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Bulletin No. 122 - The Nature of the Dry Farm Soils of Utah

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Utah Agricultural College

EXPERIMENT STATION

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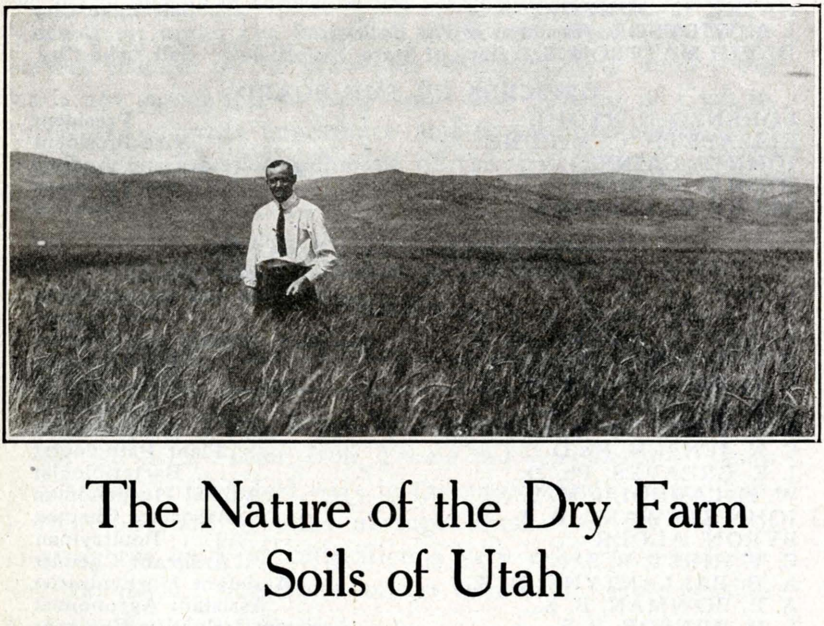

The Nature of the Dry Farm Soils of Utah

BY

JOHN A. WIDTSOE and ROBERT STEWART

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The Nature of the Dry Farm Soils of Utah

By John A. Widtsoe and Robert Stewart.

Successful farming in Utah is dependent upon two main factors: First, the economic use of irrigation water upon the lands lying under the irrigation ditch, and second, upon the correct practice of the principles of dry farming upon those lands not susceptible to irrigation. Dry farming in Utah is, therefore, of great importance and it becomes essential to learn something of the nature of the dry farming soils of the State.

LOCATION AND SURVEY OF THE STATE DRY FARMS.

In 1903 the State of Utah established six experimental farms in widely distributed parts of the dry farming section of the State. These farms were located in the counties of Juab, San Juan, Sevier, Iron, Tooele and Washington. These farms when established were in the virgin condition and supported luxuriant growths of sage brush. At the time of clearing the land for cultivation a very exhaustive soil survey was made. Numerous borings were made where possible to a depth of ten feet.

The Juab county farm was located in Juab Valley, about five miles south of Nephi, on the north slope of the Levan ridge. Four samples of soil representative of the first, third, fourth and ninth feet were submitted to chemical and physical analysis, while nine other samples were submitted to physical analysis, and in addition the nitrogen, humus and carbon dioxide were determined in all of the samples studied. Each sample studied is in turn the composite of a great number of representative borings on the same tract of ground.

The San Juan county farm is located six miles south of Monticello. Four samples representing the first, sixth and seventh feet were submitted to chemical and physical analysis, while eight other samples were submitted to physical analysis.

The Sevier County farm is located in Grass Valley about fifteen miles east of Richfield. Two samples of soil representing first and fourth feet were submitted to chemical and physical analysis, while thirteen others were submitted to physical analysis.

The Iron County farm is located near Parowan in Iron County. Four samples representing the first, fourth and ninth feet were submitted to chemical analysis, while thirteen others were submitted to physical analysis.

The Tooele County farm is located in the Tooele Valley near Grantsville. Two samples representing the first and fourth feet were submitted to chemical and physical analysis, while eight other samples were submitted to physical analysis.

The Washington County farm is located in Washington County near Enterprise. Three representative samples were submitted to chemical analysis, while nine others were submitted to physical analysis. Each of the samples analyzed in every case is the composite sample of several separate borings on a forty acre tract and is therefore very representative of the type of soil studied.

2. Geological Derivation of the Soils.

Five of the six farms are located in the Great Basin, while the sixth, the San Juan farm is located in the High Plateau country with its drainage into the Colorado River. Three-fifths of the State, comprising the western part, lies in the Great Basin, while two-fifths is divided into the Uinta-White Basin and the High Plateau country.

