirable for irrigation occupy the more elevated parts of the Valley and are those of medium texture belonging to Alicel, Palouse, and LaGrande series. Soils suited to supplemental irrigation include heavy silt loam, clay loam, or clay of LaGrande or Catherine series. Most of the natural stream flow for the growing season that could be readily diverted by ditches has been appropriated for use on lands. Use of water obtained by small pumping plants is increasing.

In a cooperative irrigation experiment in 1926-27 in the northern part of the sand-ridge, alfalfa where irrigated yielded 1½ tons at the second cutting when adjacent dry-farmed alfalfa yielded nothing. With irrigation, a good growth of pastures was obtained after the second cutting. Irrigation doubled the yield of potatoes on land included in these trials. The corrugation method was used successfully for distribution of water. With a larger head of water, strip border would probably save labor in irrigating level areas. Alfalfa received two heavy and potatoes three light irrigations. Where water was applied early to wheat, the heads were longer, straw taller, and kernels larger and heavier. Irrigated potatoes were larger and more uniform.

Water storage would make extension of irrigation possible. The most promising lands for irrigation are now devoted largely to wheat and fallow under dry farming. Irrigation would eliminate the fallow and necessitate increasing the number and reducing the size of farm units. Drainage should precede irrigation on soils containing some alkali or having imperfect drainage. Supplemental irrigation would greatly facilitate soil improvement where a crop rotation including use of soil-building legumes is practiced and the forage is fed out on the land and crop residues are plowed under.

SOIL MANAGEMENT PROBLEMS

Soil moisture control. In control of soil moisture in dry farming the aim should be (1) to build up and maintain a large storage capacity by deep cultivation and organic-matter additions; then (2) to check losses by run-off, deep percolation, surface evaporation, and plant evaporation called transpiration. Aim to get the highest possible efficiency out of every acre-inch of water stored.

Run-off is decreased where the surface is left rough or has some vegetative cover. Deep percolation is lessened by deep cultivation and additions of organic matter. Surface evaporation is checked by windbreaks, or organic mulches and may be slightly lessened by a good crumbly soil mulch. In foul land, weeds steal enormous quantities of water. A rich, well-balanced soil solution of high fertility renders sufficient the least amount of water per pound of crop.

Maintenance of soil organic matter. A good supply of soil organic matter is of fundamental importance. It increases water capacity, improves tilth, lessens erosion, makes soil warmer, loosens clay land or unites loose sandy soil, and makes soil mulch more readily. Organic matter adds a great store of energy and yields carbon dioxide and nitrogen. It serves as a culture medium for beneficial soil bacteria. Organic matter has great absorptiveness for moisture and enormous absorptiveness for nutrient bases, such as lime and potash, which it retains in nearly available form. It is rich in nitrogen and by yielding bases and nitrates increases the nutrient-supplying power of the soil. In general farming and orcharding, organic matter is frequently the key to increased productiveness.

Organic matter is lost from soil by cultivation, leaching, erosion, and fire. In maintaining organic matter, consideration should be given to soil moisture, reaction, and kind and amount of material added. Bulky nitrogenous organic matter is desirable and is best added in a moist, chopped condition. Organic matter in soil tends to increase with crop rotation, manuring, cover-cropping or green manuring, pasturing, or artificial manure.

Increase from crop rotation with legumes is almost "clear velvet." A county agent demonstration was recently conducted on the Weatherspoon farm where a sweet-clover trial was made to improve run-down grain land. Large yields of wheat have recently been reported on this sweet-clover sod land.

Artificial manure. Artificial manure can be made by fermenting straw or other organic wastes. The conditions needed are presence of moisture, lime to provide nearly neutral reaction, and nitrogen sufficient to bring the content up to two per cent. Recent experiments show that for grain straw fifty pounds of ammonium sulfate and a like amount of ground limestone are economic amounts of these materials per ton. A coating of soil or manure will help control moisture and insure decay at the surface of the compost.

