University of Arizona

Agricultural Experiment Station

Twenty-third Annual Report

For the Year Ending June 30, 1912
(With subsequent items)

Consisting of Reports Relating to

Administration,
Agriculture, Botany,
Plant Breeding, Animal Husbandry,
Entomology, Chemistry,
Irrigation Investigations, and
Agricultural Education

Tucson, Arizona, December 31, 1912

UNIVERSITY OF ARIZONA
AGRICULTURAL EXPERIMENT STATION

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(Regents of the University)

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GEORGE E. P. SMITH, C. E., - - - - - - - Irrigation Engineer
ARTHUR L ENGER, B. S., - - - - - - - - Assistant Engineer
ROBERT W. CLOTHIER, M. S., - - - - - - - - Agriculturist
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CARLOS C. CABLE, - - - - - - - - - - - - Secretary
HELEN M. A. MILLER, - - - - - - - - - - - Librarian

The Experiment Station offices and the botanical and chemical laboratories are located in the University buildings at Tucson. The range reserves (cooperative, U. S. D. A.) are suitably situated adjacent to and southeast of Tucson. The work in horticulture and animal husbandry is conducted mainly on the Experiment Station Farm, three miles northwest of Phoenix, Arizona. The date-palm orchards are three miles south of Tempe (cooperative, U. S. D. A.), and one mile southeast of Yuma, Arizona, respectively. The experimental dry-farms are near Snowflake and Prescott.

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, George W. P. Hunt, Governor of Arizona:

SIR: In accordance with the Congressional Acts of March 2, 1887, and March 16, 1906, I submit, herewith, the Twenty-third Annual Report of the Arizona Agricultural Experiment Station, for the fiscal year ending June 30, 1912.

Very respectfully,

R. H. FORBES,

Director.

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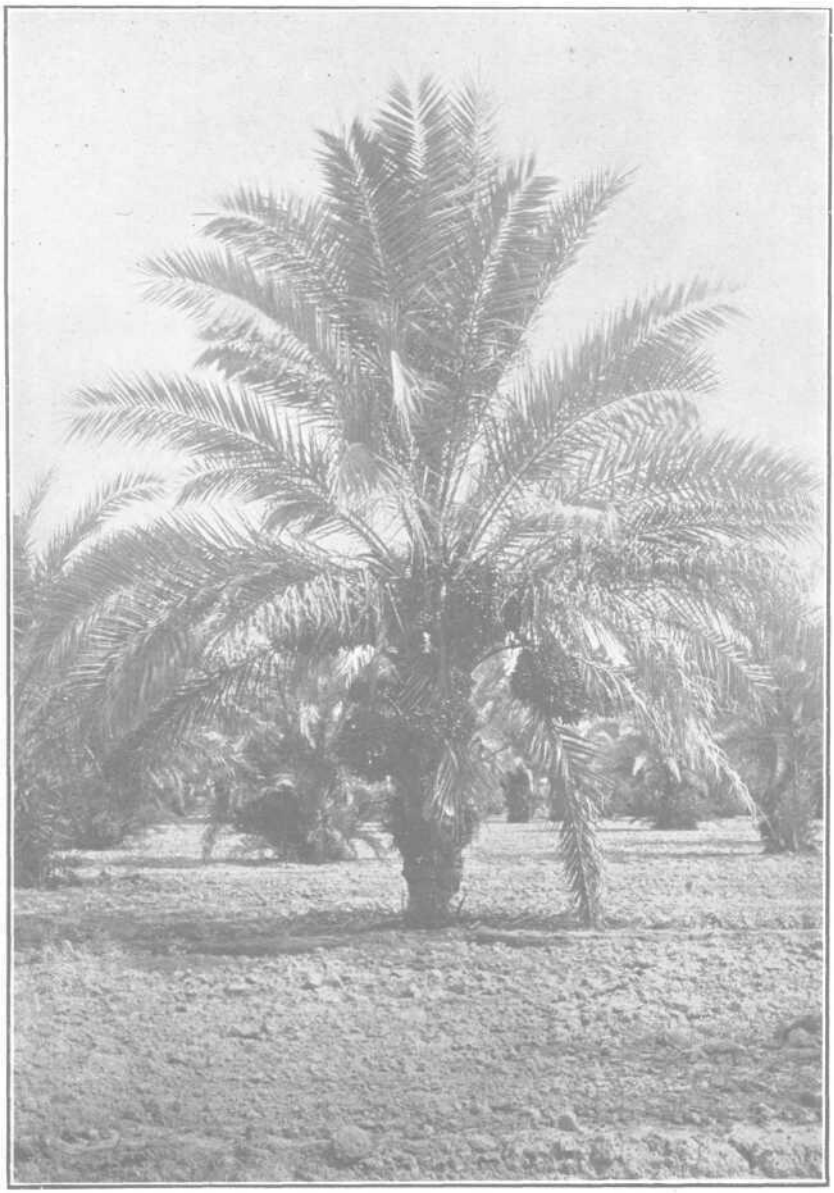

Plate I.—A Birket el Haggi date palm in the cooperative orchard at Tempe. This variety is well adapted to Arizona conditions.

Twenty-third Annual Report

ADMINISTRATIVE

The farmers of Arizona have been blessed with general prosperity during this first part-year of statehood for the Commonwealth. The even tenor of agricultural events has not been marred by unusual calamities—by storms, excessive drought, insect depredations, or market failures; and the tiller of the soil has been permitted, with minor exceptions, to reap the undiminished benefits bestowed upon him by his richly productive southwestern acres.

This generally favorable condition has been accentuated, here and there, by certain noteworthy events and discoveries which it is well to mention. Perhaps the most spectacular of these events was the completion of the siphon under the Colorado River at Yuma and the first passage of irrigating water through it, June 29, 1912. This opens to development 90,000 acres of valley and mesa lands south of Yuma; and will give impetus to the further development of the whole Colorado Valley. Already, in fact, a comprehensive plan for the complete utilization of the Colorado River from its source to its mouth, for irrigating water and for power, by the various states and the two nations interested, is under discussion, and is reasonably possible of achievement. The Newlands river regulation bill, now before Congress, seeks to provide means for the accomplishment of this and other great river-improvement works.

Of importance for the development of groundwaters by pumping, are the recently devised engines using crude oil and the cheap oil residues, which can be laid down in southern Arizona at from four to six and one-half cents a gallon. These engines, which lessen the cost for fuel, in some cases to one-third or one-fourth the cost with gasoline engines, have come into general notice during the year, and lay open to development large areas of underflow territory in Arizona.

Artesian water has been found in three new districts during the year, in the San Simon Valley, along the lower San Pedro, and on the upper Verde. While the artesian supplies of Arizona are not copious as a rule, they are wide-spread and their quality is usually excellent and each of these artesian discoveries has become the center of a new development of considerable area.

Dry-farming operations, aided by favorable summer rains, have been surprisingly successful at altitudes of 4,000 feet and above, in northern and eastern Arizona. There is good reason to believe that extensive areas will ultimately be reclaimed by systems of farming devised to meet our conditions. Drought-resistant crops, dry-farming methods of utilizing rainfall, pumping plants for an insurance water supply, silos to conserve forage, and dairy cows to convert this forage into salable produce are elements of such an agriculture.

In general, the agricultural year has been characterized by a strong tendency to develop new agricultural crops, methods, and areas, among which latter may be mentioned the San Simon, Sulphur Spring, Santa Cruz, Casa Grande, and Maricopa districts in southern Arizona, and many smaller areas throughout the State.

EXPERIMENTAL PROGRESS

Keeping in touch with the agricultural progress of the State, the members of the Station Staff have pursued their studies of underground water supply, especially in Sulphur Spring Valley, in dry-farming, with and without supplementary irrigating waters; in the breeding of alfalfa, beans, and corn; in plant introduction and acclimatization; in sheep breeding; and with dates,—varieties, methods of producing, and marketing. Publication along several of these lines has been made during the year, or is now in progress.

Dry-farming facilities have been increased by the acquisition of 100 acres of land from the Santa Fe Railroad seven miles north of Prescott, Arizona; and another dry-farming area is in process of acquisition in Sulphur Spring Valley. Also, a new and better selection of land for dry-farming purposes has been made near Snowflake.

ADMINISTRATIVE PROGRESS

Consequent upon statehood and in connection with the two sessions of the First State Legislature, careful attention was given to several measures affecting the University and the Experiment Station. Periods of reorganization and initiative, such as the State of Arizona is now passing through, are times either of danger or of opportunity to the ideas, institutions, and interests involved, according to the degree of preparation and vigilance shown in meeting such occasions. Accordingly, the legislative program of the institution was drawn up with proper care, an educational campaign in behalf of desired measures was carried out, and the enactments desired were in due time considered, in most cases amended, and finally became law.

The measures thus acted upon, directly or indirectly of interest to agriculture in Arizona, are as follows:

1. Chapter 41, Session Laws of the First Legislature of the State of Arizona (introduced as Senate Bill 13) provides that the grants of land of 150,000 acres for agricultural and mechanical colleges, and of 150,000 acres for the School of Mines, granted under the Enabling Act, shall be reserved for the use and benefit of these branches of the University of Arizona. This measure provides for the future unity and undivided strength of the University, with consequent benefit to its several parts, including the Agricultural College.

2. Chapter 45, Session Laws of the First Legislature of the State of Arizona (introduced as Senate Bill 42) provides that any high school or normal school may qualify to receive State aid not to exceed $2,500 annually, for teaching elementary courses in agriculture, mining, manual training, domestic science or other vocational pursuits. This law makes it possible for the young people of the State to receive training in these subjects at an impressionable age, at least cost to themselves, without leaving their own homes, and where their study may be conducted with reference to local conditions. These courses, including agriculture, will prepare students for the advanced work of the State University, and will afford a measure of opportunity to those who cannot afford a college course.

3. Chapter 87, Session Laws of the First Legislature of the State of Arizona (introduced as Senate Bill 56) amends the old Horticultural Commission Law to include both agricultural and horticultural plant diseases and insect pests, and improves the old law in other respects where shown advisable by the experience of the preceding three years. This law affiliates the Commission of Agriculture and Horticulture and the Agricultural Experiment Station by making the Director of the Station, *ex officio*, a member of the Commission. Under this arrangement the State entomologist, appointed by the Commission, has also been made entomologist of the Station. This affiliation harmonizes the two organizations and economizes the cost of entomological service for the State.

4. Chapter 88, Session Laws of the First Legislature of the State of Arizona (introduced as Substitute House Bill 57) appropriates $6,000 annually for investigation of the water resources of the State in cooperation with the U. S. Geological Survey, and with the Office of Experiment Stations of the U. S. Department of Agriculture, on condition that these organizations appropriate equal sums for the purpose. This law provides for the coordination, through the Director of the Experiment Station, of this work with similar experi-

mentation by State agencies in order to avoid duplication of work, with consequent waste of public money.

5. Chapter 19, Session Laws of the First Legislature of the State of Arizona (introduced as House Bill 54) appropriates $18,000 for the work of the Experiment Station in dry-farming, date-palm culture, farmers' institutes, printing, horticultural service, assistance and repairs, for one year.

Chapter 92, Session Laws of the First Legislature of the State of Arizona, appropriating $28,000 for University maintenance; and Chapter 32, Special Session Laws of the First Legislature, appropriating $20,000 for University maintenance, include $6,350 which has been designated to the use of the College of Agriculture.

6. Chapter 62, Special Session Laws of the First Legislature of the State of Arizona (introduced as Senate Bill 112) provides for the enforcement of pure food regulations in Arizona, under the joint administration of the Board of Regents and the Superintendent of Public Health.

While the Pure Food Law is not directly agricultural in character, it accomplishes a service with which the Agricultural Experiment Stations are often burdened. This affiliation of related work with the general University organization is, therefore, at once a satisfaction and a relief.

INTERNAL REORGANIZATION

Following these legislative enactments relating more or less directly to agriculture, all agricultural interests within the University, both Agricultural College and Experiment Station, have been consolidated into one organization with a view to greater efficiency in the use of funds and facilities; and in order to arrange for additional courses of instruction by the specialists of the Experiment Station Staff.

These various measures, without and within the institution, have accomplished several very important things: The consolidation of University, Agricultural College, and School of Mines land grants unifies the endowment, and makes possible the development of a strong and widely influential institution in and for the State. The endowment of agricultural courses in the high schools will prepare a larger number of students to avail themselves of advanced work in the University, and will bring University and high schools into yet closer relations. The affiliation of the Commission of Agriculture and Horticulture, and the Experiment Station, harmonizes these two organizations and materially economizes expenditures for entomological service for the State. In the cooperative irrigation investi-

gations the duplication of State work is provided against, through the Experiment Station. Appropriations sufficient for the year were made; and, finally, the most effective use of these advantages is arranged for by harmonious organization.

This all means that the State of Arizona has gone a long way towards the creation of a unified, coordinated, and comprehensive agricultural service organization, which avoids the wasteful errors of duplication of departments so frequently observed in older States, and which, ultimately, will secure the most efficient and economical administration of agricultural interests for the State.

PRESENT REQUIREMENTS

Most evident of the needs of Agricultural College and Station is a suitable building. For over twenty years the Staff has been crowded into the basement story of the old University Main Building. These rooms, though comfortable in summer, are now inadequate, and better facilities are imperative. The following extracts from the Examiner's Report (1912) to the Governor of the State clearly sets forth the need of additional room and the value of the work accomplished for agriculture:

> "The date orchards at Tempe and Yuma, the dry-farming stations at Snowflake and Prescott, the Experiment Station Farm at Phoenix, and various other stations are directly under the supervision of the Experiment Station * * * *
>
> These stations are of great value, the results of the various experiments being compiled in book and pamphlet forms, which are mailed to all interested parties. The Experiment Station has a live mailing list of 5,500 names. The books or pamphlets are mailed in franked envelopes which are supplied by the U S Department of Agriculture. * * * *
>
> As before stated in this report, the quarters occupied by the Experiment Station are inadequate, and we recommend for your serious consideration an appropriation to meet the requirements as stated in the estimate of the Director * * * *
>
> It is our opinion that the work of the Experiment Station has done much for Arizona and it should be given all possible support."

Additional land is needed, also, both at Phoenix and at Yuma, to give more room for work which has now entirely outgrown present accommodations.

With these additions to material equipment and with a moderate increase in appropriations with which to maintain and in some cases enlarge the organization, Station and College will be able to enter upon a larger sphere of usefulness, commensurate with the increased demands being made upon it by a growing agricultural population.

PERSONAL

Very few changes in the Scientific Staff or in the corps of expert workmen have taken place during the year. Dr. W. H. Ross, accepting a connection with the Bureau of Soils, U. S. Department of Agriculture, has been succeeded as Assistant Chemist of the Station by Mr. C. N. Catlin recently of the University of Nebraska. Mr. F. C. Kelton, Assistant Engineer, has gone to the engineering staff of the University, being succeeded by Mr. A. L. Enger of the University of Illinois. Professor J. J. Thornber returned in September, 1912, from a year's leave of absence which he spent in botanical work in the collections of the Smithsonian Institution and of Harvard University. Professor F. W Wilson has gone to the University of Illinois on a year's leave, beginning in August, 1912.

The organization and the State which it serves are fortunate in the public spirit with which the members of the Staff, its foremen in charge, and its experienced workmen have devoted themselves to the advancement of agriculture in the Southwest. This is characteristic of true professionalism, which cares more for the opportunity to render service than for its own welfare. In fact, the most prized return for such service is, usually, the feeling that it has been of real value to those to whom it was rendered.

PUBLICATIONS

Publications for the year, including Bulletins, Annual Reports, and Timely Hints for Farmers, are as follows:

Bulletin 67, December 20, 1911. Native Cacti as Emergency Forage Plants. — By J. J. Thornber.
and, Nutritive Value of Cholla Fruit — By A. E. Vinson.

Twenty-second Annual Report, December 30, 1911. — By the Station Staff.

Timely Hints for Farmers:

No. 90, December 15, 1911. Farm Sanitation. — By W. H. Ross.

No. 91, January 1, 1912 Resistance to Frost of Introduced Trees and Shrubs. —By J. J. Thornber.

No. 92, February 1, 1912. The Tepary Bean, a New Southwestern Legume. —By G. F. Freeman.

No. 93, March 1, 1912. The Intensive Cultivation of Alfalfa —By R. H. Forbes.

No. 94, April 2, 1912. The Sorghums for Dry-Farming in Southern Arizona. —By R. W. Clothier.

No. 95, June 1, 1912. Windmills for Irrigation Pumping. —By G. E. P. Smith.

Papers published in scientific and technical journals:

La Cienega Subsurface Dam. —By G. E. P. Smith.
Engineering and Contracting, XXXVI, 4, July 26, 1911.

The Tepary Bean. —By G F. Freeman.
Horticultural Review of Algeria, Vol. 16, No. 10 (1912).

In addition to these more formal publications, several popular articles on agricultural subjects have been contributed to Arizona and California papers by different members of the Station Staff.

The bulletin output for this year was limited to some extent by the exhaustion of the printing appropriation, which was renewed by the First State Legislature and is now being utilized for the publication of accumulated manuscripts.

FINANCIAL

For the fiscal year beginning July 1, 1912, the First State Legislature appropriated $18,000 for the use of the Experiment Station, as follows:

For dry-farming experiments at three locations	$6,500.00
Date-palm culture at Tempe and Yuma	3,000.00
Printing and binding	2,000.00
Farmers' Institutes and Demonstration Train	2,500.00
Horticultural service	2,500.00
Assistance and repairs	1,500.00
	$18,000.00

These amounts are fairly adequate for the year for which they were appropriated; but, as remarked elsewhere, a moderate increase will be called for in securing certain needed facilities, and in adding to the service asked of the Station for the next two years.

It should be mentioned here that the supplementary State appropriations are necessary for at least two reasons: (1) The Federal funds are restricted as to the purposes for which they may be expended, and (2) they are fixed in amount and cannot be made to meet increased demands for agricultural service in the State. In the expenditure of Federal funds the following limitations must be observed: The Hatch Fund ($15,000.00):

1. Not more than 5 percent ($750.00) of this fund can be spent for buildings each year.
2. The Hatch Fund cannot be expended upon substations other than the one experiment station recognized by the law.
3. The Hatch Fund cannot be spent for purchase or rental of land.
4. The Hatch Fund cannot be employed in the payment of teachers in the college, but must be used only for experimental work.
5. The Hatch Fund cannot be used for institute work.
6. The Hatch Fund cannot be used to print publications relating to work of substations; *i. e.*, dates, dry-farming, work at Yuma, etc.