The section represented by the Juab County farm was not under water at the time of Lake Bonneville. The waters of the Lake Bonneville covered only the lower part of the valley, but the dry farming section is just beyond the lower extension of Utah bay of old Lake Bonneville. The soil of the Juab valley, however, has been derived from the weathering from the adjacent mountain ranges. These ranges contain deposits of limestone and extensive deposits of gypsum. It is possible that the phosphate deposit extends to these mountains while deposits of potassium have recently been reported. These facts must be taken into consideration in a discussion of the results obtained.

The dry farming section represented by the San Juan County farm lies in the High Plateau country in the southeast part of the State to the east of the Colorado River. The section is seamed by many deep washes due to occasional torrential rains. The High Plateau country is differentiated from the Great Basin by many geological characteristics. The rock material is composed of shale and sandstone. The San Juan County farm is composed of the weathering of sandstone containing occasional layers of gypsum.

The section represented by the Sevier County farm is located in Grass Valley far above old Lake Bonneville, but is still in the Great Basin area. The soil of the valley has been derived from the erosion of the adjacent mountain ranges.

The soil of the Iron County farm has been derived by the erosion of the adjacent mountain ranges. The valley in which the farm is located was not covered by the waters of Lake Bonneville but is separated from Escalante Bay by a low range of mountains.

The region represented by the Tooele County farm is in the Lake Bonneville district being located in the Tooele Valley, an arm of the Lake. During the Lake period this bay received the storm waves of the open lake. Wave excavation of the alluvial slopes of western base of the Oquirrh mountains contributed to the soil formation.

The region represented by the Washington County farm lies in the Great Basin, being located on the north slope of the rim of the basin leading down into Escalante Bay of Lake Bonneville. The waters of the lake, however, did not cover the region represented by the farm.

The soils representing these farms being located in widely distributed sections of the State and being derived in such diverse ways offer an interesting group for study. Five of the farms are located in the Great Basin, four of these being above the waters of Lake Bonneville, while the soil of the fifth was formed during the time of Lake Bonneville. The sixth is located in the High Plateau country and probably represents soil formed in place by the weathering of sandstone.

3. The Physical Composition of the Soils.

The method of analysis as developed at this Station was used in making the physical analysis of the soil. The results obtained from the analysis of the Juab County soils are reported in Table 6 in the back of the bulletin. (1). These results indicate that the soil of this farm is a clay loam with a tendency with depth to approach a loam condition.

The results obtained by the analysis of the San Juan County soils are recorded in Table 6. These results indicate that the soil is a sandy soil and that it is quite uniform with depth. The amount of water soluble salts is very low.

The results obtained from a physical analysis of the Sevier farm are recorded in Table 7. These results indicate that the soil is of a very coarse sandy nature with considerable gravel present.

The results for the physical analysis of the soil of the Iron County farm are recorded in Table 7. The results indicate that the soil of the farm is a sandy loam, with a slight tendency to become heavier with depth.

The results obtained from a physical analysis of the soils of the Tooele County farm are recorded in Table 8. These results indicate that the soil of this farm is a sandy

1. Utah Experiment Station Bulletin No. 89

loam and that it is uniform with depth. The surface soil of the farm presents a fairly uniform surface with, however, an occasional gravel or clay spot. The water soluble salts are somewhat higher in the soil of this farm than in that of the other farms.

The results for the physical analysis of the soil of this farm are recorded in Table 8. These results clearly indicate that the soil of this farm is of a distinct sandy nature and becomes more so with depth. The water soluble salts are very low.

In a discussion of the plant food content of soils it should be clearly kept in mind that there are ten elements of plant food, namely: carbon, hydrogen, oxygen, calcium, magnesium, iron, sulphur, phosphorus, potassium and nitrogen. The plant obtains its carbon from the carbon dioxide of the atmosphere, while the oxygen is obtained either from the soil moisture or from the carbon dioxide of the air. The hydrogen is obtained from the soil moisture. Calcium, magnesium, iron and sulphur are used by all plants in such small quantities and occur in all soils in such large quantities that their supply in most soils is apt never to become exhausted. The remaining three elements of soil fertility, phosphorus, potassium, and nitrogen are used by plants in such large quantities and concentrate in the seed or more salable products of the farm that their supply may become exhausted in the soil. These are the elements of plant food which have a commercial value. The question of soil fertility from the plant food point of view has to do largely with these elements.