Straw lanes scattered with a straw spreader attachment, treated with ammonium sulfate and disked in after harvest, should partly decompose and improve the soil without depressing the growth of the following crop. Liberal use of straw as absorbent in the stable is good practice and increases the nitrogen content of straw so that decomposition microorganisms will not need to compete with the growing crop for soil nitrates when it is applied to the land. It is desirable to add about half the nitrogen needed in orchards in organic form such as bulky legume straw or cover-crops.

Control of soil blowing and erosion. One important means of keeping up fertility of soil is to reduce losses by erosion. Losses occur due to two transporting agencies: (1) wind and (2) water. Wind damage comes at velocities above 25 to 30 miles per hour. Erosion losses vary with topography, vegetation, soil porosity, and nature and time of occurrence of the storm. The most valuable surface soil and light organic fraction suffer greatest loss.

Control measures include maintenance of soil organic matter and moisture and lessening exposure. Maintaining cover on sandy land subject to blowing is accomplished by spreading straw, cover-cropping, or plowing with the mold board removed so that the stubble is left partly at the surface. In the Big Bend section of central Washington, the duck-foot cultivator has been successfully substituted for the plow. Deferred, regulated grazing on range land is needed. Use of windbreaks, such as a few rows of sunflowers or trees along the fence row may help. Planting may be done crosswise to prevailing wind. On fallow, a crumbly mulch is to be preferred to a dust mulch.

Water erosion has been especially noticeable in recent years. When snow or rain goes off with the subsoil frozen, the surface soil becomes soft and unstable. Torrential rains in hot weather have higher solubility and erosive effect. Water erosion occurs in two forms: (1) sheet erosion and (2) gullying.

Sheet erosion causes great loss of fertility. Providing cover and additions of organic matter, deep contour plowing, terracing some tiling, or seeding down steep breaks to sweet clover or alfalfa may check losses.

Gullying may be checked by keeping most of the water spread out and away from the gully. Frequent dams made of pieces of old woven fencing staked down with old short posts and sealed into the earth with straw or brush will catch silt. A quick-growing crop such as oats and sweet clover or sorghum may then be planted and allowed to fall down. On larger draws, a siphon and large tile may be needed to draw off clear water and carry it safely under the dam.

FERTILITY IN GRANDE RONDE VALLEY SOILS (TABLE IX)

The chemical analyses of official soil survey samples of the surface soil made by the Department of Agricultural Chemistry of the Oregon Agricultural Experiment Station are presented in Table IX. The results are expressed in pounds in two million, which is the weight of an acre to approximately plow depth or 6⅔ inches of normal soil. Two thousand pounds in two million is equivalent to .1 per cent.

A reaction value of pH 7.0 represents neutrality or the reaction of pure water. A lower value indicates acidity. A higher figure indicates alkaline

TABLE IX. FERTILITY IN GRANDE RONDE VALLEY SOILS

Analysis by Department of Agricultural Chemistry, Oregon Agricultural Experiment Station. All samples represent 0–7″ depth.