The Adams Fund ($15,000.00):

1. Cannot be used for administration, care of buildings or grounds, insurance, furniture, demonstration work, institutes, and general maintenance.
2. Cannot be used for printing or distribution of publications.

These restrictions as established in Congressional acts, and rulings under these acts, make it impossible for us to conduct the work at Yuma, dry-farming work at Prescott, Snowflake, and in Sulphur Spring Valley, hold Farmers' Institutes, or print the major part of our literary output without *State* appropriations.

In this connection, the railroad funds derived from the Southern Pacific, the El Paso and Southwestern, and the Santa Fe railroads, all three of which have subscribed to Station projects during the year, are of especial value in supplementing both Federal and State moneys.

To the Prescott Chamber of Commerce, also, the Station is indebted for a subscription of $1,500 which was spent for dry-farming experiments near that city.

Following is the usual detailed financial statement, exhibiting the expenditure of each fund, by schedules, departments and projects, for the year. The income of the Station for the year ending June 30, 1912, amounting to a total of $45,446.52, was derived as follows:

The Hatch Fund, from the U S Treasury			$15,000 00
The Adams Fund, from the U S. Treasury			15,000 00
Farm Sales, Station Farm	$1,161 15		
Sales, Tempe Date Orchard	522 31		
Produce, Yuma Date Orchard	501.98		
Misc. receipts, rentals, fees, refunds, etc.	684.97	$2,870 41	
Overdraft at beginning of year	35.67		
Balance forwarded to 1912-13	1,108.38	1,144.05	1,726.36
El Paso and Southwestern R. R. Fund			2,317.58
Prescott, and Santa Fe R. R. Fund			2,499.39
Board of Control, 1911, Dry-Farming			2,203.73
" " " Publications			1,800.00
" " " Institutes			1,600.00
" " " Date-palm Orchards			2,949.46
U. S. Geological Survey, contribution to work in Sulphur Spring Valley			350.00
			$45,446.52

R. H. FORBES,
Director.

EXPENDITURES BY FUNDS, SCHEDULES, AND DEPARTMENTS FOR THE YEAR ENDING JUNE 30, 1912.

		Administration	Agriculture	Animal husbandry	Horticulture	Botany	Chemistry	Entomology	Irr. and meteorology	Tempe date orchard	Yuma date orchard	Miscellaneous	Totals	
Hatch Fund, $15,000.00	Salaries	2789.97	386.25	1846.65	103.84	820.50	363.18	337.50	44.60	.....	.....	.....	6692.49	
	Labor	233.47	.....	1454.14	.....	557.26	422.50	.....	.....	.....	.....	.....	2456.43	
	Publications	182.12	542.82	3.80	.....	2.70	1.20	.....	4.73	.....	.....	.....	737.37	
	Postage and stationery	694.08	9.90	47.97	8.40	.75	1.50	1.90	5.50	32.01	.....	.....	802.01	
	Freight and express	138.67	168.50	83.38	1.88	9.92	18.15	9.26	7.55	39.20	.....	.....	476.51	
	Heat, light and water	.....	.....	.....	1.20	.....	27.49	.....	.....	.....	.....	.....	128.69	
	Chemical supplies	.....	.25	15.70	.....	.....	66.68	5.00	.....	.....	.....	.....	87.63	
	Seeds, plants, sundries	12.23	65.54	245.71	21.93	23.20	14.00	27.75	3.00	134.22	5.00	4.35	556.93	
	Fertilizers	10.00	.....	80.40	80.40	.....	.....	.....	.....	8.40	4.50	.....	183.70	
	Feeding stuffs	.....	6.35	184.39	16.65	20.60	.....	.....	.....	28.05	.....	.....	256.04	
	Library	40.97	2.00	.....	.....	.....	17.00	.....	.....	.....	.....	.....	59.97	
	Tools, imp'ts., mch'y	.....	141.19	192.11	29.29	19.00	.....	12.45	.....	82.50	.....	.....	476.54	
	Furniture and fixtures	34.54	.....	.....	5.00	.....	11.25	.....	3.58	.....	.....	.....	54.37	
	Scientific apparatus	.....	25.00	5.30	.....	.....	39.41	11.75	.....	.....	.....	.....	84.46	
	Live stock	.....	.....	187.75	.....	.....	.....	.....	.....	190.00	.....	.....	377.75	
	Traveling expenses	695.31	12.70	40.90	.....	6.30	.....	.....	30.10	13.50	20.30	.....	819.11	
	Buildings and land	128.57	61.55	174.15	30.39	60.35	69.85	.....	1.50	12.70	.....	.....	750 00	
	Totals	1959.93	1422.05	4562.35	298.98	1520.58	1152.21	408.61	100.56	540.58	29.80	4.35	.....	15000.00
Sales Fund, $1,726.36	Labor	.....	135.55	85.62	1065.10	.....	.....	1.45	7.10	87.00	.....	.....	1381.82	
	Contingent expenses	70.00	43.60	19.50	.....	.....	.....	.....	.....	.50	.....	.....	133.60	
	Buildings and land	.....	.....	210.94	.....	.....	.....	.....	.....	.....	.....	.....	210.94	1726.36
E. P. & S. W. Fund $2,317.58	Salaries	.....	150.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	150.00	
	Labor	.....	219.36	.....	.....	.....	.....	.....	122.00	.....	.....	.....	341.36	
	Freight and express	.....	.....	.....	.....	.....	.....	.....	138.91	.....	.....	.....	138.91	
	Seeds, plants, sundries	.....	24.80	.....	.....	.....	.....	.....	47.03	.....	.....	.....	71.83	
	Tools, impt's., mch'y	.....	.40	.....	.....	.....	.....	.....	670.56	.....	.....	.....	670.96	
	Scientific apparatus	.....	.....	.....	.....	.....	.....	.....	110.20	.....	.....	.....	110.20	
	Traveling expense	.....	94.95	.....	.....	.....	.....	.....	619.37	.....	.....	.....	714.32	
	Rental of land	.....	120 00	.....	.....	.....	.....	.....	.....	.....	.....	.....	120.00	
	Totals	.....	609.51	.....	.....	.....	.....	.....	1708.07	.....	.....	.....	.....	2317 58
Prescott Fund $2,499.39 and Laws of 1911 $500.00	Salaries	.....	652.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
	Labor	.....	272.60	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
	Seeds and plants	.....	30.99	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
	Sundry supplies	.....	576.73	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
	Tools and impt's	.....	230.73	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
	Freight and express	.....	106.59	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
	Buildings and land	.....	309.91	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
	Horses	.....	500.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
	Traveling expenses	.....	319.25	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
	Miscellaneous	.....	.56	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2999.39
Laws of 1911 Institutes $1,600.00	Salaries	.....	Institutes 617.38	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
	Traveling expenses	.....	884.52	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
	Printing	.....	21.25	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
	Postage and stationery	.....	5.45	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
	Sundries	.....	71.40	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1600.00
Laws of 1911 Date Palms $2,949 46	Salaries	.....	.....	.....	.....	.....	.....	.....	.....	900.00	270.00	.....	.....	
	Labor	.....	.....	.....	.....	.....	.....	.....	.....	186.25	1211.62	.....	.....	
	Seeds and plants	.....	.....	.....	.....	.....	.....	.....	.....	.....	19.02	.....	.....	
	Sundries	.....	.....	.....	.....	.....	.....	.....	.....	40.00	33.15	.....	.....	
	Freight and express	.....	.....	.....	.....	.....	.....	.....	.....	.....	10.11	.....	.....	
	Tools and mch'y	.....	.....	.....	.....	.....	.....	.....	.....	.....	36.95	.....	.....	
	Postage, sta'y and tel	.....	.....	.....	.....	.....	.....	.....	.....	.....	27.05	.....	.....	
	Buildings and land	.....	.....	.....	.....	.....	.....	.....	.....	.....	160.81	.....	.....	
	Irrigation waters	.....	.....	.....	.....	.....	.....	.....	.....	.....	54.50	.....	.....	
	Totals	.....	.....	.....	.....	.....	.....	.....	.....	1126.25	1823.21	.....	.....	2949.46

	Totals	.....	609.51	.....	.....	.....	.....	.....	1708.07	.....	.....	.....	.....	2317.58
Prescott Fund $2,499.39 and Laws of 1911 $500.00	Salaries	.....	652.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
	Labor	.....	272.60	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
	Seeds and plants	.....	30.99	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
	Sundry supplies	.....	576.73	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
	Tools and impt's	.....	230.73	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
	Freight and express	.....	106.59	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
	Buildings and land	.....	309.94	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
	Horses	.....	500.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
	Traveling expenses	.....	319.25	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
	Miscellaneous	.....	.56	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2999.39
Laws of 1911 Institutes $1,600.00			Institutes											
	Salaries	.....	617.38	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
	Traveling expenses	.....	884.52	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
	Printing	.....	21.25	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
	Postage and stationery	.....	5.45	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
	Sundries	.....	71.40	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1600.00
Laws of 1911 Date Palms $2,949.46	Salaries	.....	.....	.....	.....	.....	.....	.....	.....	900.00	270.00	.....	.....	
	Labor	.....	.....	.....	.....	.....	.....	.....	.....	186.25	1211.62	.....	.....	
	Seeds and plants	.....	.....	.....	.....	.....	.....	.....	.....	.....	19.02	.....	.....	
	Sundries	.....	.....	.....	.....	.....	.....	.....	.....	40.00	33.15	.....	.....	
	Freight and express	.....	.....	.....	.....	.....	.....	.....	.....	.....	10.11	.....	.....	
	Tools and mch'y	.....	.....	.....	.....	.....	.....	.....	.....	.....	33.95	.....	.....	
	Postage, sta'y and tel	.....	.....	.....	.....	.....	.....	.....	.....	.....	27.05	.....	.....	
	Buildings and land	.....	.....	.....	.....	.....	.....	.....	.....	.....	100.81	.....	.....	
	Irrigation waters	.....	.....	.....	.....	.....	.....	.....	.....	.....	54.50	.....	.....	
	Totals	.....	.....	.....	.....	.....	.....	.....	.....	1126.25	1823.21	.....	.....	2949.46
Laws of 1911 Dry-farming $1,703.73	Salaries	.....	1512.58	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
	Labor	.....	4.25	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
	Traveling expenses	.....	137.70	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
	Sundries	.....	7.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
	Freight and express	.....	14.75	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
	Tools and mch'y	.....	26.40	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
	Postage and stationery	.....	1.05	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1703.73
Laws of 1911 Printing $1,800.00	Ann. Rpt. and 2 bulletins	1517.20	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
	9 Timely Hints	266.80	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
	Sundries	16.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1800.00
	Grand totals	6829.93	8513.83	4878.41	1364.08	1520.58	1152.21	410.06	1815.73	1754.33	1853.01	4.35	.....	30096.52

EXPENDITURES BY FUNDS, SCHEDULES, AND PROJECTS FOR THE YEAR ENDING JUNE 30, 1912.

		Saltbush and cactus	Plant diseases	Toxicity of copper	Date ripening	Underflow investigat'n	Olive products	Alfalfa investigations	Bean investigations	Irr. and meteorology		Miscellaneous		
Adams Fund $15,000.00 and U. S. G. S. contr. $350.00	Salaries	915.00	.....	1616.65	2400.00	4182.18	100.00	1538.16	1497.90	.....	.....	.....	12249.89	
	Labor	.....	.....	.....	.....	2.00	.....	984.39	741.35	.....	.....	.....	1727.74	
	Postage and stationery	.....	.....	.....	.....	36.19	.....	35.93	5.25	.....	.....	.....	77.37	
	Freight and express	.....	.....	.....	8.74	25.52	.....	9.65	.....	.....	.....	.....	43.91	
	Heat, light and water	.....	.....	.....	.....	1.65	.....	.....	.....	.....	.....	.....	1.65	
	Chemical supplies	.....	.....	24.99	115.12	.....	.....	.75	.....	.....	.....	1.00	141.86	
	Seeds, plants, sundries	.....	.....	1.65	6.69	4.75	2.60	49.74	34.15	11.00	.....	.....	110.58	
	Fertilizers	.....	.....	.....	.....	.....	.....	37.74	54.00	.....	.....	.....	91.74	
	Feeding stuffs	.....	.....	.....	.....	.....	.....	.....	5.40	.....	.....	.....	5.40	
	Tools, imp'ts., mch'y	.....	.....	.....	.....	70.00	.....	81.86	76.63	.....	.....	.....	228.49	
	Furniture and fixtures	.....	.....	.....	.....	7.18	.....	138.30	135.00	.....	.....	.....	280.48	
	Scientific apparatus	25.05	.....	6.00	18.65	109.58	.....	7.39	1.35	28.50	.....	.....	196.52	
	Traveling expenses	.....	.....	.....	24.55	81.20	.....	2.50	.....	7.25	.....	.....	115.50	
	Buildings and land	.....	.....	.....	.....	.....	.....	34.19	44.68	.....	.....	.....	78.87	
	Totals	940.05	.....	1649.29	2573.75	4520.25	102.60	2920.60	2595.71	46.75	.....	1.00	.....	15350.00
														$45446.52

AGRICULTURE

DRY-FARMING IN SULPHUR SPRING VALLEY

The attention of the agriculturist has been directed to preparing for publication the results of dry-farming investigations begun at McNeal in Sulphur Spring Valley in 1909, and continued through the summer of 1911 Some of the most promising of the results obtained were published in the Twenty-second Annual Report. A careful study of the data obtained by the three years of investigation has been made, and a bulletin presenting the data with conclusions drawn from it has been written Briefly summarized, these investigations have given the following results

Experiments in conservation of moisture by means of fallowing were unsatisfactory during the entire three years. The summer rainy season resulted in the accumulation of considerable water in the fallowed land, but practically all was lost before the beginning of the next summer's rainy season.

This loss of moisture is probably due to the great daily range in temperature, the average for the three years being 38° F, which causes a constant expansion and contraction of the air in the dust mulch, resulting in its frequent interchange with the dry atmosphere above. The air leaving the soil in this way is saturated with moisture; while new air entering the soil is extremely dry. Moreover, the high temperature reached by the dust mulch during the spring and early summer months would tend to form convection currents in the soil air, and thus assist the expansive force in soil ventilation, the net result of the two tendencies being to counteract the effect of the dust mulch by bringing the moist soil below it in direct contact with circulating air.

The application of small amounts of irrigation water during the winter resulted in the presence of sufficient moisture in the soil at planting time to bring up crops and maintain them in a thrifty condition until the summer rainy season began. By these means crops planted the first week in June were three to four feet high before those that were delayed in starting until the rainy season began were out of the ground. If three or four inches of water were applied in this manner during the winter and early spring, and two or three inches

during the summer in case of a long dry spell between the rainy periods, yields of from thirty-five to fifty bushels of milo maize, three and a half tons of sorghum forage, and seven or eight hundred pounds of tepary beans to the acre are reasonably assured In favorable seasons yields of ten to twenty bushels of corn to the acre may be obtained by the same method of planting. The water should be applied at one time in furrows The furrows are then filled by cultivation and the ground kept harrowed or disced to prevent crusting and to retain as much of the water as possible.

In the variety tests it was found that milo maize is the most promising grain crop for this valley, and, when grown by supplemental irrigation, is probably the most promising money crop. Early Amber sorghum is the most promising forage crop, and, when grown in rows and given intertillage, has yielded from one to two tons of good quality hay upon moisture furnished only by rainfall; while by supplemental irrigation, either by pumping or from runoff, it has yielded three to three and a half tons to the acre.

Certain large varieties of corn, such as Laguna Mexican June, Mexican White Dent, and Red Dent, have given sufficient yields of forage to make them promising for silo crops, but yields of grain are uncertain. White Flint and a Mexican Flint variety have given some promising grain yields; but, in general, corn is not recommended for the Valley except, possibly, for silage.

Winter grain crops were failures and are not recommended.

The tepary bean, has proved to be a remarkable drouth-resistant variety, as well as a persistant yielder under adverse conditions. It can be depended upon to yield from three hundred to five hundred pounds to the acre when not irrigated, but the addition of three and a half inches of water two months before planting produced an average yield of 775 pounds to the acre. It is presented, therefore, to the dry-farming public as a new crop of great promise.

The writer believes that, by a combination of stock raising with the production of grain and forage crops by means of supplemental irrigation, a large part of Sulphur Spring Valley may be farmed successfully.

R. W. CLOTHIER,
Agriculturist.

NEW WORK IN DRY-FARMING

The energies of the Assistant Agriculturist have been confined almost wholly to dry-farming investigations and to placing this line of work on a more permanent basis. The difficulties incident to satisfactory experimental work on the cooperative plan became more noticeable each year and led to the policy of owning and equipping farms for these investigations. Accordingly, new farms have been selected from lands that could either be had without cost or with satisfactory arrangements to purchase. The differences in temperature and precipitation over the State require at least three points of operation; consequently, work is being done or arranged for at Prescott, Snowflake, and Cochise.

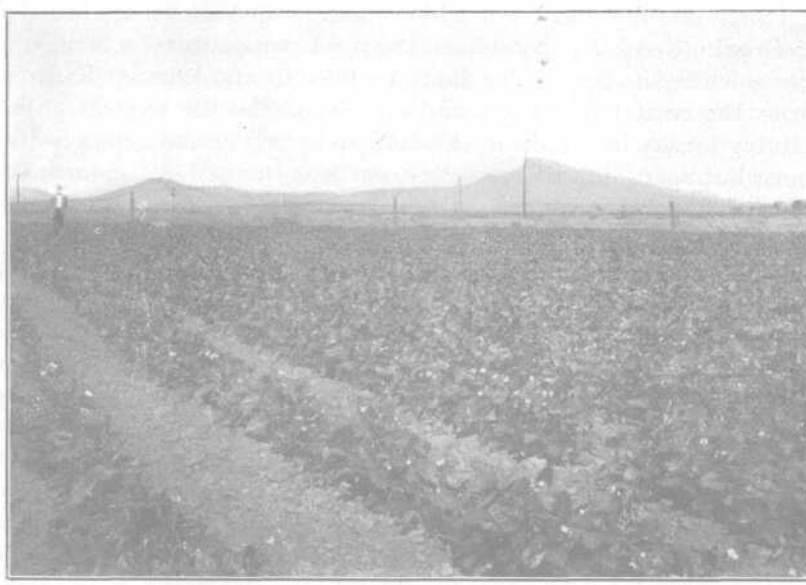

Fig. 1.—Cowpeas near Cochise, Arizona, September 1912, grown on rainfall.

