University of Arizona

Agricultural Experiment Station.

Nineteenth Annual Report.

For the Year Ending June 30, 1908.

(With subsequent items)

Consisting of Reports Relating to

Administration,
Agriculture, Horticulture,
Animal Husbandry, Botany,
Plant Physiology and Pathology,
Chemistry, Irrigation Investigations,
and The Weather for 1908.

Tucson, Arizona, December 31, 1908.

UNIVERSITY OF ARIZONA
AGRICULTURAL EXPERIMENT STATION.

GOVERNING BOARD.

(Regents of the University)

Ex-Officio.

HON. JOSEPH H. KIBBEY, - - - Governor of the Territory.
HON. R. L. LONG, - - Superintendent of Public Instruction.

Appointed by the Governor of the Territory.

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STATION STAFF.

ROBERT H. FORBES, M. S., - - - Director and Chemist.
JOHN J. THORNBER, A. M., - - - - - - Botanist.
ALBERT E. VINSON, Ph. D., - - - - - Biochemist.
FREDERICK W. WILSON, B. S., - - Animal Husbandman.
G. E. P. SMITH, C. E., - - - - Irrigation Engineer.
WILLIAM B. MCCALLUM, Ph. D., - - - Associate Botanist
J. ELIOT COIT, Ph. D., - - - - Associate Horticulturist.
WILLIAM H. ROSS, Ph. D., - - - - Assistant Chemist.
R. W. CLOTHIER, M. S., - - - - Agriculturist.
T. D. A. COCKERELL, - - Consulting Entomologist.
WILBUR O. HAVES, - - - - - - Secretary.

The Experiment Station office and the botanical and chemical laboratories are located in the University main building at Tucson. The range reserves (cooperative, U. S. D. A.) are suitably situated adjacent to and southeast of Tucson. The work in agriculture, horticulture, and animal husbandry is conducted mainly on the Experiment Station farm, three miles northwest of Phœnix, Arizona. The date-palm orchards are three miles south of Tempe, (cooperative, U. S. D. A.), and one mile southwest of Yuma, Arizona, respectively.

Visitors are cordially invited, and correspondence receives careful attention.

The Bulletins, Timely Hints, and Reports of this Station will be sent free to all who apply. Kindly notify us of errors or changes in address, and send in the names of your neighbors, especially recent arrivals, who may find our publications useful.

Address, THE EXPERIMENT STATION,
Tucson, Arizona.

LETTER OF TRANSMITTAL.

To His Excellency, Joseph H. Kibbey, Governor of Arizona:

SIR: In accordance with the Congressional act of March 2, 1887, I submit, herewith, the Nineteenth Annual Report of the Arizona Agricultural Experiment Station, for the fiscal year ending June 30, 1908.

Very respectfully,

R. H. FORBES,

Director.

CONTENTS.

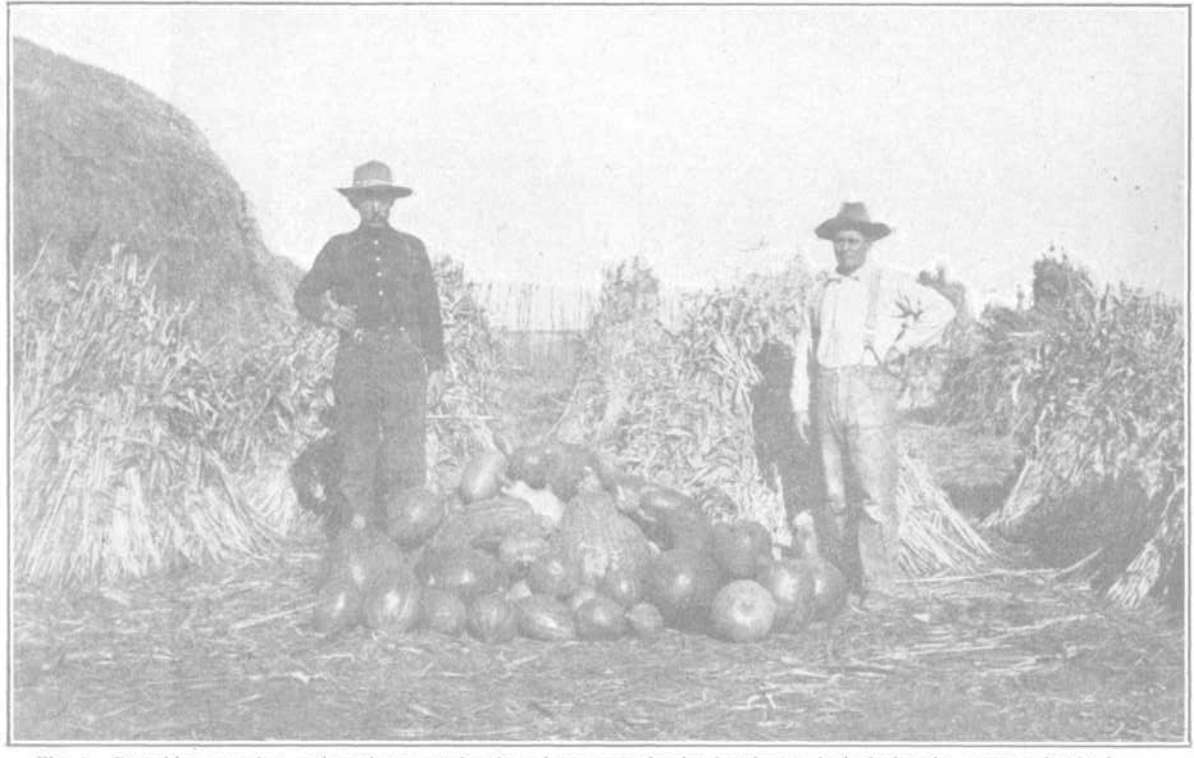

Fig. 1. Pumpkins, squashes, and sorghum stated to have been grown by dry-farming methods during the summer of 1908, in Sulphur Springs Valley.

Nineteenth Annual Report.

ADMINISTRATIVE.

AN AGRICULTURAL FORE-VIEW.

Agriculture, in Arizona, is at this time entering upon a period of rapid expansion and transformation. This development, now imminent and assured, is due primarily to the Reclamation Service, which in Salt River Valley and near Yuma has solved, both physically and administratively, water problems which have heretofore defeated the water users of these localities. These first undertakings will in time be followed by others until the water resources of Arizona are at last fully utilized.

Inasmuch as agriculture in this region mainly depends upon irrigation, an estimate of the water supply now available and forthcoming by development will help us to forecast the agricultural future of the region. Such an estimate is now possible from the measurements of stream flow made by the U. S. Geological Survey and other agencies during the last twenty years, but more particularly during the last decade. The principal source of irrigating water is the initial stream flow of our larger rivers which, named in the order of their importance to Arizona, are (or will be) the Colorado, the Salt and Verde, the Gila, and the Little Colorado. In connection with stream flow, storage reservoir sites with an aggregate capacity of about 3,654,000 acre-feet have already been surveyed on the Salt and Gila rivers, and construction is approaching completion at the largest of these sites, at Roosevelt, having a capacity of 1,284,000 acre-feet.

Next in potential value to the initial stream flow is, probably, the seepage waters which are returned to drainage channels by percolation from irrigated districts. This seepage or return water has been observed to amount to as high as 64 per cent of the amount originally applied in irrigation; and the total

amount of such return, which along a given valley may occur several times in succession with the same water supply, will ultimately stand high in proportion to original river discharge.

The underflow of the detritus-filled valleys of the arid region constitutes a third important supply which as yet has been but little studied and can only be roughly estimated.

Another little utilized water resource is the storm waters which at irregular intervals, especially during the summer season, escape uselessly from the upper watersheds where they might often in considerable part be profitably retained and utilized. With the help of auxiliary pumped or stored water, and possibly of dry-farming methods of handling the soil, these storm waters will undoubtedly some day be found of great value.

Last and least of our apparent irrigating supplies is artesian water, which has thus far been found in limited amounts in three or, possibly, four artesian districts within the Territory.

The following summary is believed by the writer to conservatively approximate the irrigating waters of the Territory reasonably within reach of economic development:

	Acre-feet per year.
Colorado River, a portion of the flow sufficient to irrigate bottom lands in Arizona, and mesa lands by pumping	2,000,000
Little Colorado, with storage	250,000
Salt River, average annual runoff of 1,200,000 acre-feet, with storage making available	840,000
Gila River, without storage and not including flood waters escaping downstream and into the underflow	150,000
Seepage and return waters from above sources conservatively estimated from 10 to 25 per cent of initial application	500,000
Underflow in the arid valleys of the New, Agua Fria, Hassayampa, Lower Gila, Bill Williams, Santa Cruz, Sonoita, San Pedro, Whitewater, San Simon, and other streams, estimated on basis of Rillito data	500,000
Artesian water now developed	10,000
Approximate annual total water supply developed and reasonably possible of development, acre-feet	4,250,000

With a water potential of 4,250,000 acre-feet a year and with a depth of from 3.5 to 5.5 feet on the land required

annually, it is evident that on the basis of this estimate of forthcoming water, Arizona may expect to irrigate 800,000 to 1,000,000 acres of land within, say, the lifetime of many now concerned in such development. This is about five times the present area under irrigation in Arizona. But under effective methods of water administration and with a better knowledge of the peculiar agriculture of this region, not only will the irrigated area be larger but it will be better cultivated. Taking into consideration the losses formerly incident to unreliable water supply, careless methods associated with low capitalization, and ignorance as to the best use of water and the most remunerative crops, it is not impossible that the small, intensively cultivated farms of the future, working with a perfected water supply, will produce twice the value per acre obtained at the present time. But five times our present acreage of doubly productive land means an agricultural output of ten times that which we at present enjoy. According to figures derived from the Crop Reporter and other sources, the value of farm products in Arizona in 1907 was not far from $9,000,000; which means, on the basis of the above approximations, a possible future income of something like $90,000,000 in agricultural products annually. This, by way of suggestion, is a sum materially in excess of the $67,000,000 valuation placed upon the total metals produced in Arizona in 1907. These estimates, moreover, are for production by irrigation only and take no account of the output of our grazing ranges or of the possibilities of dry farming in certain localities thought to be favorable to this method of agriculture.

While the forecasts ventured above may seem sanguine to readers not cognizant of the premises or who disagree with the conclusions based upon them, those who doubt are referred to such States as California and Colorado, which have within comparatively few years been transformed from almost purely mining communities to commonwealths whose principal industrial concern is agriculture.

AN EXPERIMENT STATION RETROSPECT.

During the ten years just completed, for which time the Experiment Station has been free from administrative disturbances

which characterized the first ten years of its history, a considerable body of agricultural knowledge relating to the arid Southwest has been prepared and made available to our now rapidly increasing farming public. Much of this work has been original in character, and much of it has consisted in working over and adapting to our needs the science passed on to us from those humid regions of America and Europe where it had its origin.

Although limited financial resources and a shifting personnel have to some extent heretofore compelled an opportunist policy in choice of subjects for Station work, yet by compensating changes the result is at this time a fairly well-proportioned body of agricultural knowledge, the leading features of which deserve passing mention:

1. Soils have been studied with reference to their composition and fertilizer requirements; and on the basis of the knowledge thus gained the general principles of farm practice with reference to soil fertility in a subtropical arid region have been elucidated.

2. Irrigating waters have likewise been extensively studied with reference to their character and their effects upon crops.

3. The occurrence, character, and management of soluble or "alkaline" salts has necessarily been interrelated with the study of soils and irrigating waters; and several publications relating to this important arid-region subject have been issued.

4. Purely climatic conditions, also, affecting crops—heat and cold, humidity, rainfall, wind movement, and insolation have been extensively recorded and related in many practical ways to farm practice in the region.

5. The species and varieties of crop plants available to the arid Southwest have been extensively studied from both botanical and agricultural points of view with the result that the Station is well equipped with these very important lines of information, so much needed by an increasing number of newcomers to this region. Among many of the Station's contributions to our knowledge of agricultural botany may be mentioned the publications on Eucalypts, sugar beets, date palms, a con-

siderable number of vegetable gardening crops, and the great staple crops such as alfalfa and the cereals.

6. Along with the study of production has, necessarily, gone the study of insect pests and plant diseases; for instance, codling moth, plant lice, the crown gall, and the root-rots.

7. Irrigation, from cultural and engineering points of view, has been a major subject at all times during the last ten years. Duty and measurement of water, methods of application, beneficial use, cost and methods of pumping, are some of the subjects included among the most useful of our publications.

8. Animal husbandry, a final and intensive development of agriculture, is also represented by a considerable and growing list of titles. Pertaining indirectly to animal production is the study of range conditions, from both botanical and administrative points of view. The ideas relating to management and utilization of our vast but misused range country, advanced by representatives of the Station for years past, have figured prominently in discussions of this important subject.