Type	Reaction pH	Fertility in 2,000,000 (6⅔ in.) soil				
		Potassium (K)	Calcium (Ca)	Phos. (P)	Sulfur (S)	Nitrogen (N)
		Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*
(1) *Foot-hill residuals from consolidated rock,*						
Waha clay loam	6.37	22,440	26,000	1,560	220	3,800
Tolo loam	6.30	26,560	26,000	2,580	140	4,260
(2) *Weather wind-laid materials*						
Alicel sandy loam	......	21,240	39,800	1,520	100	1,800
Alicel sandy loam, coarse	......	20,140	42,400	2,080	120	2,660
Alicel fine sandy loam	......	24,440	36,000	1,880	120	2,420
Alicel loam	......	23,780	28,600	1,840	140	3,680
Alicel silt loam	7.21	25,620	34,600	2,240	620	4,140
Palouse sandy loam	......	25,300	42,600	1,620	140	1,880
Palouse fine sandy loam	6.75	23,440	42,400	1,440	120	2,140
Palouse loam	......	24,000	36,200	2,120	200	3,400
(3) *Old terraces of coarse alluvium*						
Hyrum gravelly clay loam	7.30	20,520	34,400	2,240	240	4,400
Hyrum stony clay	6.70	16,560	25,800	1,360	220	4,680
LaGrande gravelly loam	......	19,200	42,400	2,520	220	4,720
LaGrande gravelly clay loam	......	20,980	39,400	2,800	220	4,600
LaGrande silt loam	7.65	23,860	40,200	1,840	180	3,900
LaGrande silty clay loam	......	23,040	38,600	2,220	200	4,040
Springdale gravelly loam	6.30	22,760	26,000	2,460	140	3,380
Springdale loam	6.55	28,900	21,200	3,300	100	1,920
(4) *Valley floor fine alluvial and lake-laid*						
Gooch fine sandy loam	9.30	23,760	49,200	2,040	360	1,600
Gooch fine sandy loam	9.30	30,180	35,000	1,660	300	2,200
Gooch loam	9.00	33,000	39,600	1,700	860	2,160
Gooch silt loam	8.75	27,600	50,400	2,440	640	4,680
Gooch silty clay loam	9.60	23,020	60,000	2,120	660	2,560
Klamath silty clay loam	7.20	13,300	45,000	760	140	3,300
Klamath silt loam	8.75	27,520	41,400	2,200	260	5,000
Conley silt loam	6.20	14,100	23,400	2,240	440	10,560
Conley silt loam	6.20	18,940	21,000	1,320	180	4,640
Conley silty clay loam	6.20	24,760	28,800	2,340	320	6,700
Catherine silt loam	6.40	19,140	27,800	1,740	260	5,720
Catherine clay loam	6.30	13,420	32,400	2,240	340	2,560

reaction. Growth range for staple field crops is from about pH 4.8 to 8.5 with optimum reaction at about pH 6.0. Alfalfa turns yellow in spots or becomes chlorotic at a concentration of alkalinity represented by a reaction value of about pH 8.6. It will be seen from Table IX that the soils of the Valley have a nearly neutral or desirable reaction excepting those belonging to Klamath and Gooch series. The former is saline and slightly alkaline; the latter is both saline and moderately alkaline. Soils with a reaction above 8.5 may require chemical treatment in addition to deep drainage and surface irrigation for improvement. Soils with a reaction value of above 9 to 9.5 are difficult to reclaim. The most effective treatment developed on the alkali reclamation experiment field near Vale is the use of several hundred pounds of sulfur an acre in combination with liberal applications of barnyard manure or legume green manure.

This chemical invoice shows that the soils are liberally supplied with potassium and calcium and that they are comparatively well supplied with nitrogen for soils of a semi-arid region. The phosphorus supply is only medium and variable. In some cases its availability is rather low. The most striking chemical characteristic of these soils is their very limited amount of sulfur. These analyses help explain the good results obtained from use of sulfate of lime and superphosphate in the fertilizer experiments herein reported.

FERTILITY IN CROPS AND FERTILIZERS

Losses in fertility due to fertility removed by crops are shown in Table X.

The legumes, corn, and root crops are heavy feeders of both phosphorus and potassium. Potassium is used in especially large amounts by root crops. Sulfur is drawn upon heavily by the legumes and plants of the cabbage family. Nitrogen is of primary importance with root crops. Gypsum, superphosphate, ammonium sulfate, and manure are best used to supplement the limited supply of sulfur in these soils. Soils of slightly acid reaction may best be supplied with sulfur in the neutral form or calcium sulfate called gypsum. Phosphorus is one of the necessary plant-food elements. Grain crops use relatively large amounts of phosphorus compared to the total supply in the soil. Two-thirds of the phosphorus taken by the crop goes to the seed and is therefore lost from the farm when grain is sold. The only way this loss can be made up in general farming is by the purchase of phosphate fertilizer. On the other hand, potassium is found largely in the straw and stocks which can be returned to the soil. Nitrogen, while often a limiting element, can be supplied from the air by means of a legume crop which can be turned under as in the three-year rotation (Table X).