The farm at Prescott, where distinctive soil and climatic conditions prevail, and the location at Snowflake, with variations in both soil and climate from Prescott, represent fairly well the varying factors for this work in northern Arizona. The southern dry-farming section of the State is well represented at Cochise. Under the varying conditions, found at these three locations, the problems of utilizing floodwaters, supplemental irrigation from pumping, and straight dry-farming, can be attacked where each is more pertinent.

The following general outline indicates the scope of the work undertaken (1) Variety tests, (2) planting, (3) plowing, (4) subsoiling, (5) cultivation tests, (6) retention of torrential showers, (7) depth and character of the mulch, (8) summer fallowing, (9) summer fallowing every third year, (10) rotation of crops with fallow, (11) continuous cropping with rotation, (12) fertilization tests, (13) seed selection and introduction, (14) water required to produce one pound of dry matter under field conditions, (15) soil studies, (16) supplemental irrigation, and (17) utilization of floodwaters.

THE PRESCOTT DRY-FARM

The dry-farm seven and one-half miles north of Prescott on Granite Creek was the first new selection. After a thorough canvass of Lonesome, Big and Little Chino, and Skull Valleys, the location on Granite Creek was considered the most representative, being also conveniently situated The Santa Fe Phoenix and Prescott Railroad forms the eastern boundary and Granite Creek the western. The country breaks into hills on the east, and rocky granite cliffs on the south, but opens into a large valley, partly cultivated, to the north and west. The farm, consisting of 110 acres, was given (as long as it is cultivated) to the Station by the Santa Fe Company.

Three types of soil are represented The higher mesas and knolls consist of red, sandy or gravelly loam. This type grades into a second type consisting of darker and finer sandy loam, which in turn changes into the third type, a silty loam along the creek bed. These are the three prevailing soil types of the surrounding region, and all receive and seem to retain moisture well. The soil is sedimentary in character and composed of disintegrated granite. Farther north, in the train of the lava flow from the San Francisco Mountains, the soils are basaltic in derivation. The knolls are underlain at varying depths with gravel; but the uniformity of the soil of the region is, for the most part, very satisfactory to a depth of eight feet. Scrub oaks varying in size from mere bushes to trees three inches in diameter cover the knolls and slopes. Grama, six weeks, and bunch grasses cover the surface of the entire farm.

Operations on the Prescott dry-farm began August 12, 1911, and the first land was broken September 6, 1912. From that day until the following June breaking continued intermittently until some fifty acres were ready for planting. All plowing was done with a fourteen-inch sulky plow to a depth of eight inches, and certain of the plats were subsoiled to depths of sixteen, eighteen and twenty inches. The following fall varieties of grain were planted in October, 1911:

Turkey red, Kofod, Blue stem, Sonora, Kubanka, and Gold Coin wheats; Kherson, Sixty Day and Texas Red oats, White Hulless and Six Rowed barley; and rye. With the exception of the barley and rye, these plats were all disced early in the spring, since prairie dogs and quail had thinned the stand so much that it was useless to carry them to maturity. Even the rye and barley yielded poorly as a result of the persistent work of these animals.

Spring planting commenced April 10 and continued until July 20. Some seventy varieties in all were tried out. Of the corns, Mahl's Early and Turley, both new varieties, gave most promise. Papago sweet corn, grown for the first time by dry-farming, gave evidence of great value as a roasting ear producer. Two varieties of pop-corn imported from New Mexico yielded well. The heaviest yield of forage came from Yellow Dent; and this variety could be grown well for ensilage Of the four varieties of beans, the Bates gave the heaviest yield. White teparies were very slightly superior to the Becher, a new introduction, and to the Mexican pink bean. A few plants from a few seeds of Aztec beans succeeded in maturing some fine seed. Many new introductions belonging to the sorghum family were made. One of the most promising is shallu. Egyptian corn also matured easily and yielded well. Of the plantings of dwarf milo, which were made to test the time of planting, that of May 10 gave the best return. Three varieties of cotton were tried, but were so persistently eaten off by a beetle, which also fed on the adjoining plat of potatoes, that only a few of the plants matured seed. Sufficient encouragement was received, however, to justify future trials. Coconino blue potatoes, strictly an Arizona variety, and grown by the Station for the first time, withstood the hot winds of June and yielded not less than 150 bushels to the acre. Other varieties tested were Early Rose and Early Ohio, both of which did well. Turkestan alfalfa planted in rows eighteen inches apart and eighteen inches between plants gave promise both for seed and hay production. It may also be sown broadcast or with a drill. Other varieties were Early Peruvian and Arizona common. Canadian field peas gave two crops: one planted in May and harvested in July, the other planted in August and harvested in October. The last planting could be used as a cover-crop for green manure following winter grain, and still allow the land to be plowed in the fall. Apple, peach, pear, and plum trees were started, and made substantial growth without water even when first planted.

Some interesting data on the best way in which to leave the surface so as to catch the torrential rains deserves mention. One such

storm occurred July 23, when 1.92 inches fell in slightly less than two hours. After the first forty minutes the country was a sheet of water, gullies were rushing torrents and Granite Creek became a turbulent river. Good sized streams ran down the corn, bean, and potato rows, making them appear as after a heavy irrigation. On surfaces left quite level, as after a harrow, the penetration, forty minutes after the storm ceased, was six inches, on surfaces checked with right angle discing the penetration was eight inches, and on clod mulch it was nearly eleven inches. Later, moisture determinations in these plats showed even more striking results in favor of the clod mulch. This sort of mulch is especially desirable on the heavy types of soils, since results at McNeal point to some difficulty in getting the rain to penetrate a heavy fine mulch.

Another interesting observation was made on a piece of spring-plowed land that was left until after the July rains had started the weeds. One portion of this was left untouched; a second portion was harrowed once when the weeds were very small; and a third portion harrowed twice one week later. No weeds were left on the piece first harrowed; while the piece harrowed twice, one week later, was more than two-thirds covered; and that receiving no harrowing was, of course, a solid mat of weeds. The first rains had caused practically all the weed seeds to sprout, and these, being nearly all killed by the first harrowing, solved the weed problem for almost the entire summer, or until a second crop could appear. Two harrowings on the same stand, one week later, killed not more than one-third of the weeds. Thus, with half the expense, more than twice as effective work was done by doing it at the proper time,—a lesson that could be applied with equally beneficial results to every tilled acre in the State.

THE SNOWFLAKE DRY-FARM

The Snowflake farm was moved three miles farther up Cottonwood Wash, where more favorable soils were found. The new location now occupies twenty acres of Smith Brothers' homestead and twenty acres of David Hancock's homestead, separated only by a four-rod road. Hancock's twenty acres were desired, especially, to get results on a certain type of hill land that occurs abundantly throughout this section. The farm lies four miles southwest of Snowflake, and two miles west of Taylor on what is commonly known as "Four Mile Ranch."

The soil of this farm is a light clayey loam, uniform in character to a depth of ten feet. It is both receptive and retentive of moisture.

Thirty of the forty acres have been broken for several years, but have been allowed to run so completely to weeds that we had great difficulty in keeping them out this year. The change from the old location to the new caused some delays, which prevented the spring work from opening up until April 1, 1912. The field was laid off north and south into plats of one-quarter acre. An implement and seed house was built, old fences repaired, and much new fence constructed. A rabbit-tight mesh was used since these pests interfere seriously with operations.

Spotted, pink, and tepary beans were sown from April 27 to June 27, 1912. The best yield reported was 204 pounds to the acre of pink beans, which sold at five cents a pound. All plats were injured seriously by rabbits. It was observed that the rabbits on this farm and the prairie dogs on the Prescott farm much preferred the teparies to other varieties of beans, this preference being shown conspicuously where teparies were grown side by side with pink and spotted varieties. Both white and yellow teparies were practically destroyed by the rabbits.

Amber cane, shallu, red and white kafir, dwarf and standard milo, and broom corn were tried out again, the milo being planted at four different times. It is doubtful whether these crops will mature seed in the short season of this region, but the April and May plantings of dwarf milo matured some heads, and all were far enough along to make good ensilage. The following table taken from the field records may prove of value:

YIELDS OF DWARF MILO PLANTED ON DIFFERENT DATES

No. of plat	Date of planting	Rate of seeding an acre	State of maturity	Condition of stand	Yield per acre of dry plants
32 A Sec. A	April 27	10 lb.	Partly matured	Poor	1660 lb.
33 A Sec. A	May 6	10 lb.	All headed, some ripe, heads large	Good	2468 lb.
33 A Sec B	June 5	10 lb.	Growing when frosted	Poor	780 lb.
33 A Sec. C	July 5	10 lb.	Not worth harvesting		

The spring was cold and backward, being one of the latest ever known in this section. The rainfall at the farm was very light, with but .44 inches in July and 2.00 inches in August. At Pinedale, ten miles south, 5.65 inches fell in July and 2.00 inches in August. The season was characterized, also, as being most erratic in the time and distribution of the precipitation. The condition of the range grasses showed the farm to be in a strictly localized dry belt this year. How-

ever, Mr. Flake reports that nothing died from drought. We succeeded in getting some smooth brome grass (*Bromus inermis*) to start, and it made good growth Teosinte planted both at Prescott and at Snowflake made a slight showing, but at Prescott the season is fully two weeks longer, and, for that reason, it did much better there. Some of the most promising yields at Snowflake were as follows:

YIELDS OF VARIOUS CROPS AT SNOWFLAKE DRY-FARM

Crop	Planted	Yields
Red kafir	May 20	4820 lb dry matter per acre
Dwarf milo	May 22	4760 lb dry matter per acre
Standard milo	May 22	3646 lb dry matter per acre
Broom corn	May 22	2040 lb dry matter per acre

Combined with stock-raising the possibilities of dry-farming for reclaiming these areas are very encouraging.

Observations at Pinedale, Lakeside, Mineral, and in the edge of the pine timber, usually point to success with wheat, oats, barley, rye, and corn. Many farmers have gone out from Snowflake and neighboring towns to homestead in the timber. All are succeeding well. For the past two years the writer has been advocating the growing of Turkey red wheat for milling purposes on both the dry and irrigated lands of the State. Farmers at Snowflake are beginning to grow this variety, and some grown at Mineral this year yielded forty bushels to the acre on dry lands. A cooperative observer at Pinedale also reports good yields of this variety for that locality.

THE SULPHUR SPRING VALLEY DRY-FARM

A new and permanent location for the Sulphur Spring Valley dry-farm is under consideration at Cochise, this location combining advantages of soil, supplementary water supplies, and accessibility which make it desirable. At this writing title has not yet been secured and details are reserved for future publication.

Very encouraging crops in all parts of Sulphur Spring Valley were observed this year. Yields of five to eight hundred pounds of beans were general. Kafir corn, milo, sorghum, and shallu have all succeeded in maturing profitable crops. At the Willcox fair the dry-farm products were equal in every way to those grown by irrigation. A very fine display of strictly dry-farm products was also exhibited at Light. The general outlook for the development of Sulphur Spring Valley is indeed promising.

COOPERATIVE WORK AT FLAGSTAFF

At Flagstaff, cooperative work, especially with grains and potatoes, was outlined with Mr. Greenlaw. The Station furnished him Turkey red wheat for fall planting in 1911. The field was used for pasture nearly all winter and the grain was cut for hay in July. However, some excellent, matured seed was found in the hay, and the crop was estimated to yield thirty bushels to the acre. Another piece of land has been planted this fall with seed from Mineral. Observations in this district indicate that wheat, oats, White Hulless barley, vegetables, and potatoes are certain crops. There is little doubt but that the timber area will be the greatest grain producing section of the State. The best Irish potatoes in the State are grown in these cooler areas. Yields of one hundred sacks to the acre are very common.

OBSERVATIONS AT TUCSON

Vast areas of deep, fertile soil exist in southwestern Arizona, the reclamation of which will come only by pumping water from considerable depths and conserving it by dry-farming methods. Naturally, certain crops adapted to the climate and able to produce with a minimum water supply must be found. Olives seem to be one of the most promising and, accordingly, four trees of Chemlali, or dry-land olives of Tunis, were planted in May on the University campus as a nucleus for this investigation. Tepary beans, millet, milo, and kafir also were planted between the trees, but failed to mature seed. Two olive trees, remnants of an orchard planted on the grounds of the former Indian School at Tucson, which were later cut up into town lots, continued to stand the vicissitudes of drought and heat, and to make a persistent growth each year. Other similar instances are found at Casa Grande and Florence. Dry-land olives exist without irrigation in parts of Tunis where the average annual rainfall does not exceed six inches.

A. M. MCOMIE,
Assistant Agriculturist.

BOTANY

Beginning with September 15, 1911, the writer was granted a year's leave of absence—the Sabbatical Year. During this time the work in the department of biology on the University side was in charge of Assistant Professor J. G. Brown. On the Experiment Station side, however, the investigation work was at a standstill. The routine work of irrigating the plant introduction and grass gardens, and keeping rain records on the small range reserve being looked after by a Station employee. In many respects this interruption of work was unfortunate, especially as concerns forage plant investigations and range studies, which have been carried on uninterruptedly for ten years, and which should be continued with certain additions for some years to come.

It had been planned to spend a part of the above year in northern Africa in quest of economic plants, but the writer was compelled, through force of cirumstances, to abandon this part of the plan. In place of this the writer gave over practically his entire year to the technical study of the Arizona flora, a work which he has been carrying on himself, slowly, necessarily, on account of limited time, for eleven years. Of this time, nine months were spent in the Smithsonian Institution, Washington, D. C., in the United States National Herbarium, and about six weeks at the herbarium of the New York Botanical Garden, and in Harvard University at the Gray Herbarium. It has long been the hope and ambition of the writer to publish a work on our plants, which should be at once valuable to the working scientist and to the practical person. Of necessity such a work must be extensive, inasmuch as it will treat of our plants from the standpoints of both taxonomy and ecology. It will contain a large amount of directly useful matter, of which a considerable part must be essentially original. It is no exaggeration to say at this time that from the standpoints both of plant breeding, and plant introduction and acclimatization, a work of this nature on the Arizona flora is of paramount importance; while it is part and parcel of such broad economic subjects as range studies, forage plant investigations, forestry, and the reclamation of desert tracts. In brief, it will form the very foundation of our knowledge of future Arizona botany, and of our further economic treatment of the useful native plants.

THE SMALL RANGE ENCLOSURE

The rainfall on the small range reserve for the year ending June 30, 1912, was 11.47 inches, which is nearly the average for this locality. Of this amount, 6.69 inches or 58.3 percent fell during the summer growing season, July to October inclusive, and 4.36 inches or 38.0 percent during the winter and spring growing period, leaving but .42 inches of precipitation to take place outside of these two growing seasons. With proper distribution, the summer rainfall would have been ample to promote a good growth of the forage plants of that growing period. A full month of dry, hot weather, however, intervened between the last of the July rains and the first ones of August, with the result, as would be expected, that the shallow-rooted, annual species, mostly grasses, which began growth so well with the rains in the early part of July, had mostly died before the next rainy period set in. So pronounced was this midsummer droughty spell, that even chollas stopped growth for a time, beginning a second growth with the August rains.

Likewise, there were three weeks of rainless weather between the last of the August rains and those of September. Thus with nearly five inches of rainfall in July and August, 1911, which is a good precipitation under our conditions, there was very scant growth on the mesas by the middle of September, when the third and last rainy period of the summer began. This continued intermittently through the first week of October, but the season was now too far advanced to admit of any considerable growth of the summer annuals. Thus the summer was characterized by a series of rather heavy rainy periods, which were separated by long, dry spells. The above bears out the writer's observations in an earlier publication, that under our peculiar conditions—*i. e.*, with shallow, mesa soil destitute of humus, and, hence, capable of taking up only a small amount of moisture at a time, and with quick-growing, shallow-rooted annual plants, the heaviest growth obtains with a series of well-distributed showers, rather than with a limited number of heavy rains.

No data are at hand concerning the spring growth on the lower mesas, though it was generally poor throughout the country. This was due to the scantiness as well as the untimeliness of the winter and spring rains. Likewise, no studies on the growth of the vegetation were made on the large range reserve tract during the year.

WORK WITH GUAYULE

In March, 1911, three hundred rooted plants of guayule (*Parthenium argentatum*) supplied by the Continental Mexican Rubber

Company, Torreon, Mexico, were set out on the small range reserve in rather deep, loamy, clay soil. They were planted in the bottoms of deeply plowed furrows and irrigated during the hot, dry fore-summer, *i. e.*, May 15 to July 1. During April and May, and up to the time that they were eaten back by jackrabbits, their growth was very encouraging—in fact, better than could have been expected. They never recuperated from this setback, however, and by fall were dead. For some time past there has been need of a netted wire enclosure of three or four acres within the small range enclosure, so as to exclude jackrabbits, for testing out under favorable mesa conditions such promising plants as the one under consideration. In view of the millions of acres of unoccupied and unproductive lands in Arizona, this is a particularly inviting field for work in plant introduction which the writer desires to continue.

A second lot of guayule plants was set out on the small range enclosure during the past July, with the beginning of the summer rains. These were volunteer seedling plants from a patch of older plants growing under cultural conditions on the University grounds. Previous to their being set out, they were grown in pots for several months so as to have the root systems well developed. At this time, December, 1912, practically all of these plants are alive, and most of them have made fair growth. It is planned to continue this work with guayule under varied, arid, mesa and foothill conditions until it is known definitely whether or not the plant may be grown commercially over our lower mesa and foothills country.

At this time two patches of guayule, of five hundred or more plants each, have been growing successfully on the University grounds for upwards of three years. Of these, one is growing in shallow, mesa soil underlaid with caliche, and the other is in the botanical introduction garden in somewhat deeper soil, which had been previously fertilized. Both lots of plants were given moderate irrigation up to the beginning of the present year, since which time this has been restricted. The plants in both areas have succeeded, apparently, equally well, and have never experienced any setback from frost, extreme heat, or drought. It remains to be seen whether this plant can endure our mesa and foothill conditions with the limited annual rainfall, and, also, whether it can be established over large areas in a practical way.

CONTINUED WORK WITH THE CACTI

The writer deems it desirable to carry on additional work with economic cacti. During the past three years about one thousand

plants, representing several varieties, have been grown from seeds of selected prickly pears with a view to secure varieties that will make more rapid growth than obtains in the instance of our native species. These now range from eighteen inches to three feet high, and are ready for planting out in fenced enclosures on the range. These seeds were collected in southern Italy through the agency of the United States Department of Agriculture. In addition to the above, a valuable collection of spineless and semi-spineless cacti has been secured for experimental work from the Smithsonian Institution, Washington, D. C. These are mostly species indigenous to Mexico, where some of them have long been in cultivation. Further studies of the native cacti also are under way.