Along the several general lines of effort mentioned above, the Station during the ten years ending with 1908 has issued 99 publications, exclusive of annual reports which contain much technical information of similar character. These publications, consisting of bulletins and "Timely Hints for Farmers," may be classified as follows:

Soils, waters, alkali, and farm management	21
Climate	1
Crops	35
Weeds, insect pests, and plant diseases	15
Irrigation	10
Animal industry and the range	17

When it is remembered that for years past our mailing list has enabled us to reach from forty to fifty per cent of the farming population of the Territory, it is not surprising that the effects of Station work are now generally in evidence, more particularly in our irrigated southern valleys.

AN EXPERIMENT STATION PROSPECT.

With the accession of the Adams Fund, with the supplementary support of the Territory, and with the receipt of very useful private bequests for specific purposes which bid fair to be con-

tinued, the Station may look forward to a freer and wider usefulness than formerly.

Following naturally upon the pioneering stage of its history, and on the improved financial foundation, the staff is now in position to carry out, and further plan, work which is in less proportion reconnaissant in character, and in larger measure purely investigational, than has heretofore been possible. The larger part of the attention of the Station Staff is already thus employed, as is attested by the several reports concurrent herewith, relating to fundamental questions of plant nutrition and ecology, plant chemistry, plant diseases, and water supply.

Accessory to the work centralized in the laboratories at Tucson are the cultural operations carried on in various representative agricultural localities,—the Station Farm near Phœnix, the date orchard near Tempe, the demonstration garden at Yuma, the range reserves near Tucson, and the dry-farming area in Sulphur Springs Valley recently arranged for through the support of the E. P. & S. W. Railroad.

PERSONNEL.

The only change in the Station Staff during this fiscal year was in the position of assistant chemist, Mr. E. E. Free having accepted an offer from the Bureau of Soils at Washington, being succeeded in September, 1907, with little interruption to current work, by Dr. W. H. Ross of the University of Chicago. For a major portion of his time, Mr. F. C. Kelton, instructor in civil engineering in the University, has assisted in the underflow investigations during the year, contributing materially to the progress of that work.

A new and diverting feature of the year's work has been a series of informal, semi-social sessions held in the Station library, at which lectures on scientific subjects have been delivered by certain of the gentlemen connected with the Desert Botanical Laboratory, and by members of the Station Staff.

EDUCATIONAL.

With Professor R. W. Clothier in charge, the Farmers' Institutes and Short Courses were continued, mainly in Graham County, but also at Yuma, Buckeye, Arlington, Liberty, Mesa,

Glendale, and Douglas. In all fifty-six institutes were held in twenty-two places, with a total attendance of about 3,300 people; and twelve weeks' instruction to short-course classes was given with an enrollment of 111 students.

This year's program has exhausted the item of $2,700.00 for institute work provided in the appropriation of 1903. The fund has accomplished a great deal of good, especially in Graham County among the younger people who have attended the Short Courses conducted for a few weeks each year, by members of the Station Staff. As believed when the fund was created, these Farmers' Institutes, together with the available results of Experiment Station work in the region, have prepared the way for agricultural instruction in the University. Classes have, in fact, been conducted by Professor Clothier during the current year on ground rented for the purpose, with satisfactory evidence of a healthy demand for the immediate further development of these classes. There now seems, to be no adequate reason why our long neglected agricultural courses of instruction should not at last be put into operation.

PUBLICATIONS.

The following publications have been issued under the caption of the Station during the year:

Bulletin 55, July 1, 1907. Cement Pipe for Small Irrigating Systems and Other Purposes.—By G. E. P. Smith.

Bulletin 56, Sept. 23, 1907. The Scale Insects of the Date Palm.—By T. D. A. Cockerell, and,

The Extermination of Date-Palm Scales.—By R. H. Forbes.

Eighteenth Annual Report, Dec. 31, 1907.—By the Station Staff.

Bulletin 57, June 20, 1908. Timely Hints for Farmers, collected, edited and illustrated.—By the Station Staff.

Timely Hints for Farmers:

No. 66, Aug. 25, 1907. Observations on Nurse Crops for Alfalfa —By V. A. Clark.

No. 67, Dec. 28, 1907 Pumping Plants for Irrigators —By G. E P. Smith.

No. 68, Jan. 15, 1908. Resistent Eucalypts for Planting in Southern Arizona. —By J. J. Thornber.

No. 69, Feb. 1, 1908. A Lesson in Diversified Farming. —By R. H Forbes.

No. 70, March 1, 1908. Cotton Growing in Arizona.—By R. W. Clothier.

No. 71, March 15, 1908. Preserving Eggs. —By A. E. Vinson.
No. 72, April 1, 1908. Progress and Prospects of Date-Palm Culture. —By R. H. Forbes.
No. 73, April 20, 1908. Vitality of Seeds under Water. —By J. J. Thornber.

In addition to the above list, the following titles, exclusive of newspaper articles, relating to the work of the Station, have been published by members of the Staff in scientific and technical journals from time to time:

Concrete Tile in Irrigation.—By G. E. P. Smith in Cement World, I : 12, March, 1908.

The Endo and Ektoinvertase of the Date.—By A. E. Vinson in Journ. Am. Chem. Soc., XXX : 6, 1005-1020, June, 1908,

A Concrete Caisson Well.—By G. E. P. Smith in Cement Age, VII : 4, Oct., 1908.

FINANCIAL.

For the year ending June 30, 1908, expenditures by the Station amounted to a total of $32,782.51, from sources shown in the following statement:

From the Treasurer of the U. S., Hatch Fund	$15,000.00	
From the Treasurer of the U. S., Adams Fund	9,000.00	
From the University Territorial Fund	911.30	
Farm sales, Station Farm	526.07	
Produce, Tempe Date Orchard	26.00	
Produce, Yuma Date Orchard	993.52	
Miscellaneous sales, refunds, fees, etc.	271.99	
Experiment Station Bond Fund	1,745.84	
Publications, Laws of 1907	1,485.10	
Date Orchards Fund, Laws of 1907	2,433.59	
Southern Pacific appropriation No. 2 for irrigation investigations	1,489.53	$33,882.94
Less overdraft from 1906–7	$203.99	
and balance carried to 1908–9	896.44	1,100.43
Net total		$32,782.51

Especial useful has been the Southern Pacific appropriation, which made possible an uninterupted prosecution of underflow investigations in the Rillito and Santa Cruz valleys. Following is the usual detailed statement by departments of work, by schedules and by funds:

R. H. FORBES,
Director.

		Administration.	Agriculture and Horticulture.	Animal Husbandry.	General Farm Expenses.	Botany.	Chemistry.	Entomology and Meteorology.	Date Orchards. Tempe.	Date Orchards. Yuma.	Miscellaneous.	Totals.	
Hatch Fund. $15,000.00.	Salaries	1701.00	1573.62	1528.39	35.50	1734.76	195.84	.....	382.80	.....	*Irr.*	7151.91	
	Labor	35.30	490.66	866.04	.....	765.65	254.61	6.00	581.00	.....	8.00	3007.26	
	Publications	56.42	3.85	10.55	.....	5.70	3.00	12.77	8.98	.....	10.20	111.47	
	Postage and stationery	519.33	11.95	17.84	96.50	.20	2.91	3.75	43.38	1.36	.....	697.22	
	Freight and express	119.92	59.95	85.09	8.22	10.62	70.87	5.56	6.17	.35	3.35	370.10	
	Heat, light and water	.....	.....	.....	.....	11.00	41.49	.....	4.10	.....	.....	56.59	
	Chemical supplies	.....	.....	4.80	7.30	1.00	93.54	.....	.75	.....	.....	107.39	
	Seeds, plants and sundries	3.25	164.20	104.35	69.00	93.00	26.41	.....	53.71	2.10	.70	516.72	
	Fertilizers	.....	.....	.....	220.72	.....	.....	.....	15.20	.....	.....	235.92	
	Feeding stuffs	5.25	.....	.....	130.75	.....	.....	.....	6.79	.....	.....	142.79	
	Library	1.64	6.54	8.35	16.74	.....	18.44	.....	.....	.....	3.65	55.36	
	Tools, implem'ts and mch'y	20.65	22.10	21.60	195.14	33.00	10.45	1.75	14.30	.92	19.80	339.71	
	Furniture and fixtures	176.89	.....	6.50	11.70	8.30	7.50	.....	.....	.....	.75	211.64	
	Scientific apparatus	.....	.....	6.20	.....	1.25	83.60	16.95	.....	.....	.....	108.00	
	Live stock	.....	.....	161.25	.....	.....	.....	.....	.....	.....	.....	161.25	
	Traveling expenses	322.53	579.36	39.70	.....	125.60	10.00	.....	77.35	.....	.....	1154.54	
	Contingent	15.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	15.00	
	Buildings and repairs	.....	11.78	81.59	392.59	6.75	.....	.....	64.42	.....	.....	557.13	15000 00
Sales Fund.	Labor	25.60	214.92	310.55	1.00	.....	23.35	.....	58.25	.....	.....	633.67	
	Seeds, plants and sundries	.....	.....	4.84	38.49	.70	.....	.....	2.00	.....	1.90	47.93	
	Contingent expenses	.....	.....	35.55	.....	.....	.....	.....	.....	.....	.....	35.55	717 15
Bond Fund.	Salaries	.....	.....	.....	.....	.....	.....	.....	.....	.....	*Inst.Wk* 1329.26	.....	
	Publications (printing)	.....	.....	.....	.....	.....	.....	.....	.....	.....	26.75	.....	
	Postage and stationery	.....	.....	.....	.....	.....	.....	.....	.....	.....	14.65	.....	
	Freight and express	.....	.....	.....	.....	.....	.....	.....	.....	.....	1.50	.....	
	Traveling expenses	.....	.....	.....	.....	.....	.....	.....	.....	.....	373.68	1745.84	1745.84
Laws '07, Printing.	Publications	631.20	115.85	50.00	.....	85.25	82.25	17.00	209.90	12.00	*Irr.* 281.65	1485.10	1485.10
Laws '07, Date palms	Labor	.....	.....	.....	.....	.....	.....	.....	.....	2390.46	.....	.....	
	Postage and stationery	.....	.....	.....	.....	.....	.....	.....	.....	5.20	.....	.....	
	Freight and express	.....	.....	.....	.....	.....	.....	.....	.....	19.58	.....	.....	
	Seeds, plants and sundries	.....	.....	.....	.....	.....	.....	.....	.....	18.35	.....	2433.59	2433.59
Univ. Ter. Fund.	Salaries	846.30	.....	.....	.....	.....	.....	.....	.....	.....	*Inst.Wk*	846.30	
	Furniture and fixtures	.....	.....	.....	.....	.....	.....	.....	.....	.....	65.00	65.00	911.30
	Totals	4480.28	3254.78	3343.19	1223.65	2882.78	924 26	63.78	1529.10	2450.32	2140.84		22292.98

EXPENDITURES BY FUNDS, SCHEDULES AND DEPARTMENTS FOR THE YEAR ENDING JUNE 30, 1908—CONTINUED

		Saltbush and Cactus.	Plant Diseases.	Toxicity of Copper.	Date Ripening.	Underflow Investigations.	Totals.	
Adams Fund, $9,000.00.	Salaries	603.10	1600.00	2185.39	1920.00	2209.22	8517.71	
	Labor					4.50	4.50	
	Freight and express				3 40		3.40	
	Chemical supplies		61.29	116.06	73.22		250.57	
	Seeds, plants and sundries		.75				.75	
	Library	5.00	9.09	4.40	9.82		28.31	
	Tools, implements and machinery			1.00		75.55	76.55	
	Scientific apparatus		20.35	67.45	4.10	26.31	118.21	9000.00
S. P. Fund, $2,500.00.	Salaries					457.12		
	Labor					280.49		
	Freight and express					132.04		
	Heat, light, water and power					76.10		
	Tools, implements and machinery					371.35		
	Traveling expenses					172.43	1489.53	1489.53
	Totals	608.10	1691.48	2374.30	2010.54	3805.11		10489.53

AGRICULTURE.

The work in agriculture thus far entered upon by the writer, has been directed mainly along two lines; viz., a study of the attempts being made to introduce the cotton industry in Arizona, and an inquiry into the possibilities of "dry farming."

COTTON.

Considerable interest is being shown in cotton in the Buckeye and Arlington districts and at Arlington 105 acres of short staple cotton, 3 acres of Allen's Improved long staple and 19 acres of Mit-afifi Egyptian cotton were planted in the spring of 1908. The short staple seed was obtained from west Texas and in order to guard against the introduction of boll weevil the writer visited the Arlington district and fumigated all the imported seed. He also visited the district several times during the season for the purpose of making observations upon the methods of planting, culture, and the yield of the crop, having also given substantial assistance in the matter of securing a gin for handling the crop.