The complete data regarding the chemical composition of the soils is recorded in the tables in the appendix. From this data the following tables have been compiled.

4. The Phosphorus Content.

Phosphorus is one of the essential elements of plant food which is usually added in large amounts to soils. The phosphorus content of the soils of the several farms is recorded in the following table.

TABLE I.

Acid Soluble Phosphorus in First Foot of Arid Farm Soil.

County	Juab.	San Juan.	Sevier.	Iron.	Tooele.	Washington.
Per ct. Phosphoric Acid, P_2O_5	0.419	0.24	0.26	0.23	0.31	0.24
Per ct. Phosphorus.	0.182	0.104	0.114	0.100	0.135	0.104
Pounds of Phosphorus per 2,000,000 pounds of soil...	3,640	2,080	2,280	2,000	2,700	2,080

The phosphorus content is high in the Juab and Tooele County farms and considerably lower in the soil from San Juan, Iron and Washington counties. The high content in the Juab soil is probably due to the existence of a phosphate ledge in the mountains to the east. The total phosphorus was also determined in the Juab County soils. The amount in the first foot is 0.191 per cent or 3820 pounds per acre or a difference of 180 pounds of phosphorus i. e. 95% of the phosphorus is acid soluble.

Consultation of the tables in the back part of the bulletin will show that the phosphorus content in the soil of the Nephi farm decreases slightly with depth, while in the San Juan County soil it decreases markedly with depth, there being only a third as much in the seventh foot as in the first.

The phosphorus content in the soil of the Iron County farm is very uniform with depth, while in the Tooele county soil there is a marked decrease with depth. The phosphorus in the soil of the Washington County farm is practically constant with depth. It is thus seen that the dry farming soils of this State are fairly well supplied with phosphorus. The phosphorus content of the average crust of the earth is 2200 pounds per million pounds of soil, while the average phosphorus content of humid soil and arid soils is 1044 and 1392 pounds per two million pounds of soil respectively as given by Hilgard.

Thus while our dry farm soils are well supplied with phosphorus it may become necessary in the future to add phosphorus in some form to our soils.

5. The Potassium Content.

Potassium is a second element of fertility which is applied to soils and thus has a commercial value. In many soils such as peaty swamp lands it is the limiting element of crop production. The potassium content in the dry farm soils is indicated in the following table.

TABLE II.

Acid Soluble Potassium Content in the First Foot of the Dry Farming Soils.

County	Juab.	San Juan.	Sevier.	Iron.	Tooele.	Washington.
Per ct. Potash, K_2O	1.31	0.83	0.83	0.55	0.95	0.87
Per ct. Potassium	1.09	0.689	0.689	0.456	0.788	0.722
Pounds of Potassium per two million pounds of soil	21,800	13,780	13,780	9,120	15,760	14,440

The total amount of potassium in the Juab County soils was also determined. The analysis gave 2.32 per cent potassium in the first foot or 46400 pounds of potassium in the plowed surface of the soil. The acid soluble potassium is, therefore, only 49 per cent of the total amount of potassium present in the soil. In the production of wheat only 7.5 pounds of potassium is necessary for the production of 25 bushels of grain, while 22.5 pounds are needed for the production of the straw. If, therefore, all the straw be returned to the soil there is enough potassium present in the surface foot of the Juab County farm to last for the production of a 25 bushel crop of wheat every other year for 6186 years. In other words, the potassium is sufficient for indefinite periods of time provided the farmer so cultivates his land as to render the plant food available. It is practically certain that the potassium question on the dry farms of the State is one of liberation of this plant food from the inexhaustible supply in soil and not one of addition. There are two practical ways by which plant food may be liberated from the locked up compounds in the soil. First, by practicing the system of summer fallow and thus allowing the soil to enter the winter in a porous open condition. The alternate freezing and thawing tends to liberate the plant food from its insoluble condition. Second, the addition of organic matter to the soil and its resultant decay with the production of organic acids converts the potassium into an available form.

In the Juab County soil the potassium decreases with depth, there being only 56 per cent as much total potassium in the ninth foot as compared with that in the first. This may possibly be explained by the reported discovery of potassium in the hills to the east of the valley.

The potassium content in the soils of the San Juan, Tooele, and Washington County farms is also decreased with depth, while that of the Iron County soil is practically constant with depth.

6. The Nitrogen Content.

Nitrogen is the most expensive of all the plant foods having a commercial value. Four-fifths of the air is nitrogen, but it occurs in a free or elemental form which is unavailable for the use of the higher plants. The results obtained for the nitrogen content of the dry farm soils is recorded in the following table:

TABLE III.