PLANT INTRODUCTION AND ACCLIMATIZATION

Though no new work has been done on this subject during the past year, there are many interesting results to be noted both with native and introduced plants. A few of these are given below.

Native wild cotton (*Igenhauzia triloba* D. G.): This handsome shrub of our lower, mountain canyons has proven to be a splendid ornamental for quick results in planting. From seedling plants it develops in a single season into shrubs five to ten feet high. The flowers appear in July and continue for upwards of two months; they are one and one-half inches in diameter and quite showy, the petals being cream-white and edged with rose. The leaves are glossy, bright green and deeply lobed or divided. In autumn these change to a reddish tinge with more or less yellow. Though the shrubs appear to be short lived, they grow readily from seeds, which is the easiest means of propagation.

Lippia Wrightii A. Gray: This little shrub is an inhabitant of the arid foothills and low mountains of southern Arizona. Here it is a slow-growing, compact shrub with small gray-green leaves and myriads of minute flowers. At all seasons of its growth it is possessed of a delightful aroma. Under more favorable conditions it becomes four or five feet tall, and retains its attractive appearance as well as its fragrance and long period of flowering. It is a very promising bee plant, and seems at its best with only occasional irrigation.

Huisache (*Vachellia Farnesiana* (Linn.) Wight and Arn.): This acacia-like plant is indigenous to extreme southern Arizona, and under cultivation becomes one of our most promising native ornamentals. It suffers somewhat from frost at Tucson, though at Mesa, Yuma, and in other warmer parts of the State, it is entirely

hardy. During its long flowering period it is covered with an abundance of small golden-yellow flower balls, which are delightfully fragrant, and much visited by bees. In parts of southern France and Italy it is cultivated for its perfume.

Sotol (*Dasylirion Wheeleri* S. Wats.) and bear grass or hickory grass (*Nolina microcarpa* S. Wats.): From preliminary tests made by the writer, both of these species have possibilities as fiber-producing plants. At four years of age, with occasional irrigation, these plants have grown eighteen inches and three and one-half feet tall, respectively, from seed. The leaves of both are evergreen, appearing as fresh in winter as in summer, and the plants are quite decorative. They are recommended for planting in arid or barren situations along with such other native species as agaves and yuccas, all of which endure long drought with impunity. *Dasylirion graminifolius* Zucc., of Mexico, is another species that should be mentioned along with these. It has a wealth of long, slender, recurving leaves, which start from a short base or trunk. It thrives in arid, gravelly situations, and is entirely hardy at Tucson.

Native leadwort (*Plumbago scandens* Linn.): This perennial flower is found occasionally in our lower, mountain canyons, and it must inevitably win a place in our gardens. Not only is it drought-resistant and hardy, but it grows and blooms profusely during our hottest weather, when many introduced plants of a similar nature are wilting and dying. Its flowers very closely resemble those of a perennial phlox, being pure white in color and borne at the ends of the stems. The foliage, which is abundant and deep green, becomes bronzed in the autumn. The plants are propagated readily from seeds and also by root division. As a flower, it is far superior under our conditions to the introduced Cape Plumbago.

Canyon golden-rod (*Solidago sparsiflora* var. *subcinerea* A. Gray.): Though relatively inconspicuous in our mountain canyons, along with other plants, this attractive golden-rod, with ordinary care, grows to a height of three or four feet, developing in two years from small plants into clumps of considerable size. The slender and gracefully curved panicles, often eighteen inches long, appear with their wealth of minute yellow flowers in the late summer and fall, and continue to be a feature of the garden for six weeks or two months. This golden-rod might well take the place of the introduced golden-glow (*Rudbeckia laciniata* var.), which with us suffers severely from heat and aridity, particularly at our lower altitudes.

Tradescantia scopulorum Rose: This native spiderwort inhabits rocky canyons in mountains in southern Arizona at altitudes of

4,500 to 7,000 feet. It has proven to be one of the hardiest herbaceous flowers that the writer has grown in the plant introduction garden. It is provided with an abundance of fleshy roots, which assist in carrying it over long periods of drought, and by means of which it propagates very readily. From small roots set out in March, 1910, clumps of plants six to eight inches in diameter have developed, from which grow the innumerable tangled stems. The flowers are white, tinged with blue, and, though of short duration, continue in abundance throughout the season.

Spanish Broom (*Cytisus scorparius* (Linn.) Link): This introduced shrub delights in a warm, dry climate, and is entirely at home under our conditions. In three or four years with the most ordinary care plants have attained heights of five to eight feet. The abundant, bright green twigs are mostly leafless, which gives to the species somewhat the air of our native palo verdes, to which it is distantly related. The flowers are bright yellow, showy, and fragrant, and last during the spring and early summer. The writer recommends this species for planting as an ornamental, particularly in sandy or sterile soils. In southern France and Spain, where Spanish Broom grows native, a fiber is obtained from the bark, which is made into cords, ropes, and even a coarse cloth.

Russian Oleaster (*Elaeagnus hortensis* var. *songorica* Bernh.): This small tree has grown successfully for several years in the introduction garden. It is entirely hardy to our climatic conditions, though it suffers somewhat in heavy clay soils from lack of drainage and aeration. Ordinarily, it grows as much as six or eight feet in a season. The widely spreading branches grow all along the trunk, and unless the plants are pruned carefully, they more often appear as large shrubs than as trees. This species is particularly valuable for planting at altitudes of four to eight thousand feet, where the climatic factors are more to its liking than at the lower altitudes, and where it should grow with little or no irrigation. It can endure extremely low temperatures uninjured, and tolerates a moderate amount of alkali in the soil. The trees are notably striking on account of their silvery, shining leaves and dark twigs or branches.

J. J. THORNBER.
Botanist.

PLANT BREEDING

Progress may be recorded on all of the projects previously undertaken in plant breeding. These include the breeding of alfalfa, beans, dates, and corn. Outlines of each may be found in the Twenty-first and Twenty-second Annual Reports of this Station. They, therefore, need not be repeated here. The small garden available for this work upon the University campus and the land leased from the Evergreen Nursery Company have been used for the preliminary testing of selected strains in small plots. The increase plots for promising strains and the more extensive field cultures have been transferred to the stations at Phoenix and Yuma.

ALFALFA

REGIONAL VARIETIES

The mass of data concerning the yield, chemical composition, and climatic reactions of the forty-four regional varieties of alfalfa that were grown on the Experiment Station Farm at Phoenix during the crop season of 1910 has been assembled and correlated. Among the more prominent facts which study of this material has introduced and emphasized, the following may be mentioned:

1. The mixed nature of all so-called regional varieties;

2. The importance of a careful study of the climatic reactions of varieties;

3. The necessity for better knowledge of the direct influence of the development of one part of the plant upon that of some other part whereby the behavior of the different varieties in this climate with reference to productivity and quality of hay may be correctly interpreted.

4. When seed are taken from imported varieties which are not adapted to the new conditions, climatic selection often may bring about a readjustment whereby the less vigorous individuals produce but few seed. The strains which they represent thus gradually disappear. Plots originating from seed locally grown are, therefore, more productive, and hold stand better than those from imported seed of the same variety.

5. The Peruvian type of alfalfa seems eminently suited to climatic conditions in Arizona. It holds stand well, and in yield has

exceeded all other types. It is somewhat coarse and stemmy, but this defect can be overcome to a large degree by thick stands and early cutting. Its rapid growth and the high nitrogen content of the leaves give to the hay a food value but slightly less than that of the best made from other varieties which are not so productive.

Seed crops have been taken from five of the most promising imported varieties. These will be used for planting increase plots for the purpose of testing the varieties on a larger scale, and for securing seed for distribution. Selected mother plants have been transplanted from all of the plots to the testing gardens at Tucson. These plants represent the range of variation visible in each plot at the time they were taken. The strains originating from the close-pollenated seed of these mother plants are being tested as fast as the means at the disposal of the writer will allow. The behavior of these pure races will not only serve as a biological analysis of the original more or less

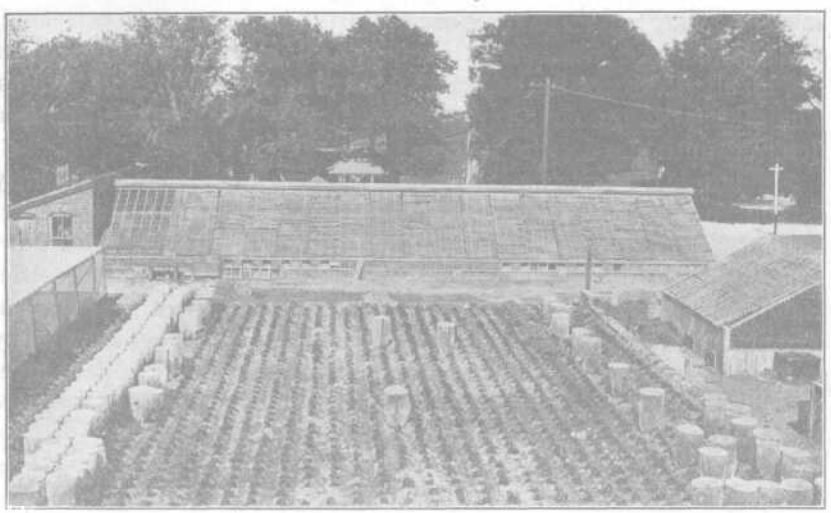

Fig. 2.—One of the alfalfa breeding plots at Tucson, showing individual breeding cages used in producing seed from pure races.

mixed varieties but may also preserve and identify valuable strains which otherwise might have been overlooked.

This experiment, therefore, so far as it relates to the old plots, has now been closed, and the land is available for other purposes.

PURE RACES

Out of seventy-nine pure strains of alfalfa tested during 1910 and 1911, seven have been selected as especially promising and seed crops

taken from these during the present season. From five of them sufficient seeds were secured to warrant planting in a field test. The crop from the remaining two strains failed completely. This seems to have been due to the fact that they are naturally shy seeders; and, in addition to this, the chalcid fly destroyed ninety percent of the seeds in the few pods which were produced. These increase plots of promising strains are now being planted on the Experiment Station Farm at Phoenix. The total area occupied is about three-fourths of an acre, and the size of the plots varies from one-tenth to one-fifth of an acre each, depending on the amount of seed available. During the fall of 1911, seeds from 144 selected mother plants were planted on the land leased from the Evergreen Nursery Company. These were planted in rows, each row representing the seed from a different mother plant. The stand has been thinned to one plant in each hill, the hills being twelve inches apart, and the rows three feet wide. Missing hills have been filled by transplanting from others in the same row that had more than one plant. The stand, thus perfected, was allowed time to become thoroughly established before attempts were made to ascertain the relative merits of the different strains. The taking of data concerning yield and quality, therefore, has been deferred until the coming season.

Preliminary tests on thirty-four strains, which were sufficiently established to allow data from four cuttings during the present season, show three strains of noticeable promise. It happens, however, that one of these, No. 333, was also included in the series tested in 1911, and was one of the three best yielders that season. The ability of this strain again to demonstrate preeminent superiority in yield over a new lot of competitors, emphasizes the excellent hereditary qualities which the original mother plant of the race was able to impart to each and all of its successive crops of seed.

DATES

The work with dates has been confined to the projects already outlined Four hundred five-gallon gasoline cans were secured and the tops removed. These were then filled with sand, and each can planted to three date seeds. The seeds used for this purpose were those mentioned on page 546 of the last Annual Report as having been derived from the female Deglet Noor (Row 9, No. 16) when pollenated from a male tree of this variety. Plantings were made April 1 to April 25.

At the present time there are 343 healthy seedlings, from nine to twenty-one inches high, and bearing one to five leaves. The remaining cans will be replanted with seeds of the same stock in order to give the project its full quota of four hundred plants for the first test orchard.

SWEET CORN

The work with Papago sweet corn is now in the third generation from the seed secured from the Indians. Breeding for yield, size of ear, and depth of grain by the "ear to row" method has been continued. The progress in the amelioration of this variety and the degree of its superior adaptation to the semi-arid regions are indicated by the fact that exhibits grown at the Prescott substation, from seed sent out by the writer, have taken first prizes for sweet corn at the recent Arizona State Fair, and, also, in the exhibits made at the International Dry-Farming Congress at Lethbridge, Canada, in November of the present year.

This sweet corn is prone to give rise to a large number of suckers at the base of each stalk. Cultural experiments to determine whether these should be removed have given negative results, in that there was no appreciable difference in total yield, size, or number of ears on those rows which had the suckers removed and those which were allowed to develop normally.

BEANS

The outline of the work undertaken in this subject is given on page 543 of the last Annual Report. Until the beginning of the present season principal attention has been focused upon Sections 1 and 3 of this outline. Some progress, however, may be reported upon the other sections. The results so far obtained have been published; first, in Timely Hints for Farmers No. 92, "The Tepary, a New Southwestern Legume;" and, later, in more complete detail as Bulletin No. 68, "Southwestern Beans and Teparies." In these publications the following topics have been discussed: (1) The importance of the bean as a money crop in Arizona; (2) the botanical relationship existing between the different types of beans grown by the natives of the Southwest, and, also, the relation of these with those varieties now grown and recognized by horticulturists; (3) descriptions of the existing local varieties of frijoles (*Phaseolus vulgaris*) and teparies (*Phaseolus acutifolius* var. *latifolius*); (4) descriptions of varieties of both

of the above groups, which were found only as admixtures in other sorts, but which, when isolated, have bred true to type, (5) food value of the tepary, (6) its culture, (7) its harvesting, (8) its yields; (9) its markets and prices

DISTRIBUTION OF THE TEPARY

This new bean is being grown by many of the settlers in the dry-farming districts of Cochise County. Seed for these plantings came mostly from pound lots distributed from this Station, and from seed purchased from the dry-farming station at McNeal, Arizona. The Tucson Seed Company, during the past year, has sold about two thousand pounds of white tepary seed for seeding purposes, the El Paso and Southwestern Railroad has distributed about six hundred pounds of seed among the farmers along its route in New Mexico; and there have been sent out from this Station about three hundred pounds, mostly in small lots, to farmers in various parts of Arizona and the Southwest

Reports have been obtained from as many as possible of the farmers who were known to have given the tepary a practical test during the past summer. These reports seem to indicate that even in dry-farming areas, if the rainfall was good, the tepary had no advantage over the pink bean. In new sections, still badly infested with jackrabbits and gophers, the tepary had the disadvantage that these rodents preferred its tender vines to all other vegetation. In several cases they were reported to have destroyed completely fields of teparies, while those of pink beans and other crops alongside were comparatively unharmed. This preference of herbivorous animals for the tepary would suggest its use as a hay crop. At Waco, Texas, and other points in the humid districts, the tepary has given unfavorable results so far as yield is concerned. In some sections of the East this plant shows a tendency to run to vine, refusing almost entirely to bloom or set seed.

On the other hand, in all parts of the dry-farming area where the rainfall was deficient and the summer was hot as well as dry, the tepary has outyielded other beans and given promise of being one of the surest crops for these situations. Several farmers have reported a yield of four to five hundred pounds of teparies to the acre where other beans were a total failure on account of drought.

The work with beans during the past year has been confined largely to Sections 2 and 4 of the bean project (Twenty-second Annual Report, p. 543). For the purpose of studying the hereditary units

in these beans, crosses have been made between several different varieties of both beans and teparies. All attempted crosses of the bean upon the tepary, or *vice versa*, have failed. Among the forty-seven types of teparies so far isolated and tested, type No. 12, a pure white well rounded form, seems to be the most promising as an economic crop. It has therefore been chosen as the type upon which to begin work in selective breeding. Among the true beans, the common frijole or pink bean has likewise been taken to form the basis of breeding stock. About an acre of each of these varieties has been grown during the past summer, in hills three feet apart each way with one plant to the hill. In this way every plant was given an equal space for development, so that the characteristics of each as to yield, habit, and time of ripening could be determined by inspection. At the time of ripening, six hundred plants in each variety were chosen, pulled, and brought together for comparative inspection. Three hundred of the poorest of each were discarded The pods from those remaining were then picked and placed in paper bags,—the seed from one plant only in each bag. These were then brought to the laboratory where they were shelled and weighed. Upon the basis of the data thus obtained two hundred from each lot will again be discarded. This will leave the seeds from one hundred of the best plants of each variety, which will be sown next summer in plant row tests for the purpose of isolating high yielding or otherwise promising strains.

FARMERS' CORN CONTEST

The desirability of growing cultivated crops in order to clean up fields which may have become foul with weeds, the need for crops that may follow grain or sugar beets and mature before frost, and the necessity for a suitable feed for finishing hogs grown from the by-products of the fast-developing dairy industry have aroused a new interest in field corn.

The larger eastern varieties do not produce well in southern Arizona, even when planted on fertile soil and irrigated abundantly, if the season of their silking and tasseling happens to fall within a period when the air is excessively hot and dry. It seems that the viability of the pollen, and, perhaps, the period of susceptibility of the silks are so reduced that, although the stalk may be vigorous and the cob well developed, only a few scattering grains will be produced. This type of corn, therefore, is grown by only a few farmers, who have learned that good crops may be secured by planting in middle and

late July, so that the tasseling season is thrown over into the cooler weather of September.

Many such farmers have been growing corn in Arizona ten or fifteen years, and have developed strains well suited to the conditions found here. In order to further encourage these local breeders to test the value of their products and to locate the strains best suited for the several types of soil and climate found within the State, a cooperative farmers' corn contest was organized. Each farmer entering this contest selected an ear of corn for planting at the Experiment Station Farm. A suitable uniform block was laid out on which one row from each of the ears entered was grown. All rows were planted on the same date and given, as nearly as possible, equal treatment in cultivation and irrigation. The winners of this contest were awarded prizes at the State Fair. There were thirty entries this season. Prizes were won by D. C. Rose of Yuma, and V. A. Vanderhoff of Scottsdale. The most striking feature of this year's contest was the great variety of types of corn that are now being grown by the farmers of the State. These range from the small, flinty Mexican and Indian types to the largest of the Eastern dent forms. No less striking were the differences in yield and economic value. The average yield of the entire block was fifty-six bushels per acre. The lowest was seven bushels and the highest 105 bushels per acre. These differences emphasize the value of a better understanding of the types most suited to Arizona, and the need of disseminating the more productive strains among those farmers who are now attempting to grow corn from inferior seed.