Fertility in farm refuse and fertilizers is shown in Table XI. Carriers of phosphate available for agricultural use in Grande Ronde Valley include superphosphate, treble phosphate, and ground raw rock phosphate. The first two contain phosphorus in available form. The first also carries some sulfur. Raw rock-phosphate is slowly available and is best used in large amounts in combination with organic matter. Potassium can be purchased as either sulfate or muriate. The sulfate has some value on Grande Ronde soils. Nitrate can be obtained as sodium nitrate, ammonium sulfate, or ammonium nitrate. The second of these leaves an acid residue and is to be preferred on soils that tend to be alkaline. There are now available some concentrated synthetic fertilizers that supply two or three nutrient elements. These are usually sold under trade names.

TABLE X. FERTILITY REMOVED IN CROPS

Crop	Nitrogen	Phosphorus	Potassium	Sulfur
	Pounds	*Pounds*	*Pounds*	*Pounds*
Alfalfa, 4 tons	200	18	96	28
Clover, 4 tons	160	20	120	13
Field pea hay, 4 tons	......	......	......	7
Wheat, 50 bushels	71	12	13	5
Wheat straw, 2½ tons	25	1	45	6
Oats, 50 bushels	33	6	8	6
Oat straw, 2½ tons	31	5	52	9
Barley, 50 bushels	42	8	10	3
Barley straw, 1¼ tons	16	3	24	3
Potatoes, 200 bushels	42	8	60	3
Corn, 15 tons fodder	90	30	120	5
Rutabagas, 20 tons	76	48	160	......
Sugar beets, 10 tons	50	18	157	2
Cabbages, 10 tons	60	8	66	39
Fat cattle, 100 lbs.	25	7	1	......
Milk, 10,000 lbs.	57	7	12	......
Butter, 400 lbs.	0.8	0.2	0.1	......
3-year rotation:				
Wheat, 50 bushels 2½ tons straw	96	16	58	......
Clover, 4 tons +	......	20	120	13
Potatoes, 200 bushels	42	8	60	3
	±	44	238	27

TABLE XI. FERTILITY IN FARM MANURE AND FERTILIZERS

Material	Fertility per ton			
	Nitrogen	Phosphorus	Potassium	Sulfur
	Pounds	*Pounds*	*Pounds*	*Pounds*
Fresh farm manure	10	3	8	5
Barnyard manure	10	3	8	5
Sodium nitrate	310	......	......	......
Ammonium sulfate	400	......	......	500
Ammonium nitrate	700	......	......	......
Raw rock phosphate	......	250	......	......
Superphosphate	......	150	......	144
Treble phosphate	......	450	......	......
Potassium sulfate	......	......	850	324
Potassium chloride	......	......	850	......
Potassium nitrate	260	......	730	......
Wood ashes	......	10	100	......
"Complete" fertilizer (6-10-3)	120	88	48	......
Gypsum	......	......	......	360
Crude sulfur (99%)	......	......	......	1980

PERMANENT SYSTEMS OF SOIL FERTILITY

Now that the soil map and chemical invoice of Grande Ronde Valley soils are available, the farmer can learn what type or types of soil occur on his farm and what their general physical and chemical characteristics are. He can plan more intelligently for their management to insure economic and sustained production. By a system of permanent agriculture is meant a program to maintain soil fertility. A system to be permanent must have an economic basis and should mean a lower production cost per unit. As far as possible the farm owner should improve his soil by use of farm manure and crop residues before investing heavily in commercial fertilizers.