County	Juab.	San Juan.	Sevier.	Iron.	Tooele.	Washington.
Per cent Nitrogen..	0.116	0.065	0.089	0.057	0.07	0.091
Pounds per two million pounds of soil.	2,320	1,300	1,780	1,140	1,540	1,820

The nitrogen content of these soils in the virgin condition is thus seen to be very low as is characteristic of the soils of arid America. The soil of the Juab farm is highest, there being 2320 pounds of nitrogen in the first two million pounds of soil, while Iron County soil contains the least or only 1140 pounds of nitrogen per two million of soil. The nitrogen content uniformly decreases with depth. It takes 48 pounds of nitrogen to produce a 25 bushel crop of wheat, 12.5 pounds for the straw and 35.5 pounds for the grain. Assuming that all of the straw is returned to the soil, there is only nitrogen enough in the plowed surface of the soil to last for the production of a 25 bushel wheat crop for only 180 years. This comparative method of study clearly indicates that on the dry farms of this State that nitrogen is the limiting element of plant food. Of course the wheat plant in its search for moisture feeds on the dry farm to greater depths than the plowed surface. These results clearly bring to mind, however, the necessity of utilizing all the waste material of the farm. Methods must be devised for the utilization of the straw stacks which are all too commonly burned on the dry farm.

The question of the importance of the nitrogen question on the dry farms has previously been discussed* for one section of the State and it is hoped that additional data will be presented for the other three great dry farming sections in the near future.

7. The Organic Matter of the Dry Farm Soils.

The humus content as determined by the methods of the Association of Official Agricultural Chemists was obtained on all the samples. This is a rough measure of the organic matter of the soil although it should be clearly kept in mind that the results are probably higher than the correct results because "humus" obtained by the official method always contains clay or finely divided soil, which loses water by hydration on heating. In these soils also the "clay" undoubtedly contains some calcium carbonate which would

* Stewart, Bulletin No. 109, Utah Experiment Station.

also lose carbon dioxide when heated. The humus results are indicated in the following table.

TABLE IV.

Humus Content in the Dry Farming Soils.

County	Juab.	San Juan.	Sevier.	Iron.	Tooele.	Washington.
Humus, per cent	1.54	1.49	1.45	1.09	1.16	1.63

These results indicate that the organic matter as represented by the humum content is low, indicating anew the marked deficiency of organic matter in our arid soils. In these high carbonate soils the results obtained on the ignition of the soil the so-called "volatile matter" is no indication whatever of the organic matter of the soil.

8. The Limestone Content.

From the amount of calcium oxide, magnesia and carbon dioxide it is possible to get a fairly accurate idea of the limestone content of the soil under consideration. The results obtained for these substances in the arid soils together with pounds of limestone per 2,000,000 pounds of soil as calculated from the carbon dioxide content are reported in the following table.

TABLE V.

Calcium Oxide, Magnesia, Carbon Dioxide, and Limestone, in Dry Farm Soils.

County	Juab.	San Juan.	Sevier.	Iron.	Tooele.	Washington.
Calcium Oxide	4.27	0.56	1.34	18.97	2.15	3.01
Magnesia	1.82	0.75	0.42	2.24	0.47	1.06
Carbon Dioxide	2.16	0.20	0.62	18.55	1.01	1.96
Limestone per two million pounds of soil	49,100	4,540	14,074	420,000	229,550	44,500

These results indicate quite clearly that with all of the dry farms in the Great Basin the soils are abundantly supplied with limestone. The San Juan farm, located in Colorado drainage district presents an entirely different aspect. The first foot soil contains scarcely any limestone, yet the subsoil in the sixth foot is abundantly supplied with it in spots as represented by Lab. No. 29088, while in other parts of the subsoil there is no more than in the surface. In the soil of all the other farms the limestone content is higher throughout, the Sevier County farm being the only one in which there is any possibility in the distant future of being deficient in limestone. In the plowed surface soil of the Juab County farm for example, there is approximately 25 tons of limestone present, while in the Iron County farm there is 210 tons of limestone. The dry farming soils of Utah are distinctly not acid in nature.

