
ARIZONA
Agricultural Experiment Station.

UNIVERSITY OF ARIZONA.



BULLETIN No. 6, APRIL, 1892.

TUCSON, ARIZONA.



“SOILS AND WATERS.”

ENTERPRISE PRINT.

Agricultural Experiment Station.

BOARD OF CONTROL:

Board of Regents of the University.

STATION STAFF:

<i>Frank A. Gulley, M. S.,</i>	- - - - -	<i>Director</i>
<i>Chas. B. Collingwood, M. S.,</i>	- - - - -	<i>Chemist</i>
<i>Vasa E. Stolbrand, C. E.,</i>	<i>Meteorologist and Irrigation Engineer</i>	
<i>James W. Toumey, B. S.,</i>	-	<i>Botanist and Entomologist</i>
<i>Joseph H. Heberly,</i>	- - - - -	<i>Assistant Chemist</i>
<i>E. L. Benton,</i>	- - - - -	<i>Horticulturist</i>
<i>Mark Walker,</i>	- - - - -	<i>Assistant Horticulturist</i>
<i>R. S. Stockton,</i>	- - - - -	<i>Stenographer</i>
<i>R. J. Ferguson,</i>	- - - - -	<i>Engineer</i>
<i>M. Moss, (Phoenix Station)</i>	- - - - -	<i>Foreman</i>

AN EXAMINATION OF THE SOIL OF THE MESA NEAR YUMA, AND OF THE WATERS OF THE COLORADO.

The investigations of which this Bulletin is a record, were undertaken at the request of Mr. H. W. Blaisdell, of Yuma. Primarily it was an investigation in regard to the agricultural possibilities of the soil of the mesa south of Yuma. As the land was to be irrigated with water from the Colorado river, a daily examination of this was undertaken. Since the first of August, 1892, one pint of water has been taken each day from the river at Yuma railroad bridge, and evaporated. The sum of the daily residues for each month has been weighed and analyzed. The result is given in the accompanying tables.

THE SOIL OF THE MESA.

The soil of the mesa is of sedimentary origin, and varies principally in the proportion of fine and coarse material. Table 1 is a partial mechanical analysis representing samples of extremes of these types. No. 1, the coarse sand, is more easily permeated by water, while No. 2 will longer retain moisture. No. 3 is Colorado river sediment for October.

TABLE I.

SEDIMENTS.	DIAMETER In Mm. 0.04 inches.	YUMA MESA.		Colorado Sediment OCT'R.
		No. 1. Coarse Sand	No. 2. Fine Sand	
Gravel and coarse sand.....	.5	12.32	16.80
Medium sand.....	.5-.25	45.73	31.60
Fine sand.....	.25-.1	25.53	27.40
Very fine sand.....	.1-.05	8.51	9.70	11.34
Silt.....	.05-.01	2.61	4.00	26.58
Fine silt.....	.01-.005	2.80	4.45	30.16
Clay by difference.....		2.48	6.05	31.92

These analyses were made by the Osborne beaker-elutriation method.

By far the larger part of the mesa is like sample 2, and, under ordinary circumstances, would be preferred, but when the water to be used for irrigation with the large amount of sediment is considered, any objection to the coarse sand vanishes. (See Table IV.)

The ground water at a distance of about 90 feet, probably does not differ from ground water in the immediate vicinity, which, while somewhat salty, is too far removed to become a factor in plant growth.

At distances of from 1 to 8 feet are strata of fine material containing appreciable and in some cases large quantities of clay. The strata are more impervious to water and have caught the soluble salts leached out of the soil. I have examined them carefully with especial reference to the injurious effect of alkali on plant growth. The result is tabulated as follows:—

CLAY STREAKS IN R. R. CUT.	PER CT. Soluble Matter.	PER CT. NA CE	PER CT. NA ₂ SO ₄	PER CT. NA ₂ CO ₃
No. 1, 4 ft. under surface	0.25	0.15	0.10	Trace
No. 2, 8 ft. " "	0.75	0.60	0.15	Trace

The amount of soluble salts in these samples does not show sufficient alkali to be detrimental to plant growth. The amount of sodium carbonate, the most injurious ingredient of an alkali soil, is so small as to be entirely harmless, and when by irrigation it permeates the soil above, will be inappreciable. I have no hesitation in saying that there will be no danger from alkali in this soil. These fine sediment and clay strata are, on the other hand, very valuable, as they will act as conservers of moisture by establishing water tables.

A chemical analysis shows the soil to be by no means

deficient in plant food, but like many soils in the arid region, it is inert, and needs to be mixed with active fertilizing material and organic matter in order to be brought into good tilth. The analysis made in this laboratory is given, accompanied by the analysis of a soil from Fresno, Cal., made in the laboratory of the California Experiment Station :

TABLE II.
COMPARISON OF THE ANALYSIS OF THE FRESNO AND
YUMA HEIGHTS SOIL.