A minimum of fertility is removed from the farm where crops are pastured or fed out on the land.

The oldest soil experiment fields develop for the humid climate permanent methods of soil fertility based on liming acid soils, crop rotation with legumes, and use of crop residues or feeding of roughage to livestock and returning phosphated manure to the soil. The work of the Oregon Agricultural Experiment Station during the past two decades has shown that the program for the eastern states requires some alteration to fit Oregon conditions. It seems just as rational to use sulfur on alkali soils in the semi-arid region as it does to use lime on acid soils to maintain a nearly neutral soil reaction. Rotation and manuring have been found to be fundamental in maintaining productiveness of our irrigated land. These practices keep up the soil-water capacity and lessen the water requirement. In a twenty-year trial at Corvallis, rotation and manuring once in three years with supplemental irrigation have built up the yield from an initial yield of 12 bushels of beans to 32⅔ bushels showing a large net return. In the same field, continuous cropping reduced the yield from 12 to 4½ bushels, which yield shows no profit. Treatments employed trebled the net return per acre-inch and cut the water cost in two. Chemical analyses show a building up to the plow depth in an acre of some 788 pounds of nitrogen and 7⅓ tons of organic matter. This building up correlates with the increase in yield and net profit obtained.

The value of sulfur as a fertilizer for legumes, discovered by the Oregon Experiment Station in 1912, has proved to be of particular value on our calcareous basaltic soils of the Northwest where irrigated with nearly pure water. On the dry farms the richer the soil solution, the higher the efficiency of available moisture. The soil solution is often poorest in nitrates in dry-farm soils. Field peas have been produced annually at the Moro Branch Station with good results. In recent controlled experiments five crops of field peas have shown an accumulation of 367 pounds of total nitrogen and a correspondingly large accumulation of soil organic matter an acre.

Crop rotation with legumes to which a sulfur carrier has been applied will give an economic source of nitrogen obtained from the air by the bacteria working in the nodules on their roots. Nitrogen-fixing bacteria which work independently of legumes are present in most semi-arid soils. Their activity is proportional to the energy available. Grain straw disked in after harvest forms a source of energy for these free-living nitrogen-fixing organisms. Legume cover-crops or bulky nitrogenous organic matter should supply at least half of the nitrogen needed in orcharding.

Recent tests of most of the soil types in Grande Ronde Valley show that numerous of the lighter-textured soils and worn grain lands are low in phosphate-supplying power. Fertilizer experiments at Union indicate that the use of phosphate fertilizers will come to be of increasing importance in connection with grain growing. Superphosphate may be used to reinforce barnyard manure and make it a more balanced fertilizer. If used in the stable, it will serve as an absorbent and check losses of ammonia nitrogen.

The basis for a permanent system of agriculture for Grande Ronde soils may be established then by crop rotation with legumes, to which sulfur carrier is applied; use of phosphated barnyard manure and pasture crops in a rotation; and the use of nitrogenous cover-crops supplemented by a fertilizer as found profitable in the orchards. Under present conditions it is believed wise to use our best lands first and to return marginal lands to pasture and let the fertility accumulate.

Thus, the Oregon Agricultural Experiment Stations are doing their share in developing permanent systems of soil fertility for our different agricultural sections. We are concerned with the avoidance of soil degeneration and with the ultimate effect of fertilizers in this regard. It is believed that the adoption of soil-building programs as above outlined will prove increasingly profitable over a period of years. It is cheaper to keep up fertility than to restore exhausted land. Soil-building makes yields more certain and larger. Intelligent fertilization also improves crop quality. The progressive farmer should farm not alone for the crop, but for the soil, and should leave the soil as rich or richer than he finds it. He should aim to add plant nutrients to the soil in the cheapest forms of refuse and market them from the land in the forms of products that will give the highest net return per unit of nutrient sold.