9. Conclusions.

A study of the results reported in this bulletin clearly indicate that the soil fertility problem on the dry farms is clearly one of the addition of organic matter containing nitrogen to the soil for the purpose of liberation of the plant food. With the exception of the San Juan County section there is no possibility of the soil becoming acid in nature. The soils are all abundantly supplied with sufficient potassium for wheat production, which will undoubtedly be the chief crop produced on the dry farms. The soils are well supplied with phosphorus and it is not probable that the addition of this element would be profitable in the immediate future. Further, investigation should be carried on regarding the nitrogen and humus content of our dry farm soils. And in the meantime every occasion should be taken to plow under the stubble and to make better utilization of the straw stacks on the farm.

TABLE VI.

Physical Composition of Soils of the Experimental Dry Farms.
(Results Expressed as Per Cent of Dry Soil.)

JUAB COUNTY FARM.

Depth in feet..	1st	2d	3d	4th	5th	6th	7th	8th	9th	10th
Lab. Nos........	29005	29606 -07-09	29014	29015 -17	29019	29026	29030	29032	29040	29049
Coarse matter...	9.59	5.29	8.94	4.43	5.85	2.20	3.64	3.93	4.54	5.38
Fine matter....	90.41	94.71	91.06	95.57	94.15	97.80	96.36	96.07	95.46	94.62
Medium sand...	8.93	8.99	8.73	11.36	15.69	8.93	16.28	12.60	23.57	15.48
Fine sand.......	20.05	16.48	12.38	18.87	19.48	27.40	25.00	22.52	26.09	21.45
Coarse silt......	21.97	19.95	22.53	19.06	23.88	22.27	21.88	21.91	19.25	18.63
Medium silt.....	15.23	16.78	17.53	17.25	15.43	13.51	13.73	17.03	10.04	15.77
Fine silt........	13.25	14.88	14.47	8.93	8.01	7.11	8.68	9.74	6.56	11.71
Fine clay.......	15.73	16.68	18.62	20.68	12.41	10.03	12.19	13.29	20.95	13.36
Real Sp. Gr.....	2.62	2.67	2.52	2.62	2.62	2.86	2.61	2.64	2.61	2.63
Apparent Sp. Gr.	1.37	1.46	1.42	1.12	1.41	1.43	1.46	1.41	1.48	1.44
Water, Sol. mat.	0.09	0.702	0.02	0.04	0.11	0.07	0.11	0.13	0.05	0.20

SAN JUAN COUNTY FARM.

Depth in feet......	1st	2d	3d	4th	6th	7th	8th	9th
Lab. Nos.	29054 -55	29059	29063	29069	29084 -88	29089 -90-92	29095	29097
Coarse matter......	1.05	1.30	.... All	0.82	3.75	2.83	1.65	0.47
Fine matter........	98.95	98.70	Fine	99.18	96.25	97.17	98.35	99.53
Medium sand	11.07	13.54	12.45	13.80	13.31	18.34	9.57	10.19
Fine sand..........	50.21	45.21	46.10	45.38	32.39	36.43	40.48	42.29
Coarse silt.........	12.80	11.40	16.78	13.58	16.50	13.87	16.55	15.71
Medium silt........	8.18	7.84	9.22	9.72	14.37	19.03	9.46	8.55
Fine silt...........	5.47	6.27	5.26	5.51	9.14	9.19	7.39	6.41
Fine clay..........	9.77	11.10	5.64	9.92	12.02	14.94	12.33	13.84
Real Sp. Gr........	2.58	2.63	2.63	2.59	2.63	2.57	2.56	2.58
Apparent Sp. Gr....	1.41	1.39	1.39	1.40	1.35	1.43	1.35	1.36
Water, Sol. mat....	0.09	0.10	0.008	0.02	0.08	0.09	0.13	0.13

TABLE VII.

Physical Composition of the Soils of the Experimental Dry Farms.
(Results Expressed as Per Cent of Dry Soil.)

IRON COUNTY FARM.

Depth in feet	1st	2d	3d	4th	5th
Lab. Nos.	28688-89-90	28694-96	28702-05	28708-10	28752
Coarse matter	1.54	3.89	3.18	4.21	3.32
Fine matter	98.46	96.11	96.82	95.79	96.68
Medium sand	13.20	8.66	11.63	16.35	22.04
Fine sand	17.77	13.03	12.85	18.46	17.34
Coarse silt	22.75	23.65	19.98	18.07	18.36
Medium silt	19.33	21.25	21.66	18.55	16.91
Fine silt	10.60	13.86	14.69	12.08	11.36
Fine clay	10.96	15.03	13.79	11.11	10.83
Real Sp. Gr	2.64	2.70	2.63	2.66	2.67
Apparent Sp. Gr	1.39	1.37	1.38	1.43	1.45
Water, Sol. material	0.48	0.22	0.31	0.29	0.40

SEVIER COUNTY FARM.