G. F. FREEMAN,
Plant Breeder.

D. F. JONES,
Assistant Plant Breeder.

ANIMAL HUSBANDRY

SHEEP BREEDING

The general plan for sheep breeding has been changed in one particular: The Oxford has been dropped on account of its high mortality. Of five well bred Oxfords purchased for our experiments all but one died within six months after their arrival at the Station Farm. One ram survived nearly a year, leaving two of his progeny which were very undesirable. Hampshires, therefore, have been substituted, and the few lambs by a Hampshire ram show characters more desirable for our purposes than the Oxford. This change in the general plan necessitates the substitution of the following description of the Hampshire for that of the Oxford in the outline for sheep breeding as given in the Twentieth Annual Report (page 571):

HAMPSHIRE

1.	.....	Not hardy.....
2.	.....	Do not breed at any season.....
3.	.....	Do not herd well .....
4.	....	Not early maturing .....
5.	.....	Not active.. ....
6.	Large in size.....	.....
7.	Medium wool.....	.. ..
8.	Fine staple wool.....	....

During the past year all sheep having no especially desirable characters have been disposed of. The table on page 686 gives the breeding, age, and number of the ewes which have been selected for further breeding.

THE MARKETING OF WOOL

Correlated with sheep breeding are a number of interesting and important problems bearing on successful sheep husbandry in Arizona, one of which is the marketing of the wool each year to the best advantage. The highest market price for wool can be obtained only by attention to the following important details:

1. *Breed and type:* A clip of wool, to bring the highest market price, should be uniform in strength, length, and diameter of fibre.

BREEDING, AGE, AND NUMBER OF EWES SELECTED FOR FURTHER BREEDING

Breeding	Six years old	Five years old	Four years old	Three years old	Two years old	One year old	Lamb	Total
$\frac{T}{2}\frac{N}{2}$	2	16	2	17	17	13	8	75
$\frac{H}{2}\frac{N}{2}$	.			6	..	..	11	17
$\frac{S}{2}\frac{N}{2}$	..	.	..	4	13	7	12	36
$\frac{T}{2}\frac{S}{4}\frac{N}{4}$	.	.	.		2	2	11	15
$\frac{S}{2}\frac{T}{4}\frac{N}{4}$	.		..	.	4	15	26	45
$\frac{T}{2}\frac{H}{4}\frac{N}{4}$		.			..	5	6	11
$\frac{H}{2}\frac{T}{4}\frac{N}{4}$		.		5	2	..	3	10
$\frac{T}{2}\frac{T}{4}\frac{N}{4}$	..	.	..	.	3	6	3	12
$\frac{S}{2}\frac{H}{4}\frac{T}{8}\frac{N}{8}$	..	.	..	..	.	2	2	4
$\frac{T}{2}\frac{H}{4}\frac{T}{8}\frac{N}{8}$	.		..	..	..	2	1	3
$\frac{S}{2}\frac{N}{4}\frac{T}{8}\frac{N}{8}$	.		..	..	.	.	1	1
$\frac{S}{2}\frac{T}{4}\frac{H}{8}\frac{N}{8}$	..		..		.	..	1	1
$\frac{T}{2}\frac{T}{4}\frac{T}{8}\frac{N}{8}$	.	..	.	.		..	1	1
Total	2	16	2	32	41	52	86	231

It follows, naturally, that the animals comprising the flock should be of similar type and breeding, so that the wool will be sufficiently uniform to satisfy the demands of the market for the particular grade offered. It is highly desirable that an individual sheep should carry a fleece fairly uniform throughout in density, quality, and length. Our range sheep, practically, are a distinct type, but there is a wide variation in individuals and in separate bands.

2. *Feed:* Uniform feed and pasture are quite desirable, because periods of poor nutrition produce correspondingly weak places in the wool. This reduces materially its value as a combing wool, for the

weak places cause the fibre to break Consequently, such wool must be utilized for other purposes, and, commands a lower price.

3. *Health:* Severe sickness extending over a period of time also causes a weak place in the fibre. Any feverish condition of the animal results in the shedding of wool. This is very common in large bands of ewes, where individual care is next to impossible The greatest danger arises soon after yeaning, while the ewe is on luxuriant pasture, and again at weaning time. Ewes that are known to be very heavy milkers should be removed from the flock and given dry feed until the lamb is able to take all the milk. If the udder becomes inflamed, place the ewe in the shade and give a purgative, such as epsom salts or oil. After draining the udder, rub it well with a mixture of two parts of turpentine and one of lard.

4. *Foreign material in the wool.* The wool of range sheep carries a large amount of sand and dirt. This is occasioned by the close herding habits of the sheep, which on scant pasture nearly bare of growth results in the stirring up of dust that settles gently over the flock, finding its way in time into the wool. Moreover, the "bed ground" in many instances is sand or loose soil, particles of which adhere to the animal and find their way down into the fleece. The migratory bands of sheep, in changing pastures constantly, and in grazing over rough country, not only lose many locks of wool on briers and bushes, but pick up large quantities of burs and seeds. Dirty shearing sheds and quarters at shearing time are also conducive to the introduction of foreign material into the wool.

In regard to feeding sheep from racks it is hardly necessary to emphasize the fact that the racks should be so constructed that seeds, and small particles of chaff and leaves will not lodge on the necks and shoulders of the sheep. For the same reason feed lots should be so arranged that it will not be necessary to pass among the flock at feeding time. The lots should be cleaned frequently so that wet bedding and voidings will not foul the wool. Fleeces that carry a large amount of foreign material are difficult to scour; and, moreover, it is impossible to remove all foreign material from such fleeces by scouring. They require additional treatment by a process known as carbonizing, which consists of treating the fleece with warm, dilute sulphuric acid. This tends to weaken the wool, making it less valuable for cloth, and adding to the manufacturer's cost of weaving.

5. *Wool brands and marks:* It is quite necessary for Arizona flockmasters to brand their sheep suitably for rapid identification, since flocks are easily mixed, especially at shearing, lambing or shipping time. Many systems of marking are more or less objectionable.

In many instances the brand covers a large space, and the writer has counted as many as three brands extending from the shoulder to the tail on small lambs, covering at least ten percent of the wool on the back of the animal. Mixtures of oil and lampblack with or without flour, and paint, tar, and crude oil are used extensively by our sheep-owners. These materials are objection able because the manufacturer must cut off the brand, since these materials cannot be removed during the process of scouring. If they are not detected and removed, small particles of branded wool play havoc with the manufacturer's machinery. The small clippings and bits of branded wool have a very low commercial value. There are a number of suitable branding fluids on the market, but inquiry as to their effect on the fleeces should be made before using them.

6. *Time for shearing:* The time for shearing flocks in Arizona varies with the locality and with the feed on the surrounding ranges. In ordinary years shearing should begin in southern Arizona about January 25 and often continues until May 15. Whenever practicable, it is well to shear the ewes before lambing; then the udders will be clean and there will be less loss of lambs from their inability to find the nipple. Then, too, the energy of the ewe is not expended for milk production to the detriment of the strength of the wool. It is well to wait until the yolk or suint (grease and dried perspiration) appears in quantity.

7. *Shearing:* The quarters for shearing should be clean and smooth, and well shaded. The wool should be clipped close to the body at the first advance of the shears, thus obviating the necessity of a second clip. The operator should hold his animal firmly and remove the wool with dispatch, keeping the animal quiet and the fleece intact. Machine shears are used economically, and, as a rule, the wool is more uniform in length, provided the operator possesses moderate skill. If the sheep are wet or damp, they should be allowed to dry off before being shorn, for damp wool is apt to mold.

8. *Tying the fleece:* Skirt the fleece, and remove all tags and locks; then roll up the fleece with the flesh side out, after turning in all the ragged edges, and tie with a proper twine, giving the end a firm knot to insure against slipping. Probably the best twine is a "hard twist" twine or a paper twine, which meets all the objections of the manufacturer to vegetable twines.

A desirable method of tying, which meets all requirements for economy except rapidity, is that of tying the fleece with a portion of the wool. The operation is as follows: Skirt the wool, remove the tags and turn the sides in until they meet over the back; then roll

the fleece from the tail toward the head, leaving a small tuft of wool. This tuft is twisted with both hands, while the operator holds the fleece with his knee to keep it from rolling back. The rope of wool should be spun out long enough to reach around the fleece twice and fastened. A large tuft or knot on the end of the rope is passed under the rope and serves to hold the fleece securely. This method also utilizes the space in the wool bag to better advantage.

9. *Grading.* Wool should be graded before being packed, so that the fleeces of ewes, lambs, wethers, and rams, and also those from dead sheep, will be kept separated. In small flocks where only a few bags of wool are produced, the fleeces may be separated in the bag by heavy sheets of paper, or by a cloth tacked in each corner, which will aid in sorting at the warehouse. These bags should be marked or numbered for reference, so that the sorter may accomplish his work with dispatch.

10. *Shrinkage of wool in storage and transit.* The following table shows the weights of the 1912 clip from the Station flock on the date packed, the date shipped, the date sold, and the grade:

SHRINKAGE OF WOOL IN STORAGE AND TRANSIT

Bag	Packed Jan. 25, 1912	Shipped Apr. 18 1912	Loss	Sold July 1, 1912	Loss	Gain	Total loss	Total gain	Grade
			lb.						
1	215	215	..	211	4	..	4	..	$\frac{T}{2}\frac{N}{2}$
2	225	225	..	225	..	.	..	..	$\frac{T}{2}\frac{N}{2}$
3	232	230	2	229	1	.	3	.	$\frac{T}{2}\frac{N}{2}$
4	238	238	..	238	..	.	.	..	N
5	195	195	..	198	..	3	.	3	$\frac{S}{2}\frac{N}{2}$
6	230	225	5	228	..	3	2	..	$\frac{S}{2}\frac{N}{2}$ and N
7	225	222	3	226	..	4	..	1	$\frac{S}{2}\frac{N}{2}$
8	140	135	5	136	..	1	4	..	Mixed
Totals..	1700	1685	15	1691	5	11	13	4	

The wool showed a shrinkage of fifteen pounds from the date packed to the date shipped, but gained six pounds while in transit to

and storage in Boston, Massachusetts. This is no doubt due to the dry climate of Arizona and the increased humidity in the East.

CONDITION OF ARIZONA FLOCKS IN GENERAL

The late fall and early winter months were unfavorable for range sheep The winter was quite cold and dry and, consequently, feed on the winter ranges was very short and sparse. Heavy losses of mature sheep were reported early. The lamb crop, usually dropped on the desert, was yeaned on higher land in the foothills. The number of lambs dropped from December to March was at least fifty percent less than in the preceding year. Shipments of all classes of sheep will be much lighter than last year, due to these losses and poor feed. Many ewe lambs that are usually marketed early will be retained to replace the losses in the ewe bands.

SWINE FEEDING TRIALS WITH MILO MAIZE

At present there is a steady demand for information concerning the swine industry in Arizona. With a view to gaining information along this line, a swine feeding trial was instituted in February, 1912, and data on the value of milo maize for hog feeding are now available.

A comparison of rations consisting of ground milo maize, chopped alfalfa, and rolled barley for Lot 1, ground milo maize and alfalfa for Lot 2; ground milo maize and wheat bean for Lot 3; and the whole milo maize for Lot 4, was made with four hogs in each lot.

In all cases the feed was mixed and soaked for forty-eight hours before being fed. The hogs in Lots 1, 2, and 3 ate the feed better when soaked, while milo maize fed in the dry state to Lot 4 was not fully digested, and left much waste in the voidings.

The hogs were placed on full feed February 6 and continued until April 26, when Lot 4 was finished and ready for the market. However, they were retained for comparison with the other lots. Lot 3, also, was nearly finished at this date, but was continued on the same ration for comparison. Lots 1 and 2 made fairly good gains but lacked finish; therefore, the ration for these lots also was changed to whole milo maize. The table for the first period gives the number of the lot, the total pounds of feed consumed, the total waste, and the total gain for the first period. Likewise the second table gives similar data for the second period.

MILO MAIZE FEEDING EXPERIMENTS WITH HOGS

FIRST PERIOD

Lot number	Ground milo maize	Chopped alfalfa	Rolled barley	Wheat bran	Whole milo maize	Waste material	Gain
1	930 00	356 00	217 50			125 75	233 0
2	979 76	485 21				199 25	180 0
3	979 76			458 00		16 50	240 5
4					1864 75	238 00	258 5

SECOND PERIOD

Lot number	Whole milo maize	Wheat bran	Waste material	Gain
1	556 5		41	93
2	556 5		52	102
3	283 5	123	7	95 5
4	556 5		76	111 5

In both periods Lot 4 consumed the most feed, left the most waste, made the greatest gain, and was the best finished at the close of each period. Lot 2 consumed the least feed, left the next greatest waste, made the smallest gain, showed the poorest finish at the close of the first period, and the second best gain for the second period. Lots 1 and 2 made uniform gains during both periods, but Lot 3 was better finished at the close of each period.

The four lots were sold to a local butcher on May 17 for seven and one-half cents a pound. The purchaser did not show any discrimination between the lots at this time, saying, "All are very much better than I have been purchasing," but he did not offer a premium for finish over the regular market price on that date.

F. W. WILSON,
Animal Husbandman.

ENTOMOLOGY

THE CITRUS THRIPS
(*Euthrips citri* Moulton)

During the fall of 1911 every bearing citrus orchard in Salt River Valley, five acres or more in extent, was visited, and an estimate made of the amount of injury done by the citrus thrips. In addition, the fruit of many of the groves was examined at the fruit packing house before and after grading. The data secured was used as the basis for estimates of the average losses, as well as of the approximate individual losses. The results of the work above mentioned indicated that, if the extent of the damage could have been foreseen, it would have been profitable for eight of the citrus growers to have invested in sprayers and to have sprayed their trees. In the case of several other growers the losses would have justified spraying if the spraying outfit had been purchased cooperatively. It would not have paid the remainder of the growers to have sprayed in 1911.

Assuming the injury from the citrus thrips during 1911 to be an indication of the injury that might be expected in 1912, the entomologist thought it desirable to place the results of the investigations in the hands of the citrus growers early in the season. But when the limited number of persons owning bearing citrus groves was considered, it was deemed unnecessary to publish these results in bulletin form at that time. Instead a two-page circular letter was prepared, giving general information concerning the status of citrus thrips in Arizona, and the methods recommended for its control. A copy of this letter was mailed to each owner of a bearing citrus orchard, together with a separate specific statement in each case, relating to the amount of thrips injury estimated for the crop of the person addressed, and advice as to whether or not spraying would have been profitable.

In response to a request from the California Commission of Horticulture an illustrated article on citrus thrips was prepared and published in their "Monthly Bulletin" for April, 1912. This was reprinted in the Southwestern Stockman (Phoenix), copies of which were sent to the citrus growers in Salt River Valley, thus supplementing the information previously given in the circular letter.

A series of examinations made in the citrus groves in the spring of 1912, during the time when the insects are capable of doing the

greatest damage to the fruit, (*i. e.*, immediately after the falling of the petals) showed that the citrus thrips were comparatively scarce. They increased rapidly, however, and by the first of June appeared to be as numerous as during the previous season. The total injury accomplished was, nevertheless, considerably less than in 1911. The most striking feature shown by the examinations was that one of the groves which ranked highest as regards the percentage of scarring in 1911, having twice as much as the average grove, showed very little damage in 1912, although no remedial measures were adopted. Adjacent groves maintained their relative amount of thrips scarring. In several instances where the percentage of scarring was considerably below the average in 1911 there was a marked relative increase in the percentage of scarred fruits in 1912.

THE HARVESTER ANT
(*Pogonomyrmex barbata* var.)

Experiments with the large agricultural or harvester ant have been continued on a somewhat larger scale than during the preceding year. This insect has been given more or less attention since May 1910, as reported in the Twenty-first Annual Report of this Station. In this work the writer has been efficiently assisted by Mr. George Acuff. The first season's work, as stated in the report mentioned above, indicates that London purple is more economical for extensive field use against the harvester ant than potassium cyanide, which appeared to rank second among the many insecticides tested. Owing to the variation in the results obtained with London purple, samples of different lots, which varied considerably in their effectiveness against ants, were submitted for analyses to the chemical department of the Experiment Station. The analyses made by Dr. W. H. Ross were disappointing. No chemical differences that could account for the variation in effectiveness were disclosed. In connection with the use of London purple, therefore, the writer recommends that the purchaser in need of large quantities should first obtain samples of different lots and, after determining which, if any, are satisfactorily effective, should purchase the full amount desired.

Special attention has been given to experimental work with potassium cyanide on a larger scale during the past year. Without going into details concerning these experiments, it is sufficient to state here that the results reported in a preliminary way in the Twenty-first Annual Report have been abundantly verified, and the use of

potassium cyanide for extensive field work has been shown to be uneconomical and not satisfactory in its results.

At the present time special attention is being given to the destruction of the harvester ant by means of carbon bisulphide, with a view to determining conclusively whether this insecticide can be used with equal or better economy than London purple. Several new ideas in regard to methods of confining the fumes and treating nests which cover large areas are being tried out in a preliminary way in preparation for extensive experiments in the spring of 1913.

THE WOOLLY APPLE APHIS
(*Schizoneura lanigera* Haus.)

In February, 1912, a new series of woolly aphis experiments was begun at Thatcher, Arizona. In these experiments three blocks of fifteen trees each and four blocks of ten trees each were treated with different qualities of tobacco dust, nicotine sulphate (Black Leaf 40), and carbon bisulphide. These experiments were carried out by Mr. R. E. L. Wixom of Thatcher in accordance with a detailed plan furnished by the writer. The examinations to determine the results were made in part by the writer and in part by Mr. Wixom. It is planned to prepare for publication in the near future, for the benefit of those whose orchards are suffering from the attacks of the woolly aphis, a report of the above mentioned experiments, with detailed recommendations for the control of the pest in Arizona.

THE CODLING MOTH
(*Carpocapsa pomonella* L.)

The investigation of codling moth mentioned in the last Annual Report has been continued in Graham County and new work in this line has been taken up near Prescott in Yavapai County. In Graham County, Mr. R. E. L. Wixom and Miss Rosalind Wixom have made painstaking observations and records of great value in pursuance of an outline provided by the writer. The information thus obtained has been put to timely use in connection with the codling moth control work under the Horticultural Law of 1909 and its amendment known as the Crop Pest Law of 1912. Observations and records made near Prescott by Mr. L. L. Bates, will prove of value not only in connection with codling moth control in that vicinity, but other portions of the State of similar elevation, especially in Navajo and Apache Counties. Codling moth records, should be continued for at

least three years in order to furnish data upon which to base general conclusions.