Six plats of cotton were planted on the Station Farm; three on heavy adobe soil and three on soil of lighter texture. The moisture conditions of the soil seemed to indicate need of irrigation after planting which was given, but this resulted in a complete failure to secure a stand on the adobe plats and in a very unsatisfactory stand on the lighter soil. The varieties planted and distances apart were as follows: Mit-afifi, rows 5 feet apart and plants 30 inches in the row; Allen's Improved long staple, rows 5 feet apart and plants 30 inches in the row; Rogers' Big Boll, rows 3 feet 9 inches apart and plants 20 inches in the row. By actual count of stalks the stand obtained was found to be as follows: Egyptian, 25.4%; Allen's Improved long staple, 34.1%; Rogers' Big Boll, 25.1%. The greater size of stalks due to wide distance apart would no doubt increase the percentage of stand considerably but it would be difficult to

estimate how much. The yields obtained were, Egyptian, 758 pounds seed cotton per acre; Allen's Improved long staple, 992 pounds; and Rogers' Big Boll, 1355 pounds. On December 19 there was still a large number of immature bolls on theplants of the Egyptian variety. The costof planting, irrigation and cultivation of the three varieties was practically the same. The cotton was picked by inexperienced labor and the time required to pick 100 pounds of seed cotton was as follows: Egyptian, 16.5 hours; Allen's Improved long staple, 15.4 hours, and Rogers' Big Boll, 16.8 hours.

In March a Timely Hint entitled "Cotton Growing in Arizona" was published, which dealt principally with the results of the experiments with Egyptian cotton conducted by the Bureau of Plant Industry of the U. S. Department of Agriculture, at Yuma, the data being kindly furnished for the purpose by Messrs. Kearney and Peterson, of that Bureau. An arrangement was made to cooperate with the Bureau in the distribution of Egyptian cotton seed acclimatized at Yuma, and visits were made to farmers which secured promises to plant 55 acres to this variety of cotton, chiefly in the Arlington district. However, on account of the accidentally hybridized condition of the seed this distribution was not finally made.

DRY FARMING.

During the summer the writer made two trips into the Sulphur Springs Valley for the purpose of investigating "dry farming" possibilities, one of which was made with horse and buggy, thus affording an opportunity also to view much of the territory lying between Tucson and Douglas. Another similar but much more extensive trip was made through the northern and northeastern portions of the Territory. Many of the mountain valleys are now being farmed more or less successfully without irrigation and attempts are being made in the Sulphur Springs Valley, and at Snowflake. It is hoped these areas may be extended. It is believed that in all probability experimental work in dry farming can be taken up with profit.

R. W. CLOTHIER,
Agriculturist.

HORTICULTURE.

DATE CULTURE.

The date trees in the cooperative orchard at Tempe, and at Yuma have continued to make a steady growth. At the Tempe orchard an unusually large number of blooms appeared, and it was very encouraging to note that several of the late maturing varieties began to bloom two or three weeks earlier than in previous years.

Following are the usual detailed statements of the condition of the orchards in the autumn of 1908:

TEMPE DATE ORCHARD.

Importations.			Condition Sept. 16, 1908.				
Date received	No. of varieties	No of trees	Varieties living	Trees living	Off-shoots growing.	Trees in bloom.	Trees dead.
Aug. 1, 1899..	5	6	..	..	..	...	6
July 17, 1900.	24	405	19	266 *	1912	146	139
May 20, 1901...	5	18	3	6 †	52	1	12
Oct. 21, 1901...	6	35	5	20	142	2	15
June 11-12, 1902	46	212	26	56	345	10	156
May 24, 1904 ..	39	41	26	26	133	13	15
July 12, 1904...	13	13	12	12	31	6	1
Aug. 8, 1904...	4	7	3	5	25	...	2
Nov. 14, 1904...	5	52	1	1	2	...	51
May 15, 1905...	54	126	30	50	94	24	76
May 24, 1905...	5	21	5	15	28	...	6
June 24, 1905..	6	13	3	5	7	1	8
July 2, 1906...	1	2	..	...	...	...	2
July 13, 1907. .	1	4	.	...	....	...	4
Aug. 8, 1907...	3	12	3	12 ‡	....	...	...
May 28, 1908...	17	33	13	17	....	...	16
Totals.... .	234	1000	149	491	2771	203	509
Less 14 repeated	.....	.....	14				
			135				

* Including 11 trees of this importation growing at Station Farm.
† Including 1 tree of this importation growing at Station Farm.
‡ Including 1 tree of this importation growing at Station Farm.

HOME GROWN TREES FROM VARIOUS SOURCES

Source			Condition Sept 16, 1908			
Description	Date received	No of trees.	Trees living	Off-shoots growing.	Trees in bloom	Trees dead
Three-year-old seedlings from Chas Purdy, Alhambra	Apr. 30, 1900	100	44	320	5	56
From all other sources, 1899–1908		159	14			145

Prior to the twelfth of July all indications pointed to a large crop of fruit On this date, however, the Tempe orchard was visited by a destructive hail storm which pelted from the trees about one-half of the crop. Much of the fruit which remained was so bruised as to be injured in quality. The trees themselves sustained but little damage. Hail storms of such severity are, fortunately, not common to this region.

YUMA DATE ORCHARD.

Importations			Condition Oct 8, 1908			
Date received	No of varieties	No.of trees	Varieties living	Trees living	Trees in bloom	Trees dead
May 12, 1905	46	95	24	40	9	55
May 20, 1905	5	19	5	13	1	6
June 22, 1905	6	38	4	16	2	22
July 3, 1906	1	2	1	1		1
Aug. 10, 1908	15	26	15	26		
Total importations	73	180	49	96	12	84
Rhars from Tempe D O, May 8, 1906	1	15	1	1		14
Ass'd suckers from Tempe D O., May 29, 1907	9	21	1	1		19
Ass'd suckers from Tempe D O, June 1, 1908	17	103	14	76		27
Total domestic	27	139	16	78		60
Total from all sources	100	319	65	174	12	144

While the young trees at the Yuma orchard continue to make satisfactory growth, they are still too small to produce fruit except in a few instances. At the Tempe orchard about fifty-

five varieties bore fruit, many of them for the first time. Some of these bore insufficient fruit to furnish reliable material for comparative studies. Such studies were made and photographs taken of nineteen new varieties from the Tempe orchard and three from the Yuma orchard This places the total number of varieties from all sources studied and described at seventy-seven.

It is very encouraging to note that the Deglet Noor date approached much nearer to perfect ripening than in previous years In fact, quite a number of bunches ripened a part of their fruit. At the Station Farm several bunches were cut on November 8 and hung up indoors. These ripened up fairly uniformly, and by December 15 many of them proved to be free from soluble tannin and very palatable, though they were lacking in color and juiciness when compared with imported Deglet Noors.

At both orchards additional plantings of offshoots were made during the year. On August 10 twenty-six offshoots, representing fifteen varieties, were planted at Yuma These were imported by Mr. B. G. Johnson and were in very fine condition when planted The Yuma orchard also received one hundred and three offshoots from Tempe, most of which were small and some of them had been injured in scorching for scale The whole lot was in very poor condition when planted. The Tempe orchard received thirty-three offshoots representing seventeen varieties imported by the United States Department of Agriculture. Twelve offshoots cut in the orchard were set in various vacant places.

The third distribution of suckers in behalf of the United States Department of Agriculture and the Arizona Experiment Station was made during the latter part of May. 489 suckers were cut and distributed, 252 on behalf of the Department and 237 to Arizona points by the Station.

DATES AT THE STATION FARM

The eighteen imported palms at the Station Farm continue to make vigorous growth. The fourteen female palms produced about eight hundred pounds of fruit, very little of which ripened

satisfactorily. On June 1 ten offshoots were cut from these trees and planted in vacant spaces in the rows.

The seedling orchard, composed of 491 trees, is in a thriving condition, and as the trees approach the age of fruitfulness they give promise of very interesting and valuable data on the hereditary tendencies of seedlings and the ratio betwen males and females. Of the trees in this orchard, 316 are Seewah and 175 are Amreeyeh seedlings. They are all of the same age, having been set out in 1902. It is already evident that the two lots differ in regard to proportion of males to females and as to the age at which they begin to bear. Of the ninety Seewahs blooming this year 45 per cent are males, while of the forty-five Amreeyehs 93 per cent are males. About thirty of the Seewah seedlings fruited this year, and while they vary greatly as regards size, shape and certain minor characters, they all possess a certain marked resemblance to the mother Seewah. They are uniformly like the parent in color, coarseness of fibre and lateness of ripening. Not one of those fruiting so far is considered worthy of propagation. These facts point to the advisability of selecting seed for planting from dates of high quality which ripen early, and whose pollen parent is known to have arisen from the seed of a soft date.

DATE EXHIBIT AT THE TERRITORIAL FAIR.

The Station made a large exhibit of dates at the fourth Territorial Fair. Many varieties of packed dates from the Tempe orchard, together with forty bunches of the green fruit cut from the seedling trees, were the basis of a very attractive exhibit which was awarded a special grand prize.

THE STATION FARM ORCHARDS.

During the year substantial additions were made to the orchards at the Station Farm. Many new varieties of peaches, apricots, quinces, Japanese persimmons, olives, pomegranates, figs, grapes, oranges, citranges and ornamental plants were set out. A new vineyard of sixty varieties of grapes intended as a beginning for a much larger collection was planted. These vines have done exceptionally well and have made remarkable growth.

Experiments have been begun in these orchards upon the following problems: the influence of different depths of planting

upon fruit trees; the effects of alfalfa upon peach trees; and the determination of the best time and method of summer pruning.

During the winter the horticultural records, previously kept in a series of books, were carefully gone over at great expense of time and labor. New maps were drawn for each orchard and the entire mass of records finally adapted to the card-index system. This greatly facilitates office work, as all data are available for instant reference.

SMYRNA FIG CULTURE.

The culture of the Smyrna fig is coming to be an important and profitable industry in parts of California, and the question has been raised as to the practicability of this industry under the climatic conditions existing in southern Arizona. During the past year work was begun towards determining the possibility and advisability of such an industry.

The orchards at the Station Farm already contain trees of four varieties of Smyrna figs, besides two trees of Roeding's Capri No. 1. That none of these Smyrna figs had ever borne fruit was due to the fact that former attempts at introducing the fig wasp, *Blastophaga gossorum* (which is necessary for the pollination of the flowers and consequent setting of the fruit), had proved unsuccessful. The first step, therefore, was to secure and establish a colony of these insects upon the Capri trees at the Station Farm.

Early in the spring the writer secured green figs of the mamme crop containing the necessary fig wasps, from several California nurserymen. These arrived on April 9, 12 and 16, and were, in each case, immediately placed in the Capri trees. The insects were seen to emerge in great numbers and enter the profichi crop, then about three-fourths of an inch in diameter. The infested Capri figs soon began to grow rapidly, assuming a deep green color. They ripened between the first and fifteenth of June, at which time thousands of the new generation of insects began to emerge, covered with pollen, seeking other figs in which to lay their eggs. A quantity of these Capri figs, having been gathered before the insects had left them, were strung upon cords and placed in different parts of the Smyrna

trees. As a result of this, all the young Smyrna trees bore a heavy crop of fruit. A large *Lob Ingir* tree, at least fifteen years old, which had never before set fruit, bore a fair sized crop of fine figs. The earliest varieties began to ripen on July 20, while the latest were practically all ripe by September 1 The fruit was very abundant and of good quality, the skin in particular being thin and tender.

Two serious difficulties were encountered, however, in caring for this fruit. In the first place, the crop ripened just at the time when summer thunder storms are most frequent, and the consequent high humidity of the atmosphere made the drying process very difficult. In the second place, the ripe fruit was attacked by a large, green beetle known as the "fig eater," or *Allorhina mutabilis*. This insect occurred in such great numbers that a large part of the fruit was literally devoured upon the trees. It was also found that under the climatic conditions of the Salt River Valley one variety of Capri fig alone is less desirable than a collection of several varieties chosen with reference to the time of year at which their several crops are borne.

Further and more extensive work on this subject is planned for the future, and it is hoped that some way may be found to overcome the above-mentioned difficulties.

CITRUS CULTURE.

During the fall of 1907 the writer made a preliminary orchard survey of all the citrus groves in the Salt River Valley. Data were collected upon the soil conditions, varieties, pruning, fertilization, yields, methods of irrigation, insects and diseases. In the summer of 1908 the citrus regions of California, and Sonora, Mexico, were visited and data of a similar nature collected. As a result of these studies a popular bulletin entitled "Citrus Culture in the Arid Southwest" has been published. This bulletin is intended to meet the growing demand for general information in regard to citrus culture in a region which is rapidly becoming an important citrus growing area.