	FRUITVALE TRACT. Fresno, California.	BLAISDELL HEIGHTS, Yuma, Arizona.
Coarse material, 0.5 mm	9.90	14.56
Fine earth	91.00	85.44
ANALYSIS OF FINE EARTH.		
Insoluble matter	67.34	74.55
Soluble silica	11.57	9.75
Potash	0.82	0.64
Soda	0.29	0.32
Lime	1.14	4.57
Magnesia	1.58	0.51
Oxide of iron	7.51	1.07
Alumina	6.30	3.28
Phosphoric acid	0.07	0.07
Sulphuric acid	0.01	0.01
Carbonic acid		3.73
Water and organic matter ..	3.28	1.50

The analysis of the Fresno soil was made in the laboratory of the California Experiment Station by Dr. Hilgard; the analysis of the Yuma soil was made in the laboratory of the Arizona Experiment Station by Dr. Hilgard's method.

As the soils are in many respects similar, Dr. Hilgard's remarks are copied from the report of the California Experiment Station for 1890, page 30. After speaking of the geological

formation of the soil, he says: "It will be seen that this soil "differs quite materially from all the soils of the immediate "neighborhood of Fresno thus far examined, the only point of "agreement being similar proportions of lime, *but it is* " *materially richer in both potash and phosphoric acid* * * * "Its supply of humus is not high and hence, on cultivation, "the addition of vegetable matter by green manuring, or the "use of nitrogenous fertilizers would probably be called for."

A comparison of the analyses will show for the Fresno soil a higher percentage of iron and alumina, the latter showing more clay. This is a small matter when the character of the irrigation water is taken into consideration. The Yuma Heights soil shows a nearly equal percentage of potash, an equal percentage of phosphoric acid, and a far higher percentage of lime. This is of great importance, as it will tend to render green manuring quickly effective by the action of lime on organic matter.

To summarize; the soil is warm, easily drained, free from alkali, deficient in humus, but not deficient in plant food. If supplied with active fertilizing material, and organic matter, it is especially adapted to early fruits and vegetables. The peculiar climatic conditions, influenced as they are in this case by the topography, leave no room to doubt that citrus fruits can be successfully grown, and that vegetables can be brought to maturity earlier than in the surrounding country.

II. THE WATERS OF THE COLORADO RIVER.

The accompanying Table (Table III) gives the results of the analyses of the daily samples of the Colorado river water, during the months from August to February, inclusive :

TABLE III

ANALYSIS OF COLORADO RIVER SEDIMENT.

Samples taken daily. Analysis made each month.	AUG.	SEPT.	OCT.	NOV.	DEC.	JAN.	FEB.	AVE'GE.
Residue expressed in parts per 100,000	414	205	1027	232	201	163	289	361
Residue soluble after evap. expressed in parts per 100,000	26	34	31	23	36	33	18	28
Parts of water to one part of sediment	242	488	97	431	497	613	346	388
ANALYSIS OF RESIDUE.								
Sand, silica, combined water & organic matter	68.66	69.14	67.75	74.20	77.40	68.42	70.85	71.19
Oxide of iron	4.20	2.90	4.52	2.73	2.65	2.32	4.04	3.32
Alumina	11.28	8.42	13.32	5.74	4.92	10.40	16.00	10.01
Lime	7.30	7.50	5.95	6.88	8.25	8.30	5.86	7.15
Magnesia	2.20	2.91	3.12	2.04	2.37	2.00	2.10	2.39
Soda soluble in water	2.44	6.30	1.30	6.57	3.18	5.77	3.71	4.18
Soda soluble in acid	1.74	1.40	1.59	0.96	0.61	1.83	0.39	1.22
Potash soluble in water	0.14	0.20	0.12	0.21	0.11	0.15	0.20	0.16
Potash soluble in acid	1.69	1.30	1.43	0.83	0.66	0.62	0.82	1.05
Phosphoric acid	0.16	0.15	0.16	0.13	0.27	0.12	0.18	0.17
Nitrogen	0.086	0.070	0.094	0.082	0.075	0.093	0.086	0.083

The water soluble alkalis (soda and potash) are in the form of sulphate or chloride with only a slight trace of carbonate. The presence of calcium sulphate (gypsum) insures the absence of appreciable quantities of carbonate of soda.

TABLE IV.

POUNDS OF FERTILIZING MATERIAL DEPOSITED BY THE EVAPORATION OF ONE ACRE INCH (27152 gall.) OF COLORADO RIVER WATER WITH THE VALUE OF THE FERTILIZING MATERIAL:

(An acre inch is the amount of water necessary to cover one acre one inch in depth. The amount of fertilizing material deposited in the soil could be found by multiplying the figures in this table by the number of inches used to produce a crop).