Depth in feet	1st	2d	3d	4th	5th	6th	7th	8th	9th	10th
Lab. Nos.	28835	28836-39-40	28843-40	28851-52	28857-61	28862	28871	28878	28881	28886
Coarse matter	20.58	29.61	28.94	36.34	37.08	25.24	30.07	29.44	34.67	27.21
Fine matter	79.42	60.39	71.05	63.66	62.92	74.76	69.93	70.56	65.33	72.79
Medium sand	26.29	37.52	25.28	33.35	37.69	26.87	27.97	28.41	30.40	34.08
Fine sand	24.63	20.04	28.07	23.29	22.99	25.82	24.07	26.32	26.13	25.34
Coarse silt	17.12	10.75	13.66	9.42	14.07	8.00	15.21	16.71	14.57	13.61
Medium silt	10.07	7.56	10.43	10.42	8.57	7.26	10.47	11.30	9.89	10.25
Fine silt	7.69	6.00	5.98	11.25	5.78	2.35	7.74	4.79	4.38	6.62
Fine clay	10.14	13.49	11.11	8.81	7.57	19.95	13.79	8.79	9.65	8.62
Real Sp. Gr.	2.67	2.69	2.68	2.69	2.72	2.65	2.65	2.68	2.64	2.67
Apparent Sp. Gr.	1.40	1.41	1.37	1.37	1.44	1.38	1.39	1.43	1.39	1.38
Water, Sol. mat.	0.15	0.076	0.06	0.12	0.09	0.19	0.10	0.13	0.10	0.20

TOOELE COUNTY FARM.

Depth in feet	1st	2d	3d	4th	5th	6th	7th	8th	9th
Lab. Nos.	28981	28982-85	28989	28992	28996	28999	29001	29003	29004
Coarse matter	5.34	5.56	13.55	6.76	9.25	3.24	2.42	3.01	3.23
Fine matter	94.66	94.44	86.45	93.25	90.75	96.76	97.58	96.99	96.77
Medium sand	11.61	11.23	11.44	9.96	9.42	7.65	10.88	....	9.63
Fine sand	32.62	30.27	29.86	28.52	29.63	26.12	26.28	30.06	36.02
Coarse silt	20.50	22.25	19.41	19.57	23.20	20.53	21.78	21.84	21.25
Medium silt	13.86	14.69	14.31	18.27	11.63	14.62	12.97	14.32	13.54
Fine silt	6.70	9.12	10.00	5.83	10.19	11.84	10.99	8.93	7.19
Fine clay	9.47	11.71	19.71	15.28	13.66	15.94	13.72	12.24	9.91
Real Sp. Gr.	2.61	2.61	2.58	2.67	2.65	2.70	2.73	2.68	2.67
Apparent Sp. Gr.	1.40	1.38	1.37	1.36	1.37	1.36	1.35	1.35	1.37
Water, Sol. mat.	0.33	0.06	0.16	0.13	0.20	0.42	0.40	0.29	0.31

TABLE VII—Continued.

WASHINGTON COUNTY FARM.

Depth in feet	1st	2d	3d	4th	5th	6th	7th	8th	9th
Lab. Nos	28356 -59	28362	28370 -74	28379	28384 -85	28389	28396	28400	28404
Coarse matter	11.71	12.02	11.28	15.90	17.63	29.14	13.90	22.05	30.94
Fine matter	88.29	87.98	88.72	84.10	82.37	70.86	86.10	77.95	69.06
Medium sand	28.26	18.25	29.37	25.94	26.83	28.52	34.56	32.54	35.71
Fine sand	29.34	27.64	26.07	28.19	28.41	32.11	26.34	27.48	27.45
Coarse silt	14.67	10.71	11.26	11.95	14.44	10.96	10.91	10.58	10.78
Medium silt	8.91	11.81	11.31	10.42	7.92	9.51	8.14	10.32	7.73
Fine silt	6.36	7.60	5.89	7.14	6.91	6.23	7.05	5.50	6.46
Fine clay	8.19	12.63	10.40	12.49	9.71	7.79	10.41	10.13	8.63
Real Sp. Gr	2.67	2.61	2.63	2.67	2.62	2.62	2.63	2.62	2.64
Apparent Sp. Gr	1.46	1.43	1.42	1.41	1.42	1.41	1.42	1.37	1.41
Water, Sol. mat	0.15	0.41	0.11	0.02	0.10	0.06	0.04	0.02	0.003

TABLE IX.