J. ELIOT COIT,
Associate Horticulturist.

ANIMAL HUSBANDRY.

The experimental breeding of sheep better adapted to the valleys of southern Arizona than either the native or introduced breeds has been continued during the past year with marked success. Feeding experiments with sheep to determine the value of ripe olives when added to a ration of alfalfa hay have been completed and the results made a part of this report. A trip over the range for the purpose of observing and studying existing conditions was made late in July. The most noticeable fact in evidence at this time was the overstocked condition of some parts of the open range and the great wealth of feed being wasted in other portions. A careful study should be made to determine under what restrictions the permanent range should be allotted. This will help conserve the natural resources of vast amounts of grazing land.

Timely Hint No. 74, Farm Management with Sheep, was prepared for publication. Observations on the poisoning of stock by oleander have been conducted during the year and are now in course of preparation for publication. It is well to note that most people do not realize the powerful effects of this poison which, especially in Mediterranean countries, has been known for centuries.

A number of animals was also fitted at the Station Farm for exhibition at the Third Annual Territorial Fair. The following prizes were secured: first prize for the best farm team, first prize on Shropshire ram two years old, first prize for Oxford ram under one year, second prize for Rambouillet ram one year old, first prize for Tunis ram two years old, first prize for Tunis ram one year old, first prize for Tunis ewe one year old, first prize for Tunis ewe under one year, and first prize for best ranch raised lamb. Although this lamb was but eleven months and twenty-seven days old, she was shown with her own lamb dropped at the time of the Fair. The lamb and its young mother made a very attractive exhibit.

SHEEP BREEDING.

The breeding flock now contains 106 two-year-old native ewes, 32 Tunis-Native ewes, 2 pure bred Tunis ewes, 1 pure bred Rambouillet ewe, 1 pure bred Shropshire ram, 2 pure bred Tunis rams, 1 pure bred Rambouillet ram, and 10 Tunis-Native rams. Five of the Tunis-Native ewes are now two years old, and four of them have produced lambs. This year's crop gives us 27 ewe lambs, 8 ram lambs and 30 wether lambs of the Tunis-Native cross.

Since beginning breeding operations we have, unfortunately, lost several very valuable Eastern bred rams, due for the most part to the sheep botfly (*Aestrus ovis*). These losses, however, show clearly the need of a particular type of sheep better adapted to the valleys of southern Arizona.

The Tunis-Native cross returns a good fleece of wool of longer staple than that from the Native dam, but somewhat shorter than that from the Tunis sire. There is more yolk in the fleece than was expected, but this fact may be attributed to the abundance of feed and the peculiar climatic conditions of our southern irrigated valleys.

The Tunis-Native fleece is rather coarse, but has a long staple with a few long hairs. The wool is a decided improvement over that of the sire, both in quality and in quantity, the fleece being a little heavier than that of the Native, produced under the same conditions.

Comparison of the weights of fleeces is made in the following table:

Station number	Breed	Sex	Weight of the fleece	Station number.	Breed.	Sex	Weight of the fleece
	Tunis-						
2	Native	Ewe	12.0	3	Native	Ewe	5 5
42	"	"	12.0	4	"	"	10.0
59	"	"	8.5	25	"	"	9.0
62	"	"	12.5	31	"	"	12.5
93	"	"	8 0	35	"	"	12.0
50	"	Ram	10.0	64	"	Ram	8.5

Average weight of fleece of Tunis-Native . . 10 5 lb.
Average weight of fleece of Native . . . . . 9.58 lb.

A wool-testing machine to be used in comparing the tensile strength, stretch and length of wool samples from the different types of sheep on the Station Farm has been devised and constructed in the engineering laboratory at the University. It is believed that valuable data will be obtained with the aid of this instrument.

The first cross of Tunis on the Native ewe produces a hardy, active, early maturing lamb that stands the warm weather well and produces a profitable quantity of wool. Out of more than 70 Tunis-Native lambs only two have been of the same type as the dam. This cross shows uniformity in conformation, in characteristics of the fleece, and in weight.

Following is a comparison of the weight of the Tunis-Native with the Native at birth, at six months, and at one year of age under the same conditions:

Station number	Breed	Sex	Weight at birth	Weight at six months	Weight at one year	Station number	Breed.	Sex	Weight at birth	Weight at six months	Weight at one year
2	Tunis-Native	Ewe	8.5	55 0	103.0	3	Native	Ewe	8.0	72.0	93 0
42	"	"	8.0	52.5	101.0	25	"	"	7.5	80.0	108.0
50	"	Ram	8.0	90.0	120.0	32	"	"	5.0	60.0	94.0
59	"	Ewe	6.5	67.5	100.0	82	"	"	9.0	60.0	79.0
91	"	"	7.5	62.0	95.0	84	"	"	6.5	48.0	73.0
93	"	"	10.0	69.0	110.0	27	"	"	7.0	51.0	71.5
62	"	"	9.0	72.0	110.0	30	"	Ram	5 5	82.5	114.0

Average weight at birth of seven Tunis-Natives . . . 8.21 lb.
Average weight at birth of seven Natives 6.93 lb.
Average weight at six months of seven Tunis-Natives 67.85 lb.
Average weight at six months of seven Natives . . 64 78 lb.
Average weight at one year of seven Tunis-Natives . . 105.57 lb.
Average weight at one year of seven Natives . . . . 90.35 lb.

SHEEP FEEDING.

Owing to the scarcity of green feed at the Station Farm during the cold weather of January and February, the flock was given opportunity to pick up weeds in the orchards and also had access to a nearby field of oats. It was noticed by the writer that the flock made frequent trips to the olive orchard,

remaining under the trees rather than feeding on the nearby field of green oats. Soon small heaps of olive pits were observed in various places where the sheep had bunched in the shade and also in the yards where they were placed at night. About this time a large fat ewe was caught in a fork of one of the trees where she remained for several hours. Evidences of her diet for sometime past were found in the casts of olive pits and skins. During the time that the flock grazed in the olive orchards the sheep gained in flesh and seemed to be very greedy for the fruit.

To determine the value of ripe olives as an addition to a ration of alfalfa hay two lots of sheep, consisting of two wether lambs, as nearly equal in weight, breeding and general conformation as could be selected, were fed in separate pens. Lot I received a ration of second-crop alfalfa hay. Lot II in addition to the same ration of alfalfa hay received ripe Mission olives. The sheep were carefully weighed each day for three days preceding the feeding trials, and each Saturday thereafter. At the end of the trials they were again weighed for three consecutive days and an average taken of the three weights. No account was taken of waste feed, and each day's feed was charged up to the animals. The following table gives the amount of hay and olives consumed, the weights on February 24 and on March 25, and the gain in weight for each lot:

Lot No	Alfalfa hay.	Olives.	Weight Feb 24.	Weight Mar 25.	Gain
I	155 lbs.		162 lbs.	165.66 lbs.	3.66 lb.
II	155 lbs.	93 lbs.	146 lbs.	162.00 lbs.	16.00 lb.

Since sheep do not injure mature trees while feeding on the waste olives, it would seem from the above experiment that they might act as excellent scavengers in olive orchards, utilizing feed that is ordinarily wasted.

F. W. WILSON,
Animal Husbandman.

BOTANY.

CONDITIONS UPON THE RANGE.

By virtue of the very favorable rainfall which obtained for the most part for the year ending June 30, 1908, stock ranges throughout the country appear in better condition, so far as forage is concerned, than they have for some years. There has been a heavier growth of the annual species on the lower mesas and of the perennial grasses of the higher mesas and mountain slopes than ordinarily obtains. The rainfall, generally speaking, was above the average during the summer months, and slightly below it during the winter and early spring months. On the small range reserve tract the total year's precipitation was 14.11 inches, or about three inches above the average. Of this amount 9.74 inches fell during the summer growing period, July to October inclusive, and 4.13 inches during the winter season, November to April inclusive. May and June were practically rainless, which is a normal condition.

As would be expected the summer annual growth was heavy, the six-weeks grasses, chief of which are the annual gramas (*Bouteloua aristidoides* and *B. polystachya*), being especially abundant over the greater portion of the mesas. In clearings of creosote and similar shrubby growth, swales and other favorable situations this growth was at the rate of 500 to 1200 pounds of dried forage per acre, the material in the above tests being pulled by the roots or cut off at the level of the ground; it was thoroughly dry, however, before being collected, and had lost all seed and some of the leafy portion. Among creosote bushes (*Covillea tridentata*), and especially where the soil is inclined to be shallow the growth was only one-fifth to one-third as heavy. Observations and experiments concerning this indicate that mesa land cleared of shrubs and weeds gradually becomes covered with a heavier growth of the annual grasses. Obvious examples of this may be seen in the case of burned-over areas where most of the shrubs have been destroyed, and of the

clearing of small tracts and streets in the vicinity of Tucson. This is believed to be due to the fact that creosote bushes and other desert shrubs with their splendidly developed root systems which reach out for considerable distances in the shallow soil, are able to take up most of the soil moisture left by a passing shower before the annual seedlings can become sufficiently established to endure a few days of dry, hot weather. Accordingly, the mortality among summer annual seedlings between showers or rain periods, even during an average rainy season, is very great, with the result that at the end of the season there is often only a scattering of plants over portions of the mesas.

The winter annual growth was light, there being about one-third to one-half as much as ordinarily obtains with favorable rainfall; this was largely due to the unfortunate distribution of the rains. Only .28 inches of precipitation took place after March 1, which is the time of the greatest winter annual growth, with the result that winter and early spring grazing was short and of limited duration. This is the third season in succession that spring forage has been cut short as a result of untimely rainfall. Over the foothills and mesa-like slopes to the north of the Santa Rita Mountains, about Arivaca, and especially in the neighborhood of Oracle, which latter station is favored with a winter rainfall that appears to be both heavier and better distributed than for most other points in southern Arizona, the grazing was better and of much longer duration than at the lower altitudes.

In connection with the above a comparative study is being made of the influence of altitude upon vegetation as expressed in terms of depth or amount of rainfall, and of temperature; and also of the effect of the varying amounts of winter and summer rainfall of different localities upon the types of plant growth or vegetation forms. Perhaps no single factor exerts so far-reaching an influence on the distribution and abundance of our native vegetation as that of moisture. As a result of this study it becomes apparent why certain sections of Arizona, for example Oracle, are noted for their late winter and spring grazing by virtue of winter annual growth, while other parts, as the Empire ranch country, are unexcelled for summer and

fall grazing on account of an abundance of the perennial bunch grasses. The study of this also enables one to determine approximately localities that are more or less promising for dry-farming methods, though in this latter connection there are other important factors to be considered.

PLANTING OF NATIVE ECONOMIC CACTI CONTINUED.

The work of planting cactus cuttings of the two previous years has been continued under conditions quite similar to those of last year. The cuttings were set rather deeply in plowed furrows and covered with a second furrow as described in a recent annual report. About 500 cuttings each, of the following varieties were set: *Opuntia fulgida; O. mamillata; O. spinosior; O. arbuscula; O. Engelmanni;* and *O. phaeacantha.* Experiments indicate that under our conditions, cuttings of the native species do not need to be exposed to the drying effects of the weather for a period before planting, in order to prevent rotting. The ravages of jack rabbits were worse this season than usual, for reasons not clear, many cuttings of the less spiny forms, as *Opuntia mamillata* and *O. Engelmanni*, being destroyed or badly eaten by them. The summer rains were exceptionally heavy, with the result that the growth is as favorable as it was one year ago. It is interesting to note that without exception growth began after the advent of the summer rains, the cuttings in the ground in the meantime doing little more than to become rooted. And this statement also holds true with reference to the growth of adult plants on the mesas. While they blossomed and fruited during the spring and early summer, the growth of new joints did not begin until after the summer rains had set in.

In order to make further observations concerning the rate of growth which may be expected from cactus plants grown from cuttings on the range without irrigation under varied conditions, a small planting was made on the lower portion of the large range enclosure in the vicinity of the gate near the northwest corner. The soil here is deeper and apparently looser than in the small range enclosure, and the shrubby growth is generally larger. This is especially true of cacti which are, however, less

abundant than in the vicinity of the small range enclosure. No perennial grasses are present and the annual growth is very limited. One hundred cuttings each, of the following species were used in this experiment, all of which are growing native on the range in the vicinity of the area planted; *Opuntia Engelmanni*; *O. spinosior; O. fulgida; O. mamillata;* and *O. arbuscula.* A large percentage of these plants were destroyed in the early part of the season by rabbits and other range rodents.

FAILURE OF SALTBUSH WORK.