MISCELLANEOUS INSECT INVESTIGATIONS

Demands for immediate information concerning the control of insect pests, as in the past, has led to more or less miscellaneous work. The corrupted lady bug (*Epilachna corrupta*), which is perhaps the most destructive of the bean pests in Arizona, has been reported from several sections of the State, and, upon the presentation of a favorable opportunity at Thatcher, Arizona, experiments were begun at that point against this pest. The two insecticides that have been favorably considered most as remedies for the corrupted lady bug are arsenate of lead and arsenite of zinc. A supplementary test of the effects of these two insecticides upon the foliage of the bean plant, conducted at Phoenix, indicates that arsenate of lead should be preferred over arsenite of zinc, at least until further experiments have been conducted to determine conclusively the comparative burning effects of these two insecticides. Observations upon the life history and habits of the green June bug (*Allorhina mutabilis*) and experiments to determine the most satisfactory methods of control have been begun. Among other insects to which more or less attention has been given is the squash capsid (*Pycnoderes quadrimaculatus*). This is an insect which has proven to be a very difficult insect to control, and deserves considerable attention to the study of its life history and habits, and to experiments for its control.

PUBLICATIONS

A nearly complete list of the publications of the writer during the past fiscal year has been included in the Fourth Annual Report of the Arizona Horticultural Commission. Of these publications only one, the article on the citrus thrips prepared for the California Commission of Horticulture, relates to experimental work. The preparation of several publications for the "Timely Hints" series is contemplated for the near future. To supply the need for general information with regard to insecticides and their use against the more common insect pests found in Arizona, a bulletin on this subject has been prepared for publication by the Experiment Station.

A. W. MORRILL,
Entomologist.

CHEMISTRY

The usual lines of work, with some changes in detail, have been followed during the past year, and beginnings have been made in certain new lines, more especially in the study of the chemical and physical properties of Arizona olive oil The biochemist was engaged at the Tempe Date Orchard for several weeks in special study and research relating to methods of handling and processing fresh dates commercially The sixth annual complete analysis of the Salton Sea water, in cooperation with the Desert Botanical Laboratory has been made, and all the water analyses on file in the department have been compiled according to river drainages, thus bringing the tabular matter of Bulletin 46 to date Many analyses of miscellaneous material, chiefly irrigating waters and soils, have been made Some of the resulting observations on the close proximity of black alkaline and calcium sulphate waters, which, when mixed in proper proportions, give a neutral water well adapted for irrigating purposes, are of such practical application as to warrant discussion in this report.

SALTON SEA WATER

The following table shows the composition of the water of Salton Sea about June 1 for the past six years The samples have always been taken at approximately the same place southwest of Mecca, California.

During 373 days from June 3, 1911, to June 10, 1912, the total soluble solids, including water of occlusion and hydration, have increased 17 9 percent, or about 17 5 percent for the year ending June 3, 1912, if the evaporation in June is assumed to be one and one-half times as great as the average for the year, as was suggested in the Twenty-second Annual Report

Calcium has increased only 10.6 percent and magnesium 16.6 percent. The lower rate of increase, especially that of calcium, points to the deposition of calcium carbonate and, possibly, magnesium carbonate from the water. Further evidence of the deposition of calcium carbonate is found in the relation between the decrease in calcium and in the bicarbonate radical. In 1911 the bicarbonate radical HCO_3 (determined volumetrically) amounted to 17.14 parts

SIX COMPLETE ANALYSES OF THE SALTON SEA WATER

	Parts in 100 000					
	June 3 1907	May 25 1908	June 8 1909	May 22 1910	June 3 1911	June 10 1912
Total solids (dried at 110 deg C plus water of occulsion and hydration	364 80	437 20	519 40	603 80	718 00	846 55
Water of occlusion and hydration			17 50	22 56	20 84	23 9
Sodium Na	111 05	134 26	160 33	189 28	227 81	270 71
Potassium, K	2 30	2 78	3.24	3 53	3 81	3 81
Calcium, Ca	9 95	11 87	12 70	13 67	15 62	17 28
Magnesium Mg	6 43	7 63	8 96	9 84	11 68	13 62
Aluminum Al	030	035	062	040	089	100
Iron, Fe	005	006	010	008	036	042
Manganese, Mn	none	none	none	none	none	none
Zinc, Zn	none	none	none	none	none	none
Lead Pb	none	none	none	none	none	none
Copper Cu			trace	trace	trace	
Lithium, Li	trace	013	017	021	025	
Chlorine Cl	169 75	204 05	240 90	280 93	339 42	395 44
Sulphuric, SO_4	47 60	56 74	65 87	76 36	91 67	106 83
Carbonic, CO_3 in total solids	6 58	7 66	7 34	6 38	5 78	
Carbonic, CO_2 total						12 09
Bicarbonic, HCO_3 volumetric					17 14	16 85
Silicic, SiO_4	1 41	1 43	1 59	1 55	1 83	1 79
Phosphoric, PO_4	009	011	01	013	trace	trace
Nitric, NO_3	18	20	none	none	none	trace
Nitrous, NO_2	none	trace	0006	none	none	none
Oxygen consumed	093	059	068	045	063	072
Boric acid	.	trace	trace	trace	trace	trace
Total constituents	355 39	426 74	501 10	581 67	697 83	

per 100,000, whereas in 1912 it was 16 85 parts per 100,000 instead of 20 31 parts, which would be required to correspond with the increase in soluble solids In 1911 calcium equalled 15 62 parts per 100,000, and, had there been no deposition, should have equalled 18.42 parts in 1912, instead of 17 28 parts—a falling off of 1 14 parts per 100,000 The HCO_3 corresponding to this decrease of 1 14 parts of calcium would be 3.47 parts, whereas a falling off of 3 46 parts was actually determined by analysis. The additional HCO_3 required for the slight decrease in magnesium would not exceed the analytical error although the ratio $Mg \cdot (HCO_3)_2$ is very high.

Sodium has increased 18.9 percent but potassium has remained stationary. This fact confirms an observation not heretofore re-

corded; namely, that since 1908 the ratio of potassium to sodium (also to total solids) in the Salton water has decreased steadily, as shown by the following table:

ANNUAL RATIOS OF POTASSIUM TO SODIUM AND TO DISSOLVED SOLIDS IN SALTON SEA WATER

	Potassium	Sodium	Total solids
1907	1	48.3	158
1908	1	48.3	157
1909	1	49.5	160
1910	1	53.6	171
1911	1	59.8	188
1912	1	71.1	222

This decreasing ratio of potassium to sodium and to soluble solids may be due in part to the inflow of drainage waters containing a less ratio of potassium; but this is not likely, since available analyses of the Colorado water show a ratio of from 1:28 to 1:87 of potassium to total dissolved solids. It is due more probably to a slow reaction of the potassium contained in the water with minerals on the bottom of the lake.

OBSERVATIONS OF THE CLOSE PROXIMITY OF BLACK ALKALINE AND CALCIUM SULPHATE WATERS

Black alkali is of common occurrence in waters received at this laboratory; and, frequently, the chemists are obliged to report such waters unfavorably, although otherwise they would serve very well for irrigating purposes. Thus each acre-foot of an irrigation water carrying ten parts of black alkali per 100,000 will add 272 pounds of sodium carbonate to the soil on which it is used. It is also known that most crops do not thrive on soil containing more than .10 percent (equivalent to 4,000 pounds in the first acre-foot) of this form of alkali. Since sodium carbonate is difficult to leach out of the soil, and since the conditions under which these waters are used often preclude the application of large amounts for leaching purposes, it may easily happen that most of the black alkali would remain concentrated in the upper stratum of soil. Under these conditions, and assuming that the land was originally neutral, we find that the limit of tolerance would be reached in a very short time, depending, chiefly, upon the depth of water applied to the land each year. Thus, in

average practice serious injury might occur easily before the end of ten years. If, however, calcium sulphate or gypsum is applied to the land or mixed with the water, a reaction will occur in which the injurious sodium carbonate, by combining with the gypsum, will be changed to the much less injurious sodium sulphate and inert calcium carbonate. The tolerance of crops for sodium sulphate is not only five times as great as for black alkali, but sodium sulphate clings much less tenaciously to the soil, and, therefore, may be leached out much more easily.

Occasionally, waters of opposite character capable of reacting in this way are met in successive water-bearing strata in the same well, but during the past year several very interesting instances of calcium sulphate waters occurring in close proximity to black alkaline waters have come to our notice. The composition of several of these is stated in the following table:

COMPOSITION OF CLOSELY ASSOCIATED CALCIUM SULPHATE AND BLACK ALKALINE WATERS

Laboratory number	4793	4794	4795	4801	4802	4986	4987	5003
Total solids at 110° C.....	17.6	39 6	135 4	119 6	114.4	62.0	48.6	175.6
Chlorides as sodium chloride.....	1.0	14.8	81.6	6.9	5.7	2.8	3.6	80.8
Permanent hardness as calcium sulphate.....	....	....	19 6	4.1	....	....	6.5	....
Temporary hardness as calcium bicarbonate.....	3.2	8.1	14.6	63.2	60.5	47.0	35.6	54.3
Alkalinity as sodium carbonate.....	8.5	6.36	....	....	0.85	10.2	....	5.5

The first three analyses in this table are of waters encountered by Director Forbes in examining the source of supply for a small irrigation project at Bear Springs about six miles above Fairview in Graham County. A simple calculation shows that water 4793 from the east well in the project carries 231 pounds of sodium carbonate in an acre-foot, and that, if three acre-feet were used annually, in ten years 6,941 pounds or .17 percent of black alkali for the first acre-foot of soil would be added to the land. Similarly, water 4794 from the middle well would add 5,172 pounds or .13 percent of black alkali for the first acre-foot. Water 4795 from the west well, however, is

rich in calcium sulphate, the natural antidote for black alkali, amounting to 416 pounds in the acre-foot and capable of neutralizing water 4793 when mixed in the ratio 1 to 1.8, and of neutralizing water 4794 in the ratio 1 to 2.4. An interesting feature in this case is, that while the water from the west well (4795) is available to correct the alkalinity of the other two, of itself it would prove rather unsatisfactory due to its large salt content. The two black alkaline waters, on the other hand, are unusually low in harmful salts other than sodium carbonate. Consequently, the neutral water resulting from mixing 4795 and 4793 in the ratio 1 to 1.8 will contain 59.7 parts per 100,000 of dissolved solids, and that from mixing 4795 with 4794 in the ratio 1 to 2.4 will contain 67.7 parts, in either case producing very satisfactory irrigating waters.

Waters 4801 and 4802 are from wells about six hundred feet apart in the Santa Cruz Valley near Tucson. The amount of black alkali in the one is not large enough to interfere seriously with its use, these waters illustrate the possibility of finding adjacent sources of entirely different composition. The fairly high percentage of dissolved solids in these two waters, which ordinarily would raise some question as to their effect after long continued use, represent an unusually large amount of harmless calcium bicarbonate, and the remaining dissolved material is mostly sodium sulphate, the least harmful form of white alkali.

Waters 4986 and 4987 are from opposite sides of the Santa Cruz underflow at the San Xavier Indian Agency. Both these waters are excellent, in that the solids are mostly calcium bicarbonate, and their salt content very low; but the black alkali in 4986 would eventually prove disastrous if used alone. If, however, the two waters are blended in the ratio 1 of 4986 to 2 of 4987, a neutral water of satisfactory composition will result.

The remaining water (5003) is from a bayou of the Colorado River, and is interesting from the fact that it is black alkaline, whereas the Colorado normally contains calcium sulphate. The water is stated to be flowing, and probably originates largely in seepage. In reclaiming a large tract of irrigable land it will be necessary to use this water part of the season; but, fortunately, only during that part when minimum irrigation is required. At other periods the Colorado flows through this channel, and abundance of calcium sulphate water of otherwise suitable character will be available with which not only the black alkali of the previous irrigations can be neutralized but the accumulated white alkali washed out.

COMMERCIAL STUDIES WITH THE DATE

During the date harvest of 1912 the biochemist was engaged in studying commercially the processes of artificial ripening, and the marketing of the different varieties of dates available in the Tempe Date Orchard. The advantages of such studies in the field soon became apparent, for at a distance it is almost impossible to realize and to develop methods to overcome the real difficulties in an industry of this nature. A few days of study and observation in the harvest revealed the fact, that, in so far as the varieties adapted climatically to Salt River Valley were concerned, artificial ripening was of secondary importance, although it might become essential to success even with these varieties under certain conditions. The real drawback to the immediate success of the fresh date industry—a phase of the industry in which we can hope to hold a natural monopoly—were the insects which infest the date in the orchard, and the poor keeping quality of many varieties

ARTIFICIAL RIPENING OF DATES

The limitations to the application of artificial ripening and its interdependence on orchard management became more apparent as the season's work progressed. The chemical methods of ripening have given the best success with the more reactive varieties, and, so far as we have been able to discover, all the varieties which seem adapted to our climatic conditions belong to this class. The less reactive varieties, especially Deglet Noor, have given larger yields by the heat process. Acetic acid and nitrous ether, either of which would have served very well, have been displaced by carbon dioxide, practically with identical results. While the carbon dioxide method may prove a little more expensive and require a more complicated plant, we believe it will be free from all objections so long as it is applied only to fruit that has reached a sufficient degree of maturity; and this precaution holds true for any method. After the fruit has been stimulated by carbon dioxide, the application of gentle warmth greatly shortens the time required for perfect ripening. By a combination of these methods Rhars dates removed green from the tree were marketed in less than forty-eight hours. When very immature green stock is ripened, it must be dried somewhat to insure reasonable keeping qualities. Observations have shown that dates ripened artificially at the end of a prolonged dry period keep well and pass through long wet periods in good condition. Even those fruits ripened several days after a rainy period began had better keeping

qualities than those ripened a week after the close of the same rainy period. A downpour seems to be far less detrimental to green stock for artificial ripening than a fog or continued humidity. In the case of Rhars dates, after considerable naturally ripened fruit had been harvested, not over twenty-five percent of the remaining green fruit could be ripened artificially. Some days later, after from sixty to seventy-five percent of the fruit had ripened naturally, about eighty-five percent of the remaining green stock responded to chemical stimulation. Thus, in handling a Rhars orchard commercially, the ripe fruit should be picked for a time, after which it will be best to remove the bunch and ripen the remaining fruits artificially. And this applies to many of the best varieties for this region. The time to remove the bunches will be determined by weather conditions, by general experience and by test batches. The grower will also bear in mind that the green stock on the trees deteriorates for purposes of artificial ripening when exposed to a humid atmosphere.

In this connection a very valuable observation was made by Mr. Simmons, that if partly ripe Rhars dates are caught by wet weather and soured, they may be separated from the good dates, which ripen later, by shaking the bunches—the sour fruit will fall away leaving the sweet dates tight on the bunch. Heretofore, it has been almost impossible to make a reasonably safe separation of sour from sweet Rhars, and often a large part of the crop has been lost that might have been saved.

PASTEURIZATION OF DATES

In experimenting with the heat method of artificial ripening, it was noticed that the small beetles (*Carpophilus dimidiatus* family *Nitidulidae*), which prove so troublesome on fruits in the Southwest, were driven from their shelter beneath the skins, where they had entered through weather cracks. More heat killed them. This suggested the application to dates of the principle of pasteurization, practiced so long and successfully with milk, in the expectation that it would not only kill insects and their eggs, but give the fruit improved keeping qualities. Pasteurization consists in maintaining a moderately high temperature long enough to destroy or retard the development of living organisms without seriously impairing the natural flavor of the substance treated. In the case of dates 65° to 70° C. maintained for two or three hours seems best adapted to secure the desired effect. Further investigation with more suitable appliances than those at our disposal the past season will determine these

conditions more definitely. The pasteurized dates were free from insects, and one lot of Rhars packed on a foggy day, when the humidity was ninety-six percent, showed excellent keeping qualities. The processed fruits are more acceptable to most people than the raw stock, and with some varieties, such as Birkets, the improvement is very marked. It is true that numerous failures were experienced, but generally these were due to imperfections in the improvised appliances, or to lack of experience in applying newly discovered processes, and not to any fallacy in the underlying principles. By the skillful application of artificial ripening and pasteurization, supplemented by partial drying under certain conditions, the harvesting and marketing of fresh dates of varieties adapted to our conditions promises to come absolutely under the control of the grower and packer, regardless of temporary unfavorable weather conditions.

VARIETY TESTS

There are in the Tempe Orchard few varieties represented by a sufficient number of trees to make really satisfactory commercial demonstrations. The most numerous are Rhars, Birkets, and Degiet Noors. Other varieties represented by one or more individuals have in some cases given promise of commercial success, and, probably, a profitable fresh-date industry could be carried on with any of them, but in other cases they have proven worthless. A few have done well in some years and failed in others.

As an aid to the conservative and, therefore, safe development of the date industry in Salt River Valley, the following observations should be given very careful consideration, and varieties selected that meet our peculiar conditions of climate, markets, and labor. We are not an isolated community but form a part of the world's markets as is attested by the fact that dried oriental dates of good quality are being delivered in our own territory at seven and one-half cents a pound, and in our natural markets at five or six cents a pound. Therefore, to secure a permanent and profitable outlet, we must either prejudice the market against the foreign product, furnish a superior product, reduce the cost of production below that of our competitors, or supply a form of the product which others cannot supply by reason of natural barriers.

It is true that oriental dates are subjected to slovenly and filthy handling that would never be tolerated in our country, and that thousands of people never would eat dates if they had personally observed these practices. However, the effect of such antipathy on

the market price of any considerable quantity of clean dates would probably be negligible.

As to the superiority of the product, that is largely a matter of adaptability to climatic conditions; and experience is showing that relatively few varieties are perfectly adapted to our climate The areas in foreign lands adapted to the culture of high-quality confection dates (for example the production of the Deglet Noor in the northern Sahara) will undoubtedly be extended greatly by the development of known underflows even in the best of the date growing country, by the consolidation of existing small holdings and more advantageous planting, and by the replacement of relatively worthless varieties with such varieties as Deglet Noor by more progressive owners, especially by foreigners. The penetration of the Sahara with railroads, which it seems will eventually occur as a military expedient if for no other reason, will bring some of the best date regions of the world closer to its markets. The people of the desert will not be found reluctant to exchange a still larger portion of their excessive date diet for wheat and corn, when it becomes possible to do so and live. The opening of other date countries such as Morocco and Arabia to western methods of culture and administration will also increase the supply of the highest quality dates; and the application of artificial ripening will extend the date industry to other districts of little value at present but as well adapted, climatically, to date growing as is Arizona.