	AUG.	SEPT.	OCT.	NOV.	DEC.	JAN.	FEB.	AVERAGE
Total residue.....	938	464	2,321	525	455	369	654	818
Clay.....	264	98	773	75	56	96	262	204
Lime.....	68	35	138	36	38	31	38	58
Phosphoric acid	1.50	0.55	3.70	0.68	1.23	0.43	1.18	1.32
Available potash	1.31	0.93	2.79	1.10	0.50	0.55	1.21	1.20
Nitrogen	0.81	0.33	2.18	0.43	0.34	0.34	0.56	0.71
Commercial value of last three substances	\$0.284	\$0.128	\$0.715	\$0.160	\$0.153	\$0.107	\$0.217	\$0.252

ESTIMATED VALUE OF FERTILIZING MATERIAL.

(Large quantities of commercial fertilizers are being used in all the States east of the Mississippi river. The selling price is determined by the amount of Nitrogen, Phosphoric Acid and Potash which they contain. These substances have a fixed and definite value. At present Nitrogen is worth 17½c. per pound, Phosphoric acid 6c. per pound, Potash 4c. per pound. These figures are used in calculating these tables).

Analysis and Fertilizing Value, per ton of	PER CT NIT'GEN	PER CT POT'SH	PER CT. PHOS. ACID.	VALUE PER TON
Barnyard manure.....	0.47	0.58	0.36	\$2 49
Col. river sediment, average for 7 months.....	0.083	1.21	0.17	0 60

Total Residue Fertilizing due Tons	74.0	43.66
	12.3	7.25
Weight and Fertilizing Value of Colorado Silt in	5,000,000 gallons (average of 7 months)	
	" "	
	30 acre inches	

Comparison of Amount of Sediment in Rivers Expressed in Terms of Ratio of Dry Matter to Weight of Water:

Colorado Run (Average of 7 months).....	1/277
Mississippi	1/1500
Nile	1/1900
Danube	1/3060

Table IV. shows the amount of fine silt added to the soil, and gives the commercial value of the fertilizing materials. The plant food added by the water is nearly all in an available condition, and contains no substances which will be detrimental to vegetation. Large as this amount is, it but inadequately expresses the value of such material, because of its mechanical effect upon the soil. The clay and silt added will in a few years completely change its texture, and from a light, sandy soil, it will become a fine loam of good strength and capable of a high state of cultivation.

There would undoubtedly be added, the first year, with the water, sufficient plant food to make sure of a crop of alfalfa. While it is still an open question as to how much nitrogen this crop derives from the air, it certainly has the power of rendering available more inert plant food than most crops, especially in the presence of a large quantity of potash. In that sandy soil the roots will penetrate many feet, bringing together the inorganic food and supplying the soil with a large amount of humus, the carbon of which is certainly drawn from the air.

An example of the value of alfalfa is shown on the University grounds. On virgin soil of no great richness, and but seven inches in depth, with water free from appreciable quantities of fertilizing material, alfalfa made a good growth. After seven months, during which four crops were cut, there still remained in the stubble and roots, seven thousand pounds per acre of dry matter containing $2\frac{1}{2}$ per cent. of nitrogen. Below, the soil was a hard lime cement, and the roots had in places actually penetrated this, and were getting the plant food con-

tained in it. This year the soil is in good condition, and now, March 23rd, the alfalfa is 20 inches high. In the soil of the Yuma mesa, the roots will penetrate as many feet as they did inches in this soil.

The mesa soil especially needs plant food and organic matter. The former will be supplied in the river water, the latter in a crop of alfalfa plowed under. It has long been known that the fertility of land irrigated with river water which contained large quantities of sediment, was practically inexhaustible. The rich, overflowed lands of the Nile have retained their fertility from time immemorial. By the aid of a complete chemical analysis of the Colorado River water, extending over a period of seven months, we can speak with certainty of its value as a fertilizer, and know that to supply a given amount of fertility, it is only necessary to supply a definite, easily calculated amount of water. As the water must in this climate be applied in order to grow a crop, the material for practically inexhaustible fertility is given free of all additional expense!

Since the first of March, 1892, daily samples have been taken of the Colorado at Yuma, the Gila at the head of the Mohawk Canal, and the Salt River at the head of the Arizona Canal. The samples will be sent to this laboratory and analyzed, and at the end of the year the results will be published. These examinations of the waters of our great irrigation sources will be followed and supplemented by investigations of the soils to which the water is to be applied.

- I. Geological formation as bearing upon the permanency of plant food, and structure of sub-soil.
- II. Water relations as affected by fineness of particles.
- III. Amount of soluble salts and best method of treating soils too heavily charged.

All communications should be addressed to Agricultural Experiment Station, Tucson, Arizona.

C. B. COLLINGWOOD