Fertility in Soil of Juab County Experimental Dry Farm.

(Results Expressed as Per Cent of Dry Soil.)

Depth in Feet	1st	3d	4th	9th
Lab. Nos	29005	29014	29017	29040
Insoluble Residue	73.12	62.10	62.00	65.69
Potash, K_2O	1.31	0.91	0.67	0.70
Soda, Na_2O	0.14	0.18	0.52	0.68
Lime, CaO	4.27	11.05	12.34	11.83
Magnesia, MgO	1.82	1.80	2.66	2.93
Sulphuric Acid, SO_3	0.13	0.12	0.17	0.07
Oxide of Iron, Fe_2O_3	3.92	3.61	2.26	2.36
Alumina, Al_2O_3	6.33	6.43	5.05	3.36
Phosphoric Acid, P_2O_5	0.419	0.471	0.356	0.264
Carbon Dioxide, CO_2	2.16	9.10	10.74	10.09
Volatile Matter	5.31	4.35	2.79	2.57
Total	99.28	100.24	99.72	100.60
Humus*	1.54	1.99	1.56	1.15
Nitrogen	0.116	0.103	0.040	0.050
Total Phosphorus	0.191	0.219	0.181	0.112
Total Potassium	2.32	1.75	1.48	1.30

* By the official method. Probably too high, since it may include water of hydration in suspended clay.

TABLE X.

Fertility in Soil of San Juan County Experimental Farm.

(Results Expressed as Per Cent of Dry Soil.)

Depth in Feet	1st	6th	7th	9th
Lab. Nos.	29054	29088	29089	29090
Insoluble Residue	88.25	54.74	68.96	86.87
Potash, K_2O	0.83	0.52	0.27	0.54
Soda, Na_2O	0.36	0.13	0.41	0.70
Lime, CaO	0.56	19.04	11.46	0.79
Magnesia, MgO	0.75	0.76	0.45	0.81
Sulphuric Acid, SO_3	0.05	0.15	0.12	0.10
Oxide of Iron, Fe_2O_3	3.10	4.69	2.01	3.02
Alumina, Al_2O_3	3.06	2.98	3.69	5.24
Phosphoric Acid, P_2O_5	0.24	0.29	0.08	0.10
Carbon Dioxide, CO_2	0.20	14.58	9.03	0.14
Volatile Matter	3.02	2.64	3.60	1.62
Total	100.12	100.52	100.08	99.93
Humus	1.49	0.61	0.65	1.35
Nitrogen	0.065	0.015	0.040	0.018

TABLE XI.

Chemical Composition of Soil From Sevier County Arid Farm.

(Results as Per Cent of Dry Soil.)

Depth in Feet	1st	4th
Lab. Nos.	28835	28851
Insoluble Residue	80.78	75.76
Potash, K_2O	0.83	0.70
Soda, Na_2O	0.34	0.42
Lime, CaO	1.34	4.63
Magnesia, MgO	0.42	1.40
Sulphuric Acid, SO_3	0.06	0.13
Oxide of Iron, Fe_2O_3	5.42	5.23
Alumina, Al_2O_3	5.74	0.14
Phosphoric Acid, P_2O_5	0.26	0.14
Carbon Dioxide, CO_2	0.62	2.79
Volatile Matter	4.14	3.64
Total	....	....
Humus	1.45	0.85
Nitrogen	0.089	0.037

TABLE XII.

Fertility in Soils of Iron County Experimental Dry Farm.
(Results Expressed as Per Cent of Dry Soil.)

Depth in Feet	1st	1st	4th	9th
Lab. Nos	28688	28689	28710	28752
Insoluble Residue	52.14	51.19	52.38	46.47
Potash, K_2O	0.55	0.56	0.45	0.42
Soda, Na_2O	0.44	0.18	0.52	0.42
Lime, CaO	18.97	17.84	17.83	20.22
Magnesia, MgO	2.24	1.22	2.08	0.75
Sulphuric Acid, SO_3	0.11	0.13	0.11	0.11
Oxide of Iron, Fe_2O_3	2.80	2.46	2.50	2.55
Alumina, Al_2O_3	2.29	3.85	4.36	6.62
Phosphoric Acid, P_2O_5	0.23	0.20	0.24	0.19
Carbon Dioxide, CO_2	18.55	17.95	15.12	20.08
Volatile Matter	3.35	5.28	4.42	2.93
Total	101.82	100.87	100.01	100.76
Humus	1.09	1.55	0.50	1.31
Nitrogen	0.057	0.086	0.040	0.025

TABLE XIII.