So far as practical results are concerned, the work with saltbushes has proved a failure. In the last annual report it was noted that the plants grown in pots were unable to establish themselves, even with occasional light irrigation, when planted as late as March, which month marks the close of the winter rainy season. It was also noted that the replanting done in July at the beginning of the summer rainy season, which was an unusually favorable one, was entirely unsatisfactory. The young plants either died out or failed to make any growth worthy of mention, though often continuing a feeble existence. This statement applies to many of the plants at this time, eighteen months after the first planting. Last October, seeds of the more valuable native species including shad-scale (*Atriplex canescens*), salt-sage (*Atriplex Nuttallii*), spiny saltbush (*Atriplex confertifolia*), *A. polycarpa, A. lentiformis, A. Coulteri,* and winter fat (*Eurotia lanata*), together with certain Australian species, the well known *Atriplex semibaccata*, old man saltbush (*Atriplex halimoides*), and *Rhagodia spinescens* were collected and planted one-half inch deep in hills six feet apart over one-half of the area; also a second lot of the seed was sown broadcast over a portion of the field plowed and harrowed. At the close of the winter rainy season, the precipitation of which was slightly below the average, a poor stand of seedling plants resulted in most instances. These, however, entirely disappeared during the normally dry May and June. Except at the upper end of this area used for saltbush work, along which a small irrigation ditch passes and which as a result has been subject to occasional watering by means of seepage, overflow and gopher holes, none

of the species of saltbushes have made growth of any considerable note. Australian saltbush (*Atriplex semibaccata*) has done best, though in the case of this variety growth is not sufficient for economic purposes. Where this plant has secured a foothold along the banks of the irrigation ditch it has made a remarkably heavy growth as would be expected, and this is also true for the other species. It must be admitted that the ground under consideration has not been cultivated or irrigated with ditch water since the experiment began; but this was intentional, since the work was designed to be an arid-culture test. If cultivation and irrigation were to be employed, one might much better grow alfalfa as is abundantly shown by the yield of this crop in nearby fields where similar soil conditions obtain.

RESISTANT EUCALYPTS.

Timely Hint No. 68, entitled "Resistant Eucalypts for southern Arizona" was issued January 15, 1908. The increasing interest in our Territory in the economic possibilities of this valuable group of trees made it desirable for the Station to publish at this time a conservative statement concerning our present knowledge of Eucalypts for this climate. It was noted that there is good reason to believe that the most drought-resistant varieties, when once established on lands that are of secondary value for culture purposes on account of limited water supply, will be able to maintain themselves with the annual rainfall in addition to possible underflow or limited irrigation. Several varieties are valuable additions to our list of ornamental and shade trees, being evergreen, possessed of a pleasing aroma, and apparently free from fungus and insect pests. The conditions under which Eucalypts must grow in the warmer parts of Arizona in order to prove successful were given as endurance to maximum temperatures of 108 to 120 degrees F. with low humidity and intense sunlight, and ten to twenty degrees of frost in winter. The upper Gila Valley appears to be the coldest location in southern Arizona where Eucalypt trees have been tried with any degree of success; at Safford *Eucalyptus rostrata*, *E. tereticornis*, and *E. rudis* are growing apparently uninjured with cold, though with some protection afforded

by nearby buildings. The following species were described briefly with reference to their economic, resistant and ornamental qualities, certain ones being suggested for the varied climatic conditions of the different agricultural sections: forest red gum ((*Eucalyptus terelicornis*); red gum (*E. rostrata*); desert gum (*E. rudis*); red box (*E. polyanthema*); narrow-leaved iron-bark (*E. crebra*); manna gum (*E. viminalis*). The middle of February to the first of April according to location, is recommended as the best time to set out plants, though young plants in pots may be set out at almost any time of the year. The widespread interest which has been shown regarding this publication and which continues now may be taken as a safe index of the trend of popular sentiment in the Southwest concerning tree planting for commercial purposes.

VITALITY OF SEEDS UNDER WATER.

The Timely Hint on this subject was issued to meet a want existing in the Colorado RiverValley with reference to the sowing of seeds previous to the annual rise of this river on lands submerged for periods of two to six weeks. It was generally known that sorghum could be treated in this way, though with varying degrees of success with reference to the stand obtained. Prof. V. A. Clark, formerly of this Station, began the work some years ago, and it was completed last year by the writer. It was found that amber cane or common sorghum could be grown over practically the entire flood plain area of the Colorado River, since 45 per cent of the seed germinated even after fifty days' submergence. For obvious reasons double the quantity of seed was recommended to be sown. None of the varieties of forage, as African red top cane, dwarf milo maize, Jerusalem corn, white Kafir corn, German millet, or pearl millet can be depended upon to endure submergence for any considerable time. Japanese and Honduras rice seed began growth under water and continued until the soil became quite dry. Neither Johnson grass nor Bermuda grass seed could be destroyed with continuous submergence of fifty days.

J. J. THORNBER,
Botanist.

PLANT PHYSIOLOGY AND PATHOLOGY.

The greater part of the work in plant physiology and pathology during the past year has been the investigation of plant diseases. These, while of no more ultimate importance than the physiological problems which have arisen, present more immediate need of investigation. The diseases which have been most destructive to crops in Arizona during the year are: several root-rot diseases especially on alfalfa, melons, cantaloupes, tomatoes and apple trees, tomato fruit rot, dry rot of potato tubers, early blight of potatoes, melon fruit rot, onion mildew, onion mould, pear blight and cabbage rot. Rose mildew has been common in some localities, but not serious, and a trouble which causes the death of eucalyptus trees has been studied. A number of these diseases was described and remedies given in Timely Hint No. 76 recently published, and these need no further mention. A brief description of the others will be given.

FUSARIUM DISEASES.

By far the most destructive class of diseases with which we have to deal is that due to fungi belonging to the genus *Fusarium*. To this class belong the root rots, or wilt diseases of alfalfa, melon, cantaloupe, cucumber, tomato, and many other plants, the fruit rot of tomato and melon, and the dry rot of potatoes; and they are frequently the cause of the damping off of seedlings. In the cases of the wilt diseases the fungus lives in the soil and attacks the plants through the roots, the filaments of the fungus growing into and plugging the water-conducting vessels sufficiently to block the passage of water and cause the wilting of the plant. The roots affected finally rot away. The fungus lives on indefinitely in the soil and is able to withstand all the extremes of heat and drought. On alfalfa the fungus is very destructive, often ruining a large part of the crop. It usually starts in small spots which gradually enlarge in a more or less concentric manner. As these areas join each other the diseased patches become quite irregular in outline. The first indication

is a yellowish appearance of the outer leaves. This gradually spreads until all the leaves and even the stems have lost their green and assumed a light yellow color. This is either accompanied by, or more usually followed by, the wilting and death of these parts. On the melon and cantaloupes, and also on tomatoes the attack may affect only individual plants, or may include large areas. In the vicinity of Tucson whole fields of melons were destroyed. The roots are attacked in the same manner as those of the alfalfa, and the plants suddenly wilt. The fruit rots on melons and squashes and that on tomatoes were especially harmful this year. The characters of the diseases are much the same in each case, the first indication being a small black shrunken area at the outer end of the fruit. This gradually extends until the greater part of the fruit may be included. The outer part of the diseased portion is black, shrunken, and quite hard, while the inner part is soft and rotten. In the melons this is often associated with the wilt disease, but in the tomato it is abundant where there is no wilt

The relation between these different forms of Fusarium is not yet clear. It seems certain that there are several species concerned, but the relationships have not yet been worked out. Whether each disease is due to a distinct form or whether one species may be the cause of more than one disease is of vital importance. Field observations point to the latter, but such observations are not reliable for they do not distinguish, in the same soil, between one form with a wide range of host plants, and several distinct forms each attacking different plants. The only way to determine this is by inoculation of sterile soil with pure cultures of each of the fungi and by planting these with each of the crops to be tested. Pure cultures of alfalfa, watermelon, tomato, and apple root rots, of potato dry rot, and of melon and tomato fruit rots have been isolated and grown in quantity. Each one of these is mixed with enough sterile soil so that a sufficient number of each of the plants mentioned can be planted in the soil inoculated with each fungus. These experiments are still in progress. It is certain that in the seedling stage the alfalfa fungus will cause a damping off of alfalfa, tomatoes and watermelons. Further conclusions, however,

should not be drawn until the experiments are completed. Laboratory investigation on the growth of these fungi, their methods of reproduction, how they gain entrance to, and their effects upon the plants, their resistance to extremes of heat, cold and drought, and other points, have been conducted and much interesting information obtained, which will be published in detail later. As the root-rot forms of these fungi live entirely in the soil it does not seem probable that we shall arrive at practicable methods of destroying them, and while much may be done by careful sanitary precautions and proper crop rotations, yet it seems to the writer that the ultimate solution will have to come in the production of resistant or immune varieties. The difficulties in the way of securing resistant strains upon which to work, and the hope of being able to find a way of determining resistant individuals other than by the uncertain field observations has led the writer into investigations as to the causes of immunity. Almost nothing is known of the real nature of immunity of plants to disease, and a knowledge of this would enable us to replace the present entirely empirical procedure with more direct and rational methods of investigation.

MISCELLANEOUS DISEASES.

A number of other diseases required attention during the year. Among these were two damping-off fungi which occurred in several seed beds. One was a species of *Fusarium* and the other was a *Sclerotinia*. These fungi are probably present in most soils in this region and are able to develop when the seedlings are too thick and the ground shaded and moist.

A number of eucalyptus trees, of the variety *rudis*, have died in this locality during the past year or two. Examination showed no fungus or bacterium present, but the soil in all cases was poorly drained and had become soggy and in some cases soured. Experiments with young trees in boxes of soil showed that better aeration would avoid the trouble.

Nematode worms in some soils constituted a serious pest Their presence is indicated by the conspicuous nodules which they induce upon the roots. Ornamental plants on the University campus were severely injured and several beds of flowering

plants were destroyed. The statement has been made that flooding the soil for five days will kill them. Experiments to determine this showed that in boxes of soil, after being completely submerged for ten days, the nematodes were abundant enough to entirely destroy cantaloupes and tomatoes subsequently grown in the boxes.

PHYSIOLOGICAL STUDIES.

In addition to pathological work investigations of a physiological nature have been carried on.

Potato investigations. With the desire to secure a way to induce an earlier formation of tubers, investigations on the various factors involved in tuber formation were undertaken. Some of the results give promise of valuable application. Tubers kept in a dry, light place form sprouts of a peculiar character; they are short, thick and strong, purplish in color, dotted especially toward the base with numerous root primordia, and showing many suppressed lateral shoots. Some of these latter elongate somewhat into short lateral branches while others swell up into rounded tuber-like structures. These are often quite numerous and the base of the main shoot may be surrounded with small tubers. When such a tuber is planted the central sprout continues to develop and forms the leafy shoot while most of these already formed tubers continue to enlarge. This gives such a potato considerable advantage over those planted in the usual way and it matures its tubers much earlier. The exact amount of sprouting to be accomplished before planting in order to secure the best results is a matter of considerable importance and has yet to be decided. If carried too far it loses the desired effect and indeed may be carried so far as to occasion a serious retardation of vegetative growth.

During the very hot season tubers are but seldom developed but there is instead a luxuriant growth of tops. Experiments indicate that if this excessive foliage development is suppressed tubers may form. This may be accomplished in several ways, one of which is by removing the newly forming shoots. In one experiment where the tips of the shoots were cut off and all the axial buds removed the plants produced from June 9 to

July 19 a fair crop of medium sized tubers, while check plants beside these developed luxuriant foliage but no trace of tubers.

Many chemical substances are known to produce a depressing effect on certain phases of growth and it is possible that some of these may be utilized to counteract this undesirable stimulation by the high temperature. Over twenty such substances were tried and the results ranged all the way from a marked stimulation to a retardation so great that no foliage shoots at all were produced. The results justify further investigation and continued experiments are under way. It may be remarked that we are dealing here with a principle of wide application in this climate, being seen in many plants in excessive foliage development at the expense of fruit.

Experiments on tomatoes: These experiments were one of a larger series instituted to determine to what extent the early conditions of a plant influence its later behavior. Plants sown on various dates were divided into several lots and each treated differently. Only one of these results will be mentioned. Of tomato seeds sown in plats on November 15 one lot was potted into small pots on December 27, repotted on January 23 and again on February 25. They were kept in a rather cool, well-lighted greenhouse and given as little water as they could do well with. With each transplanting the roots were broken and new ones came on close in to the stem. When set out on March 25 they were strong, bushy plants, about 10 inches high, with thick, short stems, tough, hardy leaves, and an occasional blossom. The root system was strong and vigorous with numerous thick roots bunched close in to the stem, so that they were not injured and received scarcely any setback from the setting out. They took hold and grew vigorously from the first, and bore their main crop of fruit fully three weeks before those sown and set out in the usual way.