The reduction of our costs of production below those of the Orient seems beyond expectation, since in the Old World oases the date workers are remarkably skillful, mounting the trunks of the highest palms with the agility of monkeys and in less time than it takes our workmen to erect a ladder. Our laborers, moreover, receive from six to eight times the pay of free laborers in those countries, and work not over two-thirds the number of hours. In the date harvest we can scarcely say that our laborers are more efficient. At the packing houses there is abundance of cheap labor available for artificially ripening and packing fancy confection dates.

In the production of fresh fruit dates, however, we have a natural monopoly, for it is not likely that fresh dates can be made to keep for ocean transportation. In cold storage we have found them to mold soon. The demand for fresh dates is strong, and grows rapidly when high-class fruit is offered. The consumer, also, seems willing to pay almost as much for first-class fresh dates as for fancy confection dates, and, if large amounts of both products were thrown on the market, it is doubtful whether the additional price paid for the con-

fection dates would cover the extra cost of preparation, and the fresh fruits will not be obliged to meet foreign competition

Thus, the date which it appears will meet most nearly our requirements after the industry has become established and extensively developed, should have the following characteristics

1. It should be adapted as perfectly as possible to our conditions of climate, and should ripen the greater portion of its fruit naturally, since every manipulation with high priced labor puts the product at a disadvantage in competition with the products of more suitable climates and cheaper labor. The fruit, however, should not ripen too early, for during hot weather the demand for sweets is not strong.

2. The fruit should be susceptible to rapid and perfect artificial ripening, so that it may be saved during unfavorable weather or ripened to supply unusual demands.

3. The fruit should be easily and cheaply handled both in the orchard and packing house. This requires that the fruit stems should be long enough to carry the bunch out well from the interior of the tree. The fruits should hang to the stems, but still be easily shaken loose when wanted. These conditions offer the best possibilities for the invention of mechanical pickers, and reduce several times the cost of hand picking.

4. The fruits should be as large as possible, but quality in the sense of lusciousness and lack of fiber is probably not of great importance. It has been observed that the consumer will eat larger quantities of the coarser dates than of the very rich varieties, which soon cloy the appetite. A tight, tender skin, however, is a decided advantage in the date. The fruits should be resistant in the immature stages to the effects of wet weather, neither being attacked by rot nor the skins cracking and curling.

5. The palms should be prolific bearers and should bring practically all their fruits to maturity.

These conditions have been met almost perfectly by Birket el Haggi. Its chief faults are that its skin separates from the flesh when the latter dries, and, that it has a tendency to crack at the point in damp, hot weather. This cracked portion does not sour, as is the case with Rhars, but often forms a hard woody tissue that ruins the date for commercial purposes. It is possible, however, that many of those so affected could be ripened artificially before the woody tissue forms. Otherwise the quality of the fruit is improved rather than injured by damp weather. The Birket date is perfectly adapted for Salt River Valley, and will ripen almost all of its fruit naturally, but, when found desirable, it is one of the most responsive varieties to

artificial stimulation. Sour dates of this variety are easily detected and separated. It bears prolifically, being equal to Deglet Noor in this respect. The fruits are large and attractive, and not too rich. They quickly come into favor for the table, and, wherever we were able to offer Birkets on the market, there followed a strong increase in the demand, which undoubtedly would have grown if the dates had been available. Fourteen trees, many of which were in their off year, bearing light crops only, gave in gross $223 and enough fruit was used for experimental purposes to have increased this to $250. It is estimated that this variety at a net profit of five cents a pound, one hundred pounds of merchantable fruit annually to the tree, and forty trees to the acre would yield a grower $2,000 net, including his own labor on a ten-acre orchard, with almost no labor other than irrigating during the hot months of May, June, July and August.

We may say safely that the date industry with Birket el Haggi is established in Salt River Valley today, and will bear expansion successfully to very large proportions. The market is ready, and will increase with the supply; the variety is perfectly adapted to our climate; and for natural reasons we need fear no foreign competition. Other varieties, however, deserve mention and some have made remarkable showings; namely, Tadala, Tennessim, Khadvawi, Maktum, Kustawi, Behri, Nesheem and, possibly, a few others. Rhars has not made a good showing, although with our present method we expect to save nearly the entire crop as fresh or as dried dates. The manner in which Rhars date is borne on short stems in the interior of the tree, and the difficulty of detaching the fruit have made it very expensive to harvest. It is also very sensitive to damp, hot weather, which cracks and curls the skins of the green fruit, causing it to ripen and sour almost simultaneously. Rainy weather promotes the natural ripening of this variety, and at times very large quantities ripen rapidly under conditions that make harvesting almost impossible before the fruit sours. While the variety is difficult to handle and heavy losses will be sustained from time to time, the culture of Rhars, possibly, might become profitable, but there are many varieties better adapted to our conditions. Rhars, moreover, for the most part, is too early for the best market. In years that the Nazl el Bacha has borne, it has given promise of equaling the Birket, which it resembles in several respects.

A. E. VINSON,
Biochemist.
C. N. CATLIN,
Assistant Chemist.

IRRIGATION INVESTIGATIONS

This phase of the Experiment Station work proceeded without interruption through the fiscal year. The general office routine has been continued. This includes the collection of logs of wells throughout the State wherever it is possible to obtain them, special blank forms being furnished for the purpose. The calls for consultation and advice, both by visits and by letters, have been greater than usual. These calls cover a wide range of subjects along the lines of irrigation and general farm engineering. Special lines of investigation are as noted below.

SULPHUR SPRING VALLEY

The great area comprised within the Sulphur Spring Valley is divided into two parts by a chain of hills opposite Pearce. The larger northern part has centripetal drainage to a central playa lying between Willcox and Cochise. The area lying northwest of Willcox has a good groundwater supply, and there appear to be dry-farming possibilities in certain portions of the Valley. A reconnaissance survey of this area was made in May, particular attention being given to groundwater supplies suitable for supplementary irrigation.

The smaller division of the Valley, lying south of the Pearce hills, drains southward into Mexico through the Whitewater River, the longest feeder of which rises in the Chiricahua Mountains on the south slope of the highest peak. The side slopes of the main valley from the base of the Swisshelms on the east and from the base of the Mule Mountains on the west are singularly smooth, and well merit the name of clinoplains. The soil of these slopes is excellent, and dry-farming has proven successful in wet years. With average rainfall, such as occured during the last three years, supplementary irrigation is required to produce profitable dry-farm crops. Such irrigation can be accomplished by utilizing the stormwaters that flow down the broad flat draws, by ditches from the creeks and river, or by pumping from wells. Irrigation for intensive farming and for alfalfa is possible within certain areas by pumping from wells.

In order to obtain comparative rainfall data for different parts of the watershed, rain gages have been installed in critical places. Six gages at high altitudes on the mountains are maintained cooper-

atively by the U. S. Forest Service and this Station. The rainfall at high altitudes is proven to be very large. Some comparative records are given in the following table:

RAINFALL RECORDS 1911-1912

	Douglas	McNeal	Courtland	Rucker Canyon	Chiricahua Peak
Altitude	3966	4150	4660	5200	9400
1911	Inches	Inches	Inches	Inches	Inches
August	2.29	2 21	2.63	.....	7 12
September	1.25	4 24	2 22	4.40	7 05
October	2.87	2.21	2 21	3 13	4 33
1912					
July	2 31	3 16	3 76	6.09	7 35
August	4 17	3 85	4.93	6 70	6 95
September	0 82	1 09	1.22	1 25	7 58
October	0 70	0 58	1.09	1 25*	3 55*

*To October 15.

It is apparent that the rainfall increases rapidly with altitude, and as a corollary, the water supply of the Valley must be dependent in a large measure upon the discharge of floods from the surrounding mountain canyons.

Direct measurements of the discharge of floods in the Whitewater River have been made at Douglas and at the Taylor bridge fifteen miles northwest of Douglas. The Douglas station was installed in July, 1911. In September it was accepted by the hydrographic branch of the U. S. Geological Survey; since then it has been maintained cooperatively. The discharge is given in the table on page 709.

It is notable that the floods are confined almost wholly to the summer months. In order to determine the source of these floods the gaging station at the Taylor bridge was established in June, 1912, and was maintained through the summer. Observations have been made, also, of the flow of the river above Whitewater post office, and of the flow from Leslie Canyon. Since July, 1911, there has been no flood from above Whitewater or from Leslie Canyon that reached the lower river course. Practically all the river flow has come from the Mule Mountains and the adjacent slope.

GROUNDWATER STUDIES

Logs of the wells scattered throughout the Valley have been systematically collected and studied. From the standpoint of

DISCHARGE OF WHITEWATER RIVER AT DOUGLAS, ARIZONA

Month	1911	1912
	Acre-feet	Acre-feet
January	. . .	0
February	. . .	0
March	. . .	900*
April	. . .	0
May	. . . .	0
June	. . .	0
July	. . . .	1482
August	1406	4238
September	3802	1097
October	2186	293
November	0	0
December	0	0
Total		8010

*Approximated from maximum height and duration of flow.

groundwater supply, the Valley south of the Pearce hills can be divided into four areas as follows:

1. The Whitewater fan: This has its apex at the Whitehead ranch and its base passes through the Double Rod ranch. Its soil is sandy, and of Recent origin. The groundwater supply increases in abundance from the base of the fan toward the apex, but the depth to the water plane also increases. Development should be made by means of a cordon of wells along the line of thirty feet depth to water.

2. The Swisshelm slope: The surface here is almost a plane unbroken by erosion, with soil of adobe but gravelly in some places. Rains and floodwaters penetrate only a short depth, and return to the surface to be evaporated or transpired by grass and other vegetation. Wells for supplementary irrigation are possible, and stormwaters should be controlled and used.

3. The Mule Mountain slope: On the west side of the Valley, sand and silt constitute the major part of the valley fill. It is probable that wells of large capacity can be obtained by careful selection of strainers. Homesteaders are beginning to use the stormwaters in the draws. It were better for the water to be led out in broad ditches onto higher land than used in the draws.

4. The bottomland or trough: The center of the Valley for a width of one-quarter to one mile has been eroded in Recent time and subsequently has been partly refilled. The Recent deposits contain excellent gravel beds, which are uncemented and cleaner than the

gravels in the surrounding Pleistocene beds. Good wells at very shallow depth are possible along the trough of the valley. For economical development and high utilization of the storage capacity of the gravels, the wells should be of large yielding capacity and should be spaced at intervals of about one-half mile rather than placed at random. Considerable of the bottomland is so impregnated with black alkali, bicarbonate of soda, that it is fit only for pasture, and the sod of salt grass never should be plowed. The water from the

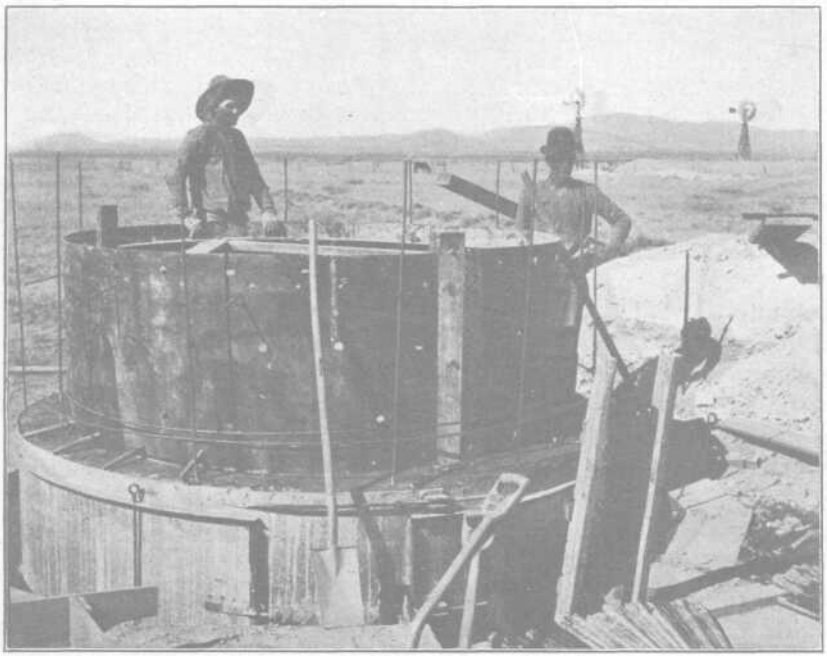

Fig. 3.—Building a reinforced-concrete caisson curb for well at Elfrida, Arizona. Inside forms have been raised and set; outside forms have been loosened. Vertical and horizontal reinforcing rods are shown, also taper pins which make holes through the concrete wall to admit the water.

wells can be pumped up to higher ground that is free from alkali, or it can be led out in ditches. At the northern end of the valley trough in the vicinity of the Four Bar ranch, playa conditions have prevailed during the upbuilding of the valley fill, and hence the well logs of the district show clay and adobe almost exclusively. The best wells will be found south of the playa-built area.

For developing the shallow wells of the Valley, the caisson curb of reinforced concrete, as designed and used by this Station in Pima County, is excellently adapted. Consequently, much effort has been made to introduce the caisson curb into Sulphur Spring Valley.

For this purpose the Station has collected an equipment for building and sinking the curbs. The equipment includes all-metal forms for a curb eight feet inside diameter; all-metal forms for a curb four feet inside diameter, a special sinking pump of 900 gallons a minute capacity, and capable of pumping silty water without injury, a guy derrick and hoisting buckets; and a 2-horsepower distillate hoisting engine. Three ranchers have been found who were glad to cooperate in sinking wells, the Station furnishing the equipment and supervision and the rancher furnishing materials and labor. A committee of the Chamber of Commerce of Douglas has cooperated with the Station on a fourth well. It is proposed to establish gardens under these pumping projects, leasing from three to ten acres to each gardener. Many more wells of similar character should be sunk along the valley. They do not require great capital, are sure of results, and will permit the development of vegetable gardening, whereby Douglas, Bisbee, and other neighboring mining camps and cities may be provided with home-grown produce.

Another fact that should be pointed out at this time is that the mountain canyons surrounding Sulphur Spring Valley and the valley slopes close to the mouths of the canyons, are preeminently adapted to the production of high-grade apples, pears, and other fruit. Even with such adverse conditions as bouldery soil, and the fitful character of the stream-flows, it is possible to establish orchards, using heavy irrigations during rainy seasons and using pumped water sparingly at other times. The great development of orchards along the rim of the valley is confidently predicted. It will require ingenious and unique methods of developing water and of irrigating.

ADVANCES IN PUMPING MACHINERY

The recent introduction of internal combustion engines that burn cheap fuel oil promises to revolutionize pump irrigation. These engines are wrongly called crude oil engines; they cannot be run on California or Texas crude oil. However, they do burn successfully a cheap grade of residual oil left after the heavy oils and base have been separated for locomotive use, and the lighter oils have been taken off as gasoline. Some of these new oil engines are built on the Otto, or four-cycle principle; others are of the two-cycle type. It has been maintained by the writer that with gasoline engines under Arizona conditions, pump irrigation for alfalfa is limited to areas where the water is less than 25 feet from the surface. With the new engines the limiting depth can be more than doubled.

Scarcely less important has been the great improvement in the design and construction of pumps for irrigation This is largely in response to an awakened public demand for pumps of better efficiency and better mechanical construction. Only a few years ago irrigation pumps were uniformily of the cheapest type, while now many pumps of 70 percent efficiency are being installed. This again will double the limit of economical lift of pumping For five years this Station has fostered a demand for better pumps by publishing tests and other data showing the comparative wastefulness of ordinary stock pumps.

GASOLINE ENGINE TROUBLES

In recent years the gasoline engine has been universally adopted, not only for pumping but for a great variety of uses. There are a host of gasoline-engine owners who have never taken the time to study their engines and to learn to differentiate between the many "troubles" to which a gasoline engine is subject. As a consequence trouble occurs frequently, sometimes causing vexatious and costly delay; when, if the operator were conversant with engine troubles, a few minutes' search would reveal the difficulty and the necessary adjustment or repair could be made. What is needed in such cases is a classified list of troubles so arranged that the operator can, by a process of elimination, locate the exact position and nature of the difficulty. A few such lists have appeared in the technical press. Two years ago the writer began the preparation of such a list. It has been revised frequently until it is believed to meet the requirements of the ordinary four-cycle engine of whatever size, and will be issued as a bulletin in the near future. The bulletin will contain, in addition, separate articles on the housing of an engine, an explanation of the four-cycle principle, fuel consumption, and the magneto.

WINDMILLS FOR IRRIGATION PUMPING

In certain portions of Arizona windmills are of economic importance as a means of irrigating garden crops and alfalfa, the two essential conditions being high wind velocities and groundwater at shallow depths. The power of the wind varies as the cube of the velocity, so it happens that while the wind velocity at Douglas is scarcely twice the velocity at Phoenix, the power of the wind at Douglas is seven times the power at Phoenix. Many families in Cochise County with the aid of windmills raise large amounts of vegetables, partly for home consumption, partly for sale. The windmill is the poor man's power. Over large areas, too, the material of the valley fill

is not such as to permit the development of large wells, but the slow draught of windmills can be applied month after month and the water pumped through the non-growing months can be applied and stored in the soil.

A study of windmills was made during the past year and the results have been published as Timely Hint No. 95. Some of the conclusions expressed in the brochure are repeated here

The galvanized steel windmill is much to be preferred over the wooden mill. Towers may be of wood if the cost is much reduced thereby, though three-post steel towers are better.

Back-geared mills should be used for all sizes up to 16 feet. Larger sizes may be direct-stroke.

Where groundwater is shallow and cost of wells is slight, it is better to use two or more small mills than one larger one, since the cost of windmills increases with the size much faster than does the power. The windmill is unique, for this principle does not hold true for any other form of power.

Windmills for house service should be lightly loaded, but for irrigation they should be heavily loaded, so that they will utilize strong winds though they stand idle in light breezes. For house service fresh water daily is desired, for irrigation, a maximum total quantity of water.

Small earth reservoirs are desirable in connection with windmills. They should serve as accumulators of water so as to provide an irrigating "head" rather than as storage. The water should be applied as soon as possible and retained in the soil by means of cultivation.