Fertility in Soil of Tooele County Experimental Dry Farm.

Depth in Feet	1st	4th
Lab. Nos	28981	28992
Insoluble Residue	80.13	78.49
Potash, K_2O	0.95	0.80
Soda, Na_2O	0.41	0.51
Lime, CaO	2.15	3.21
Magnesia, MgO	0.47	0.66
Sulphuric Acid, SO_3	0.06	0.05
Oxide of Iron, Fe_2O_3	4.49	4.28
Alumina, Al_2O_3	5.60	6.47
Phosphoric Acid, P_2O_5	0.31	0.12
Carbon Dioxide, CO_2	1.01	2.04
Volatile Matter	4.38	4.19
Total	99.97	100.82
Humus	1.16	0.77
Nitrogen	0.007	0.040

TABLE XIV.

Fertility in Soil of Washington County Experimental Dry Farm, Enterprise, Utah.

(Results Expressed as Per Cent of Dry Soil.)

Depth in Feet	1st	4th	8th
Lab. Nos	28359	28379	28340
Insoluble Residue	81.74	78.20	71.96
Potash, K_2O	0.87	0.74	0.50
Soda, Na_2O	0.23	0.30	0.28
Lime, CaO	3.01	6.00	9.71
Magnesia, MgO	1.06	0.59	0.65
Sulphuric Acid, SO_3	0.10	0.08	0.11
Oxide of Iron, Fe_2O_3	3.14	2.79	2.92
Alumina, Al_2O_3	4.19	4.43	3.85
Phosphoric Acid, P_2O_5	0.24	0.23	0.23
Carbon Dioxide, CO_2	1.96	3.95	7.14
Volatile Matter	3.83	3.46	2.95
Total	100.37	100.77	100.21
Humus	1.63	1.69	1.55
Nitrogen	0.091	0.10	0.025

TABLE XV.

Nitrogen, Humus and Carbon Dioxide in Soils.

(Results Expressed as Per Cent of Dry Soil.)

JUAB COUNTY FARM.

Depth in feet	2d	2d	2d	4th	5th	6th	7th	8th	10th
Lab. Nos	29006	29007	29009	29015	29019	29026	29030	29032	29049
Humus	1.71	1.86	2.43	1.80	1.63	1.50	1.72	1.21	1.62
Nitrogen	0.054	0.084	0.064	0.047	0.028	0.026	0.030	0.032	0.029
Carbon Dioxide	3.79	9.18	5.82	11.33	12.41	11.12	11.62	8.64	7.88

SAN JUAN COUNTY FARM.

Depth in feet	1st	2d	3d	4th	6th	8th	9th
Lab. Nos	29055	29059	29063	29069	29084	29095	29097
Humus	1.62	1.84	1.08	1.58	1.78	1.79	1.32
Nitrogen	0.070	0.060	0.042	0.026	0.023	0.018	0.021
Carbon Dioxide	0.36	0.08	0.38	0.11	0.015	....	1.86

SEVIER COUNTY FARM.

Depth in feet..	1st	2d	3d	4th	5th	6th	7th	8th	9th	10th
Lab. Nos........	28835	28836 -39-40	28843 -44	28851 -52	28857 -61	28862	28871	28878	28881	28886
Humus	....	....	....	....	....	....	....	....	....	....
Nitrogen	0.084	0.046	0.044	0.037	0.033	0.029	0.025	0.016	0.16	0.019
Carbon Dioxide.	0.62	0.08	1.58	1.98	0.89	0.47	0.50	0.47	0.46	0.38

IRON COUNTY FARM.

Depth in feet..............	1st	2d	3d	3d	4th	4th
Lab. Nos..................	28690	28694	28696	28702	28705	28708
Humus	1.48	2.20	2.21	1.68	2.58	1.50
Nitrogen	0.092	0.058	0.062	0.041	0.052	0.040
Carbon Dioxide...........	15.77	18.80	18.23	16.23	16.99	15.76

WASHINGTON COUNTY FARM.

Depth in feet..............	3d	5th	5th	6th	7th	9th
Lab. Nos..................	28374	28384	28385	28389	28396	28404
Humus	1.65	0.81	1.74	1.51	1.60	1.41
Nitrogen	0.047	0.032	0.042	0.030	0.034	0.032
Carbon Dioxide...........	3.04	3.22	5.02	3.06	8.96	4.60