W. B. MCCALLUM,
Associate in Plant Physiology and Pathology.

CHEMISTRY.

The work in chemistry during the past year has been confined mainly to the continuation of investigations which have been discussed in previous reports. The study of the toxicity to farm crops of copper compounds contained in irrigating waters and mining detritus by R. H. Forbes has been materially advanced. The extensive and very exacting analytical work required in these studies has occupied much of the attention of the assistant chemist. During the past year E. E. Free has accepted a position with the Department of Agriculture, Washington, D. C., and W. H. Ross has taken up the work of assistant chemist with little interruption to operations. Since leaving this Station Mr. Free has compiled and published the results of his researches on the solubility of basic copper carbonate under certain conditions occurring in irrigating waters.

The corrosion of metals with special reference to the action of ground waters on iron conduits and pumping machinery is being investigated by Dr. Ross, and although incomplete, much valuable information has been obtained. Several methods of extracting the water soluble material in soils have been compared with a view to determining the most efficient method of extraction in the case of alkaline soil. Analyses tracing the sequence of change in composition of the water of Salton Sea are also being made from year to year.

Investigations on the ripening of the date by A. E. Vinson have been practically completed, and the results published in a second paper on the enzymes of the date. Further work on the causes of souring of certain varieties of dates is now under way. This department has also assisted in developing a laboratory method of wool scouring to be used in connection with experimental sheep breeding.

Owing to the rapid agricultural development of the country an unusually large number of applications has been made for the analysis of irrigating and domestic waters, all of which have

been complied with. The composition of a number of deposits of bat guano has also been determined, and information and advice on several technical questions have been furnished on request.

Timely Hints for Farmers, No. 71, Preserving Eggs, has been published in the course of the year.

ANALYTICAL CHEMISTRY.

THE SOLUBILITY OF PRECIPITATED BASIC COPPER CARBONATE IN SOLUTIONS OF CARBON DIOXIDE.

The work of Mr. Free, published under the above title in Journ. Amer. Chem. Soc. Vol. xxx, No. 9, September 1908, furnishes much accurate and hitherto unavailable information in regard to the solubility of basic copper carbonates in water containing carbon dioxide and the influence on such solutions of various substances usually present in irrigating waters. It was found that basic copper carbonate, precipitated under varying conditions, was unstable and showed wide differences in solubility, but after continued treatment with carbon dioxide these various compounds finally showed a uniform solubility in carbon dioxide solutions of like concentration. The addition of small amounts of sodium chloride or sulphate caused no decided change in their solubility, but large amounts of these salts increased it. Calcium sulphate was without action. Sodium and calcium carbonates decreased the solubility in about the same ratio.

ANALYSES OF SALTON SEA WATER.

Since its formation in the early part of 1906, partial analyses of samples of water taken at the same time from different parts of the Salton Sea have been made at intervals. The soluble matter in the water increased very rapidly during the first few months, due to the soil which now forms the bed of the lake having been very strongly impregnated with soluble salts. This increase took place most rapidly near the shore and at the bottom of the lake, and least rapidly at that side into which the Colorado River flowed. As the level of water in the lake continued to rise the water became more and more dilute, and more nearly uniform in concentration. On February 10, 1907

the Colorado River was turned into its proper channel. The following spring the water had become practically uniform and reached its minimum concentration. Apart from the effect of small streams which still continue to flow into the lake, the concentration now depends on evaporation from the surface. At the suggestion of Dr. D. T. MacDougal, Director of the Desert Botanical Laboratory, Tucson, a series of complete analyses of the water after it had become uniform was undertaken, to be repeated every year until the lake shall have dried up. A study is to be made at the same time of the order of deposition of the salts in solution, as well as of the nature of the vegetation extending down the slopes of the lake as the water recedes. The following table gives the composition of the water in June, 1907, and again in May, 1908:

	June 3 1907. Parts per 100 000.	May 25, 1908. Parts per 100,000.
Soluble solids (dried at 110° C.)	364.8	437.2
Sodium, Na	111.1	134.3
Potassium, K	2.3	2.8
Calcium, Ca	9.9	11.9
Magnesium, Mg	6.4	7.6
Aluminium, Al	.030	.035
Iron, Fe	.005	.006
Manganese, Mn	None	None
Zinc, Zn	None	None
Lead, Pb	None	None
Lithium, Li	Trace	Trace (.01?)
Chlorine, Cl	169.7	204.0
Sulphuric, SO_4	47.6	56.7
Carbonic, CO_3	6.6	7.7
Silicic, SiO_4	1.4	1.4
Phosphoric, PO_4	.009	.011
Nitric, NO_3	.18	.20
Nitrous, NO_2	None	Trace
Oxygen consumed	.093	.059
Boric acid		Trace

The increase in soluble solids from June 3, 1907, to May 25, 1908, as shown by the table amount to 20 per cent. The proportions of dissolved solids, however, remains for the most part the same. Thus:

In 1907, Total solids : Cl=2.15 : 1
In 1908, Total solids : Cl=2.14 : 1
In 1907, Total solids : SO_4=7.66 : 1
In 1908, Total solids : SO_4=7.71 : 1
In 1907, Total solids : Na=3.28 : 1
In 1908, Total solids : Na=3.25 : 1, etc

These facts indicate, in the absence as yet of salts separating out by crystallization from the concentrating waters, that, since the Colorado River was turned into its proper channel, Salton Sea remains apparently unaffected in composition by salt deposits in tributary soils or by salty seepage waters which may be materially different in composition.

MISCELLANEOUS ANALYSES.

During the year analyses were made of the water-soluble materials in a number of soils. To determine the best method of completely extracting the soluble matter in such cases, 50 gram portions from the same sample were treated with a liter of water in different ways; viz., by frequently shaking up at room temperature for 10 hours, by shaking on the water bath for the same length of time, and by percolation. Practically the same results were obtained by the three methods of treatment as shown by the analyses made for chlorine and total soluble solids in different soils:

	Soil No. 3901.		Soil No. 3902.	
	Total solids. Per cent	Chlorine. Per cent	Total solids. Per cent	Chlorine. Per cent
By shaking up with water 10 hrs. at room temperature..	4.21	1.90	1.13	.46
By shaking up with water 10 hrs. on the water bath....	4.28	1.91	1.17	.46
Extraction by percolation with water at room temperature.	4.20	1.87	1.24	.46

Since treating on the water bath gives quickest results, it was the method employed in subsequent work.

Some of the most interesting materials of an agricultural nature sent to the Station to be analyzed are here given:

No. 3856. A sample of water taken from a hole dug in Tempe Date Orchard, showing the high degree of alkalinity of the soil solution in which date palms are able to thrive.

No. 3931. Sample of water from the new prison well at Florence, Arizona.

No. 3901. Sample of the first inch of soil taken in Tempe Date Orchard from around a young date seedling which had been killed by the alkali.

No. 3902. Sample of the first six inches of soil, same location from which No. 3901 was taken. The analyses are of the water-soluble matter only.

No. 3907. Salt prepared from a hot spring on the ranch of Mr. C. W. Francis, Thatcher, Arizona, which contains 10,055.4 parts of soluble matter per 100,000.

	No. 3856. Parts per 100,000.	No. 3931. Parts per 100,000.	No. 3901. Per cent.	No. 3902. Per cent.	No. 3907. Per cent.
Soluble solids	343.4	83.8	4.23	1.180	.....
Sodium, Na	108.4	16.5	1.47	.365	35.03
Potassium, K	5.6	1.3	.12	.059	.....
Oxides of Aluminium and Iron, $Al_2O_3+Fe_2O_3$	.....	Al .069 Fe .074	.005	.013	.03
Manganese, Mn	.....	None	None	None	.....
Calcium, Ca	8.9	9.6	.033	.023	1.60
Magnesium, Mg	4.7	2.4	.017	.006	1.50
Silicic, SiO_4	.....	6.8	.026	.063	.....
Carbonic, CO_3	.....	10.1	.136	.128	.....
Chlorine, Cl	160.0	23.9	1.90	.460	58.65
Sulphuric, SO_4	35.6	10.5	.41	.064	3.30
Nitric, NO_3	4.4	2.6	.071	.011	.....
Nitrous, NO_2	.115	.013	None	None	.....

BIOCHEMISTRY.

CHEMISTRY OF THE DATE-PALM FRUIT.

The results of investigations on the relation of invertase to the ripening of the date have been published in a paper by A. E. Vinson, entitled The Endo and Ektoinvertase of the Date, Journ. Amer. Chem. Soc., Vol. XXX, No. 6, June, 1908. It was shown that invertase, which in the green condition of the fruit is insoluble in the ordinary solvents of enzymes, becomes soluble when the fruit ripens. This was proven to be independent of the presence of soluble tannin but probably due to some change in the chemical relation of the enzyme to the protoplasm and not to a change in the permeability of the plasmatic membrane. Further studies on the date are being made to determine why certain varieties sour on the tree during unfavorable weather, while others do not. It has been found that each variety ripens when the fruit contains approximately a quantity of dry matter peculiar to itself. In some cases this was not over 54 per cent in the partially ripened and 60 per cent in the fully ripened fruit, which would correspond to juice sufficiently dilute to furnish a favorable medium for the growth of yeast and bacteria. During fair weather this juice is concentrated rapidly by natural drying and the fruit becomes virtually sugar cured. Other varieties begin to ripen first when the dry matter in the green fruit exceeds 60 per cent, and contain when fully ripe, 70 per cent or more of solids.

Such varieties are perfectly sugar cured when they ripen. Consequently they tolerate considerable damp weather before absorbing sufficient moisture to render their juice fermentable. Comparative tests have shown no appreciable difference in the hygroscopic character of the dry matter of different varieties.

A LABORATORY METHOD OF SCOURING WOOL.

The determination of pure wool in a fleece, without subjecting the whole to either hand or machine scouring, is very desirable in many phases of experiment station work. The breeder should strive to produce not only a maximum weight of fleece but one which will scour with minimum loss. It is also desirable to know the effect of changed conditions on the scouring quality of wool, such as bringing flocks from the range to alfalfa pastures in the valleys. Furthermore, such a method would afford a convenient means of defending the flockmaster against the discriminations of the buyer. The loss in scouring wool is due to the removal of two classes of substances: the yolk, which is a normal physiological secretion of the animal, and foreign dirt, including seeds, sand, etc., for which the nature of the wool is only in part responsible. An open fleece permits the ready access of dirt, while a close one prevents it; but the conditions under which the animal is kept are of far greater importance in causing this loss. Thus from the breeder's standpoint it is often advantageous to distinguish between the two sources of loss, since the latter is only partially amenable to better breeding.

When pure wool is to be determined, we have followed a method based on that used by wool-scourers in which the wool is placed immediately into the scouring solution; but when sand and dirt are desired in addition to pure wool, a preliminary washing in clear water facilitates the determination. The following scouring solutions are used:

FIRST WATER.

Potassium carbonate	4.6	parts
Soap (olive or red oil)	3.5	"
Water	1000	"

SECOND WATER.

Soap	30	parts
Water	1000	"

The soap and potassium carbonate are kept for convenience in stock solutions of one part to ten of water. These may then be measured off instead of weighing Wool-scourers use very much stronger stock solutions but they are not suitable for laboratory use. The sample of wool, weighing about 25 grams, either with or without preliminary washing in clear water, is placed in a suitable vessel with sufficient of the first solution to cover it nicely and permit thorough washing. It is then manipulated with the fingers from one-half to one hour, during which time the temperature is held at 50° to 51° C. The wool should be pulled apart rather than pressed, so as to permit the free escape of dirt and reduce matting to the minimum. Straw, seeds, and burrs are separated and laid aside to be weighed with the dirt. After washing thoroughly the wool is pressed out of this bath with the hands, and the few remaining fibers caught on a piece of wire netting. The solution may now be set aside to allow sand and dirt to settle out, if these are to be determined.

The second scouring is conducted like the first, using the second solution, which lathers very freely, and holding the temperature at 52° to 53° C. This is about the extreme limit that can be borne by the hand, but will not scald. After washing thoroughly, remove the wool as before and rinse at least five times with water at about 38° to 40° C. The first two or three rinse waters will still contain some sand if the water is very dirty, and should be reserved for the dirt determination. The various sediments are washed several times by decantation, combined, dried, and weighed. The wool is spread out, thoroughly air-dried, weighed, and percentage of air-dried wool calculated. This is then further dried for some hours over concentrated sulphuric acid, again weighed, and percentage of pure dry wool calculated.