BEAR SPRINGS ARTESIAN WELLS

It is the intention of the Station to carry on investigations of the various artesian districts of Arizona. As a first step the small artesian area at Bear Springs near Pima, Graham County, was examined in April of this year.

Bear Springs is situated at the foot of a high terrace where Matthews Wash has at some time eroded a crescentic area in the Pinaleno bajada. About twenty-five small artesian wells have been bored near the base of the terrace along a line for which there are many evidences of faulting, the south side being thrown upward. The artesian pressure is due to the presence of Cottonwood Wash a mile to the southward. This wash drains a large area of the Pinaleno Mountains, but after leaving the base of the mountain, it contributes generously to the groundwater through seepage into the bed of the wash. The general movement of the groundwater is at right

angles to the course of the wash, and hence water is carried from Cottonwood Wash northeasterly to and beneath Matthews Wash. In the vicinity of Bear Springs groundwater contours and surface contours of the same elevation intersect, giving artesian conditions.

The materials shown in the steep bluffs of the terrace are brown thin-bedded lacustrine clays and fine sands. The same material is encountered in drilled wells. At a depth of 110 to 140 feet on the south side of the fault-line, there is a 10-foot stratum of loose porous sand. North of the fault-line the sand lies at a depth of about 240 feet. One deep well, at least 1,000 feet, should be drilled on the south side in the effort to discover more water bearing strata.

The flow from an artesian well depends upon two things: the pressure-head and the perviousness of the water stratum. The former is measured by the height above the surface to which the water will rise in a pipe without overflowing; the latter is dependent upon porosity, coarseness of sand grain, and the uniformity of the material. The wells at Bear Springs appear to be in fairly good pervious material, but the pressure-head is not enough to bring the water much higher than the ground surface along the fault-line.

At Bear Springs a valuable experiment was carried out to determine the effect of increasing the artesian head. One of the wells yielded only 11 gallons per minute when discharging on the surface. A trench was dug to it, so that the outlet was 6½ feet lower, whereupon the flow increased to 20 gallons per minute. A tunnel was then run from an adjacent arroyo, tapping the well at a depth of 23 feet, and the discharge became 65 gallons. The same result could have been obtained by installing a pumping plant on the surface and creating a 23-foot suction lift. The increase in yield was six-fold, and suggested at once the practicability of drilling larger wells, freeing them by hard pumping for some hours, and then either pumping them continuously, or tapping them with tunnels from the level of the bottomland a few hundred feet away.

In all the artesian districts of Arizona, it is the custom at present to leave the wells running free and open throughout the year. This entails both waste of water and loss of artesian head. Every well should be provided with a globe valve, and, when the water is not being used beneficially, the valve should remain closed. This rule should be enforced by law.

G. E. P. SMITH,
Irrigation Engineer.
F. C. KELTON,
Assistant Engineer.

AGRICULTURAL EDUCATION

INSTRUCTION IN THE COLLEGE OF AGRICULTURE

A well known man of affairs remarked to the writer, not long since, that the western agricultural and mechanical colleges seemed to be educating young men away from the farm—that they were training engineers rather than agriculturists, and that the main function of these institutions—to promote agricultural education—was not being fulfilled

How far this is true of the Agricultural and Mechanical College of Arizona, which is incorporated with the University, may be judged by the following statement, partly approximated, of the amounts of Morrill and Nelson Funds that have been devoted to the agricultural courses of instruction within the institution:

From 1890 to 1899 almost no agricultural instruction was rendered, the funds being used for the teaching of engineering, mining and general branches. Even a large portion of the Hatch (Experiment Station) endowment was for a time indirectly misused for instruction along these lines.

From 1899 to 1908 no agricultural class work was conducted at the institution; but the Hatch and Adams Funds were used entirely for agricultural experimentation as intended by the laws creating them. During this period much new knowledge of the peculiar agriculture of the Southwest was put into publication, and the way was prepared, through this acquisition of knowledge, for a successful organization of course work in agriculture.

During the second period, farmers' institute work was developed on Territorial appropriations; and this was followed by the organization, first, of a two-year agricultural course in 1908, and, second, of a four-year course in 1911. The apportionment of Morrill and Nelson Fund moneys to this work is shown in the following table:

Year	Total endowment Morrill and Nelson Funds	Apportioned for agricultural courses of instruction
1908-1909	$35,000	$1,750
1909-1910	40,000	3,300
1910-1911	45,000	6,950
1911-1912	50,000	7,900
1912-1913	50,000	7,600

These statements seem to substantiate the criticism quoted in the beginning of this discussion, and it remains for us to inquire into the reason for this condition.

Twenty years ago, when the agricultural and mechanical colleges of the Rocky Mountain and Great Basin States were being shaped along the lines of their then greatest usefulness, these states were most of them predominantly engaged in mining, and it was but natural that the mechanical and engineering sides of their curricula should have had precedence. Gradually, however, agricultural development has overtaken and in some states exceeded mining development, especially since Reclamation Service operations have added millions of acres of irrigated lands to the region. With this unforeseen agricultural growth comes the demand for corresponding courses of instruction in our Agricultural and Mechanical Colleges.

Beginning in 1899-1900, the Arizona Experiment Station has done a limited but gradually increasing amount of farmers' institute work each year in agricultural sections of the State; and has conducted short courses of instruction, two to six weeks in length, in high schools and academies. This work has become popular and has culminated in the Farmers' Demonstration Train which, with exhibits and lecturers, through the friendly cooperation of the railroads, was carried over all the principal lines in the State, November 18 to December 25, 1912.

This institute work is an effort to carry agricultural knowledge to the farmer, who needs it but who cannot come to college for it. Institutes, however, are but one way of accomplishing the result, which can also be promoted through demonstration farms, crop growing contests, farm management service and other agencies. *All these agencies are needed at all times to get agricultural knowledge into practice,* for agricultural knowledge, copiously published by many institutions, is far ahead of average agricultural practice, especially in the newer, partly developed, western farming districts.

The Lever Bill, now before Congress and said to be likely to become a law, appropriates $10,000 annually, to each State, with additional amounts prorated among the States, for the purpose of giving instruction and demonstrations in agriculture and home economics to persons not attending the Agricultural College; and is *an effort to bring about the practice of what we preach in agriculture.*

There is, indeed, at this time a widespread feeling that many of our institutions for agricultural teaching and research operate for the interest and benefit of a few, more than for the great majority of those most personally and vitally concerned. The fruits of re-

search are, therefore, slow to find their way out of print and into practice; while advanced agricultural instruction, as was once aptly expressed to the writer, "oftentimes seems only to serve the purpose of teaching teachers to teach teachers to teach."

As a matter of educational policy at this time, it is desired in the University of Arizona College of Agriculture to benefit the many rather than the few, and in a measure to close the gap that already impends between laboratories and classrooms, and the farmer. Without weakening the effort in research, therefore, farmers' institutes and high school courses should be strengthened throughout the State; and thorough course work, calculated to develop better farmers and those directly contributing to agricultural welfare, should be developed within the Agricultural College.

Consistently with these sentiments, a farmers' two weeks short course is offered by the College of Agriculture for the first time, February 10 to February 22, 1913. This course will consist of lectures by Station staffmen on topics of direct and practical interest to the farmers of Arizona, who will be welcomed, housed, instructed and entertained on the University grounds for the two weeks of their stay, at minimum cost, and it is hoped, at maximum profit to themselves.

Classwork in agriculture in the University College of Agriculture was organized and begun by Professor R. W. Clothier, in September, 1908, beginning with a two-year course. In 1911 a four-year course, also, was offered, in which the largest enrollment now stands.

The results of Professor Clothier's effort are indicated by the following statement of enrollment:

ENROLLMENT IN THE AGRICULTURAL COURSES FOR THE YEARS 1908 TO 1913

Year	Courses	Enrollment
1908-1909	Two-year	9
1909-1910	" "	15
1910-1911	" "	26
1911-1912	Two-year and four-year	38
1912-1913	" " " " "	55 (Feb. 1, 1913)

While these enrollments are small, it must be remembered that the facilities have been limited, and that the whole teaching staff has consisted of two,—Professors Clothier and Fowler. The effort has succeeded in demonstrating the demand for agricultural instruction, and the cooperation of College and Experiment Station will add to

the range and amount of instruction offered, limited only by the funds available in payment therefor.

The University Farm, three miles from the campus, is well adapted to educational uses, presenting problems in water development, in land leveling, in drainage, in alkali reclamation, in soil management and crop production, and in farm economics, of the utmost significance and value to students who will be required in practical life to solve these various problems as they encounter them throughout the Southwest. The University Farm has been misunderstood because of the many problems in reclamation which it presented. The study of chemistry, however, requires us to solve chemical problems, engineering work requires us to solve engineering problems, the practice of medicine presents new and difficult problems in surgery and therapeutics, general business constantly presents difficult financial and economic questions; why should not the teaching of agriculture require the presentation to its students of problems in pumping, in soil management, in drainage, and in alkali reclamation?

The University Farm has recently been connected with the campus by means of an auto bus line, and is now more convenient for instructional purposes than many farms connected with agricultural colleges in other parts of the United States.

It is impossible, however, to make material increase in classroom work without the agricultural building imperatively needed for Experiment Station and Agricultural College purposes at this time. With such a building, the institution enjoys almost exclusive occupation of the southwestern field, which should turn here naturally with the problems peculiar to the region, while the student personnel will in time carry advanced knowledge and training back to its application in tne soil.

R. H. FORBES,
Director, College of Agriculture.

FARMERS' INSTITUTES

METHODS EMPLOYED

The growing demand for instruction along different agricultural lines is so general and pressing that special attention was given this work during the past year. A definite plan was outlined, which, when put into operation fully, will place the institute work of the State on a firm and economic basis. There is a decided lack of organization and unity among farmers generally, more particularly in the older settled communities. Difficulty in getting sufficient publicity, and in finding some capable person to organize an enthusiastic local institute has been the rule rather than the exception. In the newer sections, however, this is not generally true. To meet this emergency, the need of an organization with officers from among the farmers and business men to cooperate with the Superintendent of Farmers' Institutes was apparent. Furthermore, the organization must not in any way savor of selfish interest, but rather tend to inspire confidence in farmer and business man alike by virtue of its great educational value.

Accordingly, the "Maricopa County Farmers' Institute" was formed as the first unit of a state-wide organization. The county organization is made up of fourteen districts, each with its own set of officers. Each district holds meetings monthly, and two assemblies of the county organization are held annually. The first President of the county organization is Mr. P. I. Edson, R. F. D. 1, Phoenix, and its Secretary is W. S. Humbert, Phoenix. The President, Vice-President, Secretary, Treasurer and five directors constitute the officers. Each director is the chairman of some committee, and selects a part of his committeemen from the various district organizations. The Superintendent of Farmers' Institutes and the Director of the Experiment Station are directors in the state organization, and, *ex-officio*, in the county units. All institute work of the counties will be done through these organizations. The officers serve gratis, any money received being used to conduct county fairs and to employ talent from outside the State for special instruction on special subjects. From one to six-day institutes will be held under this organization.

The second method of instruction was short courses in the high schools. The demand for such instruction became so urgent that sufficient money was appropriated by the last legislature to provide instruction in agriculture and other vocational pursuits in those

schools meeting the requirements. This demand was stimulated by the work that this department has done in the high schools. Those schools not receiving the benefits of the State fund will still be taken care of by the Superintendent of Institutes as far as means permit.

A third device employed was one-day institutes in churches and schoolhouses in rural communities, where from one to three lectures were given. By the use of the stereopticon, these lectures have been much improved.

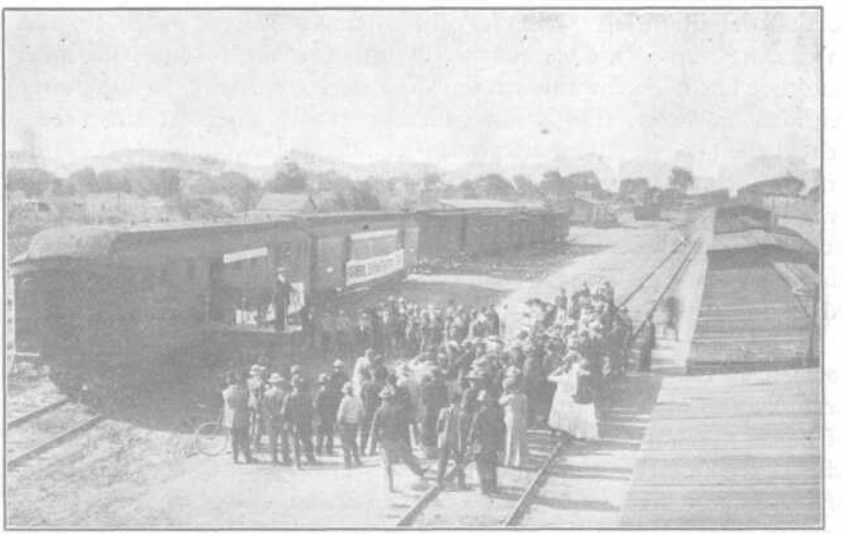

Fig. 4.—The Farmers' Demonstration Train at Mesa, Arizona. A lecture on dairying is being given.

A fourth means was inaugurated this year, when one special line was made to occupy the attention of a day's institute. This was eminently successful in the northern districts where stock judging was conducted. Specimens of all classes of live stock were brought to the grounds and judged by the lecturer.

As a fifth means, short courses for farmers were conducted at night in most places where day work was given in the high schools and in Latter Day Saints' academies. Wherever possible, work in domestic science and arts was included.

The Farmers' Demonstration Train, run during November and December, 1912, is the sixth feature to appear.

When sufficient means are available to employ the necessary staff that this plan requires, the agricultural extension work will

indeed be thoroughly handled. To make the plan more complete and quite sufficient for all contingencies, the University inaugurated this year a course of lectures on mining, public health, and other educational subjects.

RESULTS FOR THE YEAR

While the complete development of the whole plan was not realized during this fiscal year, nearly all branches have been commenced. The one-day institutes, short, night courses for farmers, and high school instruction have received the most attention. The work of the institute organization was apparent at meetings held at Phoenix and Tempe in April and May, at which lectures on "Intensive Cultivation of Alfalfa" by Director R. H. Forbes, "Sheep Breeding" by Professor F. W. Wilson, and "Irrigation Practices" by Professor A. M. McOmie were delivered. Plans for a midsummer fair were also completed, which, it might be stated, in passing, were carried out successfully in July.

Specialized day meetings proved eminently efficient in the northern division, where the idea was first tried. On account of the scattered condition of Arizona's people, institute instruction is even more effective and necessary than in the more densely populated states, since her farmers have less opportunity of learning the approved but changing practices The additional names on the mailing list, the greatly increased correspondence of the Experiment Station, necessitating twice the clerical force formerly required, and an increase in attendance at the Institutes of seventy percent over last year speak well for the growth and efficiency of this work

A brief summary of the work by counties follows

The work opened in Maricopa County November 5, 1911, where Dr. A. E. Vinson and Professor A M. McOmie held a series of fourteen institutes in various school districts and towns of Salt River Valley. Soil and farm management, date and olive culture, and dairying were the principal topics of discussion. Stereopticon views were used to illustrate the evening lectures. Mr. W. W. P. McConnell gave special lectures on dairying at Tempe and Fowler. The attendance ranged from 48 at Lehi to 359 at Tempe, the total attendance for the series being 2,431.

Four other special meetings were held in this county under the auspices of the Maricopa County Farmers' Institute at which Director R. H. Forbes, Professors F. W. Wilson and A. M. McOmie, and Messrs. P. I. Edson and W. W. P. McConnell appeared on the pro-

gram. These meetings were held at Phoenix and Tempe with an attendance of 266, making a total of 2,697 for institutes in Maricopa County.

Cochise County was covered more thoroughly than ever before. Ten places were visited, from Douglas at the extreme south to San Simon on the north. In all these new settlements much intelligent interest was shown, and, although the settlers were few and scattered, a total of 738 attended the meetings. The lecturers were Professors G. E. P. Smith, G. F. Freeman, and A. M. McOmie.

The usual live interest was shown in Graham County. Here Director R. H. Forbes and Professor R. W. Clothier held meetings from Ft. Thomas to Lebanon, visiting eleven districts with a total attendance of 1,106.

The first meeting in Pinal County was held at Casa Grande where seventy-seven people, nearly all being new settlers, were eager for information. Director R. H. Forbes and Professors A. M. McOmie and W. L. Fowler lectured on alfalfa, irrigation, and livestock in the order named.

Yuma, the principal city in Yuma County, responded with an attendance of eighty-three at two sessions held by Professors A. M. McOmie and W. L. Fowler. Wellton, a pioneering settlement, turned out its entire population of seventy-two to hear the same speakers and program. Yuma County shows a total of 155 for the year.

Yavapai County received some agricultural stimulus by the installation of the Prescott dry-farm, and lectures were offered on this subject on the Chautauqua course in June. A course in soils was conducted by Professor A. M. McOmie at which a total of 2,200 people were present. The Verde Valley also was included with meetings at Campe Verde, Central Verde, Cottonwood, Upper Verde and Cornville. A lecture on orchard management was given at each place by Professor A. M. McOmie. The total attendance for the county was 2,534.

Pima County was given its first institute this year, a meeting being held at the Davidson schoolhouse with Director Forbes and Professors Clothier, Fowler, and Freeman on the program. Forty-three farmers were present.

Navajo County with its widely scattered settlers gave a total attendance of 995 at the seven places visited. Professors McOmie and Fowler discussed dry-farming and stock improvement respectively; and with the many animals brought to be judged, much real instruction was given.

In Apache County, St. Johns, Springerville, Eagar, and Hunt gave a total attendance of 641. St. Johns gave the largest attendance of any northern town. Professor McOmie lecturing on dry-farming, Professor Fowler on stock improvement, and Miss Emma Fredrickson on home sanitation, constituted the lecturing staff of this series.

The initial work in Coconino County was done in April at Flagstaff and Williams. Dry-farming and stock improvement were discussed by Professors McOmie and Fowler. The total attendance for both places was 287.

Thus ten of the thirteen counties of the state were given instruction according to their needs, and 9,273 people attended the meetings.

Besides the work done in this manner, short courses of two weeks duration were held at the Thatcher and Snowflake academies and at the Phoenix and Mesa high schools. These courses were conducted by Professor A. M. McOmie with a total attendance of 8,096. The total attendance for the year at all meetings was 17,369, which shows an increase of about seventy percent over last year.

A. M. McOMIE,
In Charge of Farmers' Institutes.