The method was applied first to a small lot of very clean, greasewool from the shoulder, which could be sampled easily. The samples were of 10 grams each and gave larger differences than would be expected when working with larger samples. These scoured 58.2 and 59.0 per cent, respectively, of pure wool, and gave 4.1 and 4.5 per cent dirt. By far the greater difficulty in scouring small samples lies in taking the sample. With care

and some practice it is possible to take consecutive samples varying from each other by not much over two per cent. This was tried on a several pound lot of wool with the following results:

PURE WOOL IN GREASEWOOL.

	Air-dried.	Over sulphuric acid	At 100° C	Dirt.
No. 1 . .	48.93	46.7	46 1	20.6
No. 2	51 44	48 9	48 3	20 1

It is interesting to note in this connection that if the yield of pure wool is corrected for the average amount of dirt, 20.3 per cent, it becomes 59 6 per cent, which is approximately the same as was found for the wool previously mentioned. The greasewool contained 20 per cent of ash, whereas the scoured wool contained but 1 46 per cent

This method was next compared with hand scouring of an entire fleece by the tub method Two separate samples of 25 grams each were taken from the fleece and scoured in the laboratory, while the remainder was scoured in a tub. In taking the samples, the fleece was spread out and taken up in portions about the size of the hand from each of which a correspondingly large tuft was removed and reserved for the laboratory test. The entire fleece was gone over in this way, which for careful work required from fifteen to twenty minutes. The accurate sampling of a bale of wool would be quite difficult, but the entire product of a flock could be very closely approximated by reserving and sampling separately the entire fleece of about every fiftieth sheep. The sampling, as indeed the entire process, can be done by any painstaking person.

Two fleeces of widely different character were used. That of a Shropshire ram represented a very coarse and rather clean type. It weighed 5 lb. 5 oz. in the grease, air-dried. The other was from a Rambouillet ram, very fine, exceedingly dirty and foul smelling, and weighed 10 lb. 8½ oz. in the grease. The two fleeces, while varying greatly in weight, were about equal in bulk both before and after scouring The scouring mixture in the case of the fine-fibered Rambouillet required further strengthening, but this is a matter which must be decided by the operator,

since the mixture must be varied to match the wool. The results are given in the following table:

Breed.	Method.	Sample.	Air-dried.	Over sulphuric acid.
Shropshire...	Tub.....	Entire.. .	55 9	53.8
	Laboratory .	Sample 1 ...	54.5	53.4
		Sample 2 ...	52.9	51.3
		Average..	53.7	52.4
Rambouillet...	Tub..... .	Entire.	32.0	30.9
	Laboratory .	Sample 1 ...	31.3	29.8
		Sample 2 ...	31.5	30.2
		Average..	31.4	30.0

In both cases the laboratory method gave lower results than the tub method using the whole fleece. This is due in part to the more thorough cleansing of the smaller sample.

From these results it appears that the yield of pure dry wool by the laboratory method, using a small sample, corresponds closely with that obtained by scouring the whole fleece with the same solution. The laboratory method has the following advantages:

1. It requires no more time than the tub method and is much more agreeable.

2. It can be carried out at a much lower cost for materials, and leaves the bulk of the fleece in condition to sell or use for further tests.

3. The temperature can be controlled with greater accuracy.

4. The pure wool is left in better condition for further chemical or physical examination, since matting can be avoided to a degree practically impossible in the tub.

5. The entire scoured sample can be dried over sulphuric acid and does not require further sampling as in the case of the whole fleece.

6. The laboratory method also permits the determination of foreign dirt when desirable.

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Biochemist.
W. H. ROSS,
Assistant Chemist.

IRRIGATION INVESTIGATIONS.

The underground waters of the Rillito Valley, described in the last Annual Report, have been further studied during 1908. Deep drilling with a portable well rig of the walking beam type has furnished important information concerning the geology and earlier topography of the valley, and has revealed deep beds of water-bearing gravel of great value. It now seems quite conclusively proven that an agricultural district of eight or ten thousand acres can be developed in the vicinity of Tucson, principally in the Rillito Valley. An important problem still to be solved is the cheap power problem. There are water power possibilities in neighboring mountains, but they require high capitalization and very expensive construction. All fuels are brought in by freight from California and New Mexico and are expensive to use. Small individual power plants operated by farmers have many drawbacks. It is believed that the ultimate solution will be a central power plant situated near the railway northwest of the city, and electrical distribution to pumping plants situated at strategic points where the underground water supply can be drawn upon most effectively.

DUTY OF WATER.

For several reasons it has seemed desirable to collect some information concerning the duty of water in the Santa Cruz Valley. The cost of pumping per acre, the water supply needed for a given acreage, and the adjudication of water rights all require actual or assumed knowledge of this function of irrigating streams.

A beginning was made in 1908 by measuring the duty of water on two alfalfa fields, one of 47.7 acres situated in heavy loam and watered by a gravity ditch from the Santa Cruz river, the other of 23.2 acres in clayey soil watered from a pumping plant. The former was naturally divided into two plats, and the records were obtained separately for much of the time. The results may be briefly summarized as follows:

Field No.	Plat.	Depth of water applied.	Depth of water per ton of alfalfa.
		Inches.	Inches.
1	A	85.7	19.8
	B	55.4	11.5
2		13.75	5.7

The very high result on plat A was due to the carelessness of incompetent irrigators, who applied no less than forty inches depth of water in one irrigation in the latter part of April. At least fifty-five acre-feet of water was absolutely wasted thereby.

It will be observed that the depth of water applied to Field No. 2 was only about one-fifth the amount used on Field

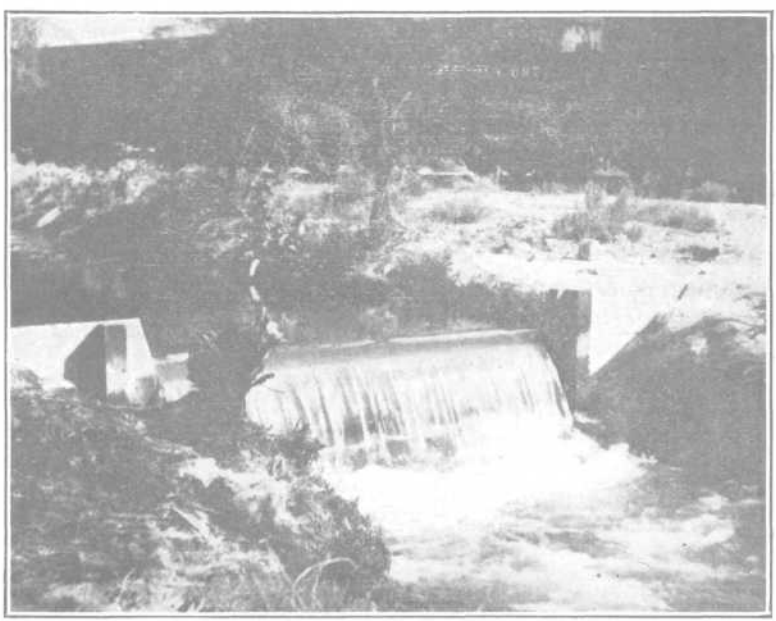


Fig. 2. Seven-foot Cippoletti weir on Flowing Wells ditch, costing $26.50; with a capacity of thirty cubic feet per second.

No. 1; and the difference in soil texture was not enough to account for much of the discrepancy. So far as economy of water is concerned Field No. 2 gave the better results, for it must be inferred that to have doubled the crop on Field No. 2 would

have required the application of four times the amount of water These results might be modified by a consideration of the rainfall. Two and a half inches of rain in February and March contributed to the growth of the first crop, while seven inches of summer rainfall in July and August made further irrigation unnecessary for the fourth cutting.

CONCRETE CAISSON WELLS.

In many sections of the Southwest two facts relating to irrigation stand out prominently: first, the future development of irrigating water will be almost wholly by pumping; second, no other feature of a pumping proposition is of such importance, and at the same time so neglected, as the wells.

The usual irrigator's well in Arizona is a shallow timber-curbed well of temporary construction and of too limited water supply. There are some drilled wells, and this type is to be recommended where deep water-bearing gravels exist. But in many valleys the water supply is limited to shallow beds of gravel, and wells of great lateral dimensions are required. This is especially true of the Santa Cruz Valley, where the gravel beds are often less than twelve feet in thickness.

For irrigating purposes it is believed that caisson wells of reinforced concrete should be widely adopted, since they combine the four qualifications of ease in sinking, large water supply, comparative economy in cost, and permanency.

Such a well was designed and built under the auspices of this Station during the spring and summer of 1908. It has been fully described in the Cement Age, October, 1908, to which reference is hereby made, but a brief description will be given.

The concrete casing is circular, eight feet in diameter inside, and twenty-four feet in depth. It was built at the surface of the ground, in sections three feet high, and was allowed to sink slowly downward while the interior was being excavated. The concrete wall tapers from eleven inches in thickness at the shoe to eight inches at the top.

The shoe is built of two-inch plank, protected by a small angle-iron. The lower or cutting face is five inches wide. More recently a similar well has been built by the same foreman, using a concrete shoe, at a considerable saving in cost.

The reinforcement consists of vertical bars one-half inch square, and of old wire cable wound up spirally through the concrete at intervals of twelve inches.

The concrete was mixed in the proportions of five barrels of gravel and two and a half of sand per barrel of cement. Much of the sand and gravel used was excavated from the well and was of excellent quality. Only high grade cement was used, a rule that should be general in a territory where freight rates make the cheaper brands of cement almost as high in price as the very best brands.

Seep holes through the concrete wall are provided at intervals of twelve inches horizontally and nine inches vertically. They taper outward to a minimum diameter of three-fourths of an inch. Recesses were left in the wall for placing timbers to support the pump frame.

No difficulty was experienced in sinking the caisson or in keeping it plumb. Many large boulders were encountered under the shoe, several being over twenty inches in longest dimension. They were readily undermined and brought into the well by the use of a long-pointed pick. Progress in sinking was limited only by the difficulties of handling the large volume of water, for workmen cannot excavate advantageously while standing in more than two feet of water.

With a set of metal forms which can be used repeatedly, and with experience in building and sinking the wells, the cost can be made as low as that of the inferior wells now in vogue. In cases where the waterlevel is twenty-five feet or more below the ground surface, it will be economy to build a four-inch wall *in situ* from the waterlevel up, after which the caisson can be built nd sunk from the waterlevel downward.

PUMPING PLANTS FOR IRRIGATORS.

Timely Hint No. 67, on this subject, was published in December, 1907. It is intended to assist the individual rancher who owns or contemplates purchasing a small pumping plant. Tests of existing plants are described and errors pointed out. Wells, pumps, power, and piping are separately treated and discussed. The need of symmetry in a pumping plant, and the

necessity for careful design are shown, and a simple method of testing a plant is given.

MISCELLANEOUS.

Much cement testing has been done, and the quick setting of cement under the influence of high temperatures has been studied. At the request of county officials, the boundary line between Yuma and Maricopa counties was determined by longitude observations. Pumping plants have been tested, and much correspondence has been had with owners of pumping plants.

To encourage the measurement of ditches by weirs, an open offer was made at the beginning of the season of 1908 to install weirs if the material were furnished. In this way weirs were installed on the Flowing Wells, Farmers', Indian School, and Bayless ditches.

Reconnaissance trips to study the water resources of the Santa Cruz were made to its headwaters and down the river to the point where it ceases to have any definite channel.

At the request of the Board of Supervisors of Pima County a design was made for the county bridge over the Rillito River, and during its construction the bridge was daily inspected. On account of some novel features a brief description may not be out of place. After the summer floods the groundwater level sinks to a depth of sixteen feet below the river bed. Advantage is taken of this in the omission of the steel cylinders usually found on piers in sandy river beds. Each pier consists of two pedestals especially designed to resist the swift current of the Rillito floods. They have a sharp point up stream, and curved shoulders, the same principle being involved as in the design of a ship. The pedestals rest on broader concrete footings on driven piles, and are braced together by a reinforced concrete web. There are five steel spans, each of sixty feet length. The trusses are of the Pratt type with four panels. They are designed to carry a concentrated load of eight tons. Pile trestle approaches are provided at each end, as the river bed is very wide.

G. E. P. SMITH,
Irrigation Engineer.

THE WEATHER FOR 1908.

The weather, the world over, is the one topic that never fails to be of interest; and as Arizona weather is of the somewhat different sort it has attracted a rather unusual amount of attention. A review of certain of the year's phenomena, therefore, seems to be advisable, together with more or less reference to our climatic conditions in general.

The Territory, with an area of almost 114,000 square miles, extends from north to south over nearly six degrees of latitude, and has altitudes varying from less than 90 feet above sea-level in the Colorado Valley below Yuma to over 13,000 feet on the highest mountain peaks; so that there are necessarily great differences in temperatures and precipitation in various localities. But the region as a whole has what is termed an inland arid climate, there being no large body of water contiguous to any part of its area, and the intervening mountain ranges shutting out most of the moisture-laden breezes from the Pacific Ocean. The air is therefore dry to an unusual degree, the amount of precipitation is relatively quite small, the number of sunshiny days in the year is large, and the geographical location results in semi-tropical temperatures in a considerable portion of the Territory.

TEMPERATURES.

The high temperatures recorded during the summer months in portions of Arizona have perhaps caused more comment than any other feature of our climate. The following table has therefore been compiled from data published by the U. S. Weather Bureau, showing the highest and lowest temperature for each month of the year, as well as for the year as a whole, at seven representative points, of which Fort Mohave, Flagstaff, and Holbrook are located in the northern half of the Territory, in the western, central, and eastern parts, respectively; while

Yuma, the Experiment Station Farm near Phœnix, the University of Arizona near Tucson, and Willcox stretch in a similar order across the southern half. The elevation above sea-level of each place is also given in the table.

MAXIMUM AND MINIMUM TEMPERATURES RECORDED EACH MONTH AND DURING THE YEAR AT SEVEN REPRESENTATIVE POINTS.

	Fort Mohave.		Flagstaff.		Holbrook.		Yuma.		Station Farm, Phoenix.		University, Tucson.		Willcox.	
Elevation, feet...	604		6907		5069		141		1092		2434		4164	
1908	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
January.....	79	30	54	3	59	16	75	35	73	28	76	26	65	16
February.....	87	36	60	−12	72	4	87	28	83	27	84	22	77	19
March.....	98	34	71	6	79	20	96	40	91	30	88	28	82	24
April.....	100	45	72	16	81	26	99	41	93	40	91	36	85	30
May.....	*	*	71	22	86	31	101	46	98	44	96	41	91	35
June.....	117	55	83	23	102	31	112	50	111	43	108	43	100	38
July.....	118	70	84	41	99	52	114	69	108	62	106	64	101	50
August.....	119	64	84	44	100	55	110	72	105	67	100	63	96	60
September.....	117	58	83	25	95	27	109	51	107	46	102	48	94	35
October.....	103	38	74	15	85	20	104	38	100	36	98	29	90	21
November.....	*	*	62	6	81	18	90	30	91	31	88	25	81	27
December.....	*	*	48	−14	73	16	72	34	76	27	74	23	70	16
For the year.....	119	30	84	−14	102	4	114	28	111	27	108	22	101	16

* Not given

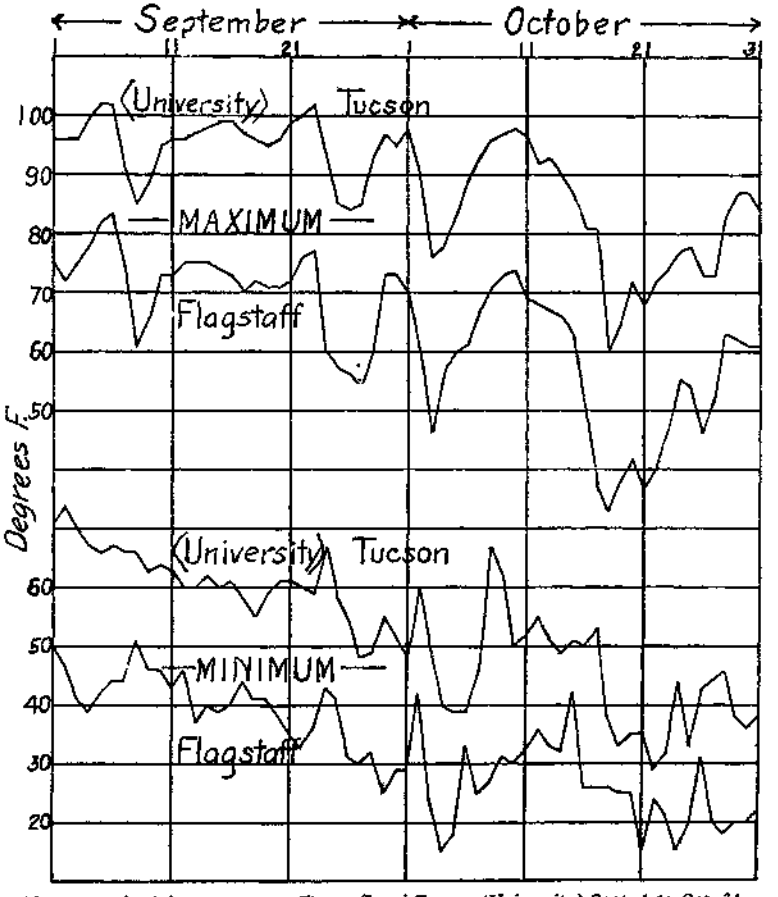
As the respective maximum and minimum temperatures given in the foregoing table for the most part occurred on but a single day, the following table has been similarly compiled to show the averages, or means, of the maxima and of the minima for each month at the same points.

AVERAGES, OR MEANS, OF THE MAXIMUM AND MINIMUM TEMPERATURES FOR EACH MONTH OF THE YEAR AT SEVEN REPRESENTATIVE POINTS.

	Fort Mohave		Flagstaff.		Holbrook.		Yuma.		Station Farm, Phoenix.		University, Tucson.		Willcox.	
1908	Mean Max.	Mean Min.	Mean Max.	Mean Min.	Mean Max.	Mean Min.	Mean Max.	Mean Min.	Mean Max.	Mean Min.	Mean Max	Mean Min.	Mean Max.	Mean Min
January.	67	40	43	18	51	23	69	43	68	35	68	35	60	25
February	67	43	41	15	53	26	69	43	67	38	63	36	60	28
March.	77	44	52	24	64	30	81	49	77	42	76	42	74	34
April ..	90	54	58	27	70	35	88	54	85	48	82	46	76	38
May...	*	*	60	30	74	38	90	55	89	52	87	50	83	40
June.. . .	105	67	74	37	89	47	101	62	100	59	99	59	95	50
July.... .	111	78	80	51	95	59	106	78	102	73	97	71	92	64
August .	109	77	75	50	89	60	104	78	101	74	95	70	89	64
September .	100	67	71	40	86	49	99	66	98	63	95	61	87	54
October.	85	51	56	26	73	31	85	51	86	46	83	45	78	32
November	*	*	51	18	69	25	78	47	77	43	75	41	67	37
December ..	*	*	41	14	53	25	65	42	66	38	65	37	59	26

* Not given.

From the table of extremes it will be seen that there is a wide range of temperatures each month, and on comparison of these extremes with the means of the maxima and of the minima it will be evident that great variations likewise occur from day to day. These were more violent this year during September and October, and the following cut shows the maxima and minima curves for those two months for the University near Tucson and for Flagstaff.



Maxima and minima curves for Flagstaff and Tucson (University) Sept. 1 to Oct. 31, 1908, showing their synchronous character.

The cut also forcibly calls attention to the uniformity in point of time with which temperature variations occur at these two places, which are over two hundred miles apart as the bird flies. It may be added that this uniformity holds good for Flagstaff and Tucson for the rest of the year, and applies in a somewhat less degree also to most of the Arizona towns at which Weather Bureau stations are maintained. This would seem to

indicate that these great changes in temperature from one day to another result from air movements of such magnitude that they affect vast areas in a similar manner.

There are likewise equally striking variations in the temperatures during each twenty-four hours, as will be seen from the following table, which at the same time shows the temperatures at different hours of each day during the most severe hot spell of last summer at Tucson.

VARIATIONS OF TEMPERATURE DURING HOT SPELL AT TUCSON, JUNE 22 TO JULY 4, 1908.

	1 A. M.	4-5 A. M.	8 A. M.	10 A. M.	12 NOON.	2-3 P. M.	5 P. M.	8 P. M.	10 P. M.	Daily range.
June 22.	67	58	88	92	96	100	97	85	79	42
" 23	74	62	86	96	98	103	99	84	78	41
" 24	68	59	94	104	106	108	101	94	92	49
" 25	87	84	96	101	104	106	102	88	82	26
" 26	75	70	97	104	106	108	104	97	88	38
" 27	80	78	92	98	102	105	102	94	86	27
" 28.	78	67	88	94	100	103	101	88	84	36
" 29	72	69	90	90	103	104	99	85	80	35
" 30	68	60	95	103	106	107	102	86	84	47
July 1	72	64	94	101	103	106	101	90	85	42
" 2.	76	71	91	98	102	104	100	88	88	33
" 3	79	70	88	95	100	103	100	90	85	33
" 4	77	73	92	98	102	104	100	89	84	31

These rather violent fluctuations are due principally to the dryness of the air, which allows extremely rapid losses of heat by radiation from the soil, from water surfaces, and from buildings and other objects the moment the direct rays of the sun for any reason no longer strike them.

From a human standpoint there are two beneficial effects of this dryness. In the first place it makes easily endurable degrees of heat that in more humid regions would be intolerable. This results from the rapidity with which the perspiration is evaporated from the body, keeping it comparatively cool so long as the supply of moisture is maintained by an ample supply of water. A temperature of 90 degrees in Eastern States invariably causes many fatalities; while even in those parts of Arizona where the thermometer may register from 105 to 115 degrees in the shade each day for weeks at a time, sun-stroke

is unknown. Secondly, a dry atmosphere insures that comparative coolness during the night time which makes refreshing sleep possible every night in the year, and blankets a necessity during most of them.

PRECIPITATION.

The following table shows the total precipitation for each month and for the entire year at the same seven points for which temperature data have been given:

MONTHLY AND ANNUAL PRECIPITATION AT SEVEN REPRESENTATIVE POINTS.

1908.	Fort Mohave.	Flagstaff.	Holbrook.	Yuma.	Station Farm, Phoenix.	University, Tucson.	Willcox.
January...	0.12	1.21	0.67	0.16	0.30	0.76	0.71
February..	1.07	2.89	1.49	0.84	1.97	2.08	2.15
March.....	0.11	1.94	0.52	0.08	0.42	0.39	0.58
April.....	0.10	1.10	0.81	0.05	1.12	0.10	0.24
May.....	*	1.43	0.66	0.00	0.04	0.16	0.12
June.....	0.00	0.69	0.24	0.00	0.00	Tr.	Tr.
July.....	0.50	3.90	2.15	1.34	2.78	4.77	3.89
August.....	0.10	4.69	2.71	0.30	1.81	2.18	1.63
September...	1.13	0.99	0.26	0.34	0.47	0.55	0.34
October.....	0.05	0.99	1.31	Tr.	0.53	0.26	Tr.
November...	*	0.34	0.21	0.24	0.50	0.17	0.41
December...	*	5.74	1.51	2.58	1.97	2.62	1.09
Total for year	†3.18	25.91	12.54	5.93	11.91	14.04	11.16

*Not given. †As far as given.

At Flagstaff and Holbrook a considerable portion of the winter precipitation fell in the form of snow, there having been a total snowfall of 77.5 inches at the former place and 22 inches at the latter during the year. Fort Mohave, Yuma, and Phœnix had no snow during 1908. The only snowstorm at Tucson was on the morning of February 13, four inches of snow being on the ground at the University at 6:30 o'clock A. M., practically all of which was melted before noon. Willcox had six inches of snow in February, and no more during the year.

During this year, as always, there were heavy falls of snow in the mountains, not only in the northern part of the Territory, but also in southern Arizona. This has an important bearing

upon irrigation, as these mountain snows on the various watersheds act as great reservoirs whose supplies are released by the melting of the snow and flow down into the irrigated valleys at a time approximately midway between the winter and summer rainy seasons. In the many valleys which have as yet no reservoir constructions established or under way, this great water storage provision of Nature will be a main reliance for many years to come.

Taking the Territory as a whole, the precipitation for the year has been slightly above the normal; while for Tucson it is over three inches higher than the average for the preceding twenty-seven years. Arizona has two rainy seasons, one occurring in July and August and the other usually beginning in November and often continuing more or less intermittently until the last of February. During 1908 it will be seen from the preceding table that there was at least some precipitation practically every month of the year at the seven points given, which is rather unusual. The summer rains this year were the heaviest, in certain cases causing damage from washouts. For instance, there were three distinct floods at Bisbee in August, causing considerable property loss, as against none for many years previously. The rain was in some cases accompanied by hail, the Experiment Station Date Orchard at Tempe suffering the loss of nearly half of this year's crop of dates in the storm of July 12. The driest month of the year was June, during which month several of the water courses in the southern section of the Territory became almost dry. In general, however, conditions have been very good indeed, the widely distributed and somewhat generous (from an arid country point of view) rainfall having kept ranges in good condition and generally benefited the agricultural and stockraising interests, and having also increased the amount of water available for the mining operations which so largely contribute to Arizona's prosperity.

W. O. HAVES,
Secretary.