

University of Arizona

Agricultural Experiment Station

Twenty-fifth Annual Report

For the Year Ending June 30, 1914
(With subsequent items)

Consisting of reports relating to

Administration,
Agriculture, Botany, Plant **Breeding**,
Horticulture, Animal **Husbandry**,
Entomology, Chemistry,
and Irrigation Investigations

And including a **report** on

AGRICULTURAL EDUCATION

Tucson, Arizona, December 31, 1914

UNIVERSITY OF ARIZONA
AGRICULTURAL EXPERIMENT STATION

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The Experiment Station offices and the botanical and chemical laboratories are located in the University buildings at Tucson. The range reserves (co-operative, 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. B. A.), and one mile southeast of Yuma, Arizona, respectively. The experimental dry-farms are near Cochise, Snowflake and Prescott, Arizona.

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 name 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-fifth Annual Report of the Arizona Agricultural Experiment Station, for the fiscal year ending June 30, 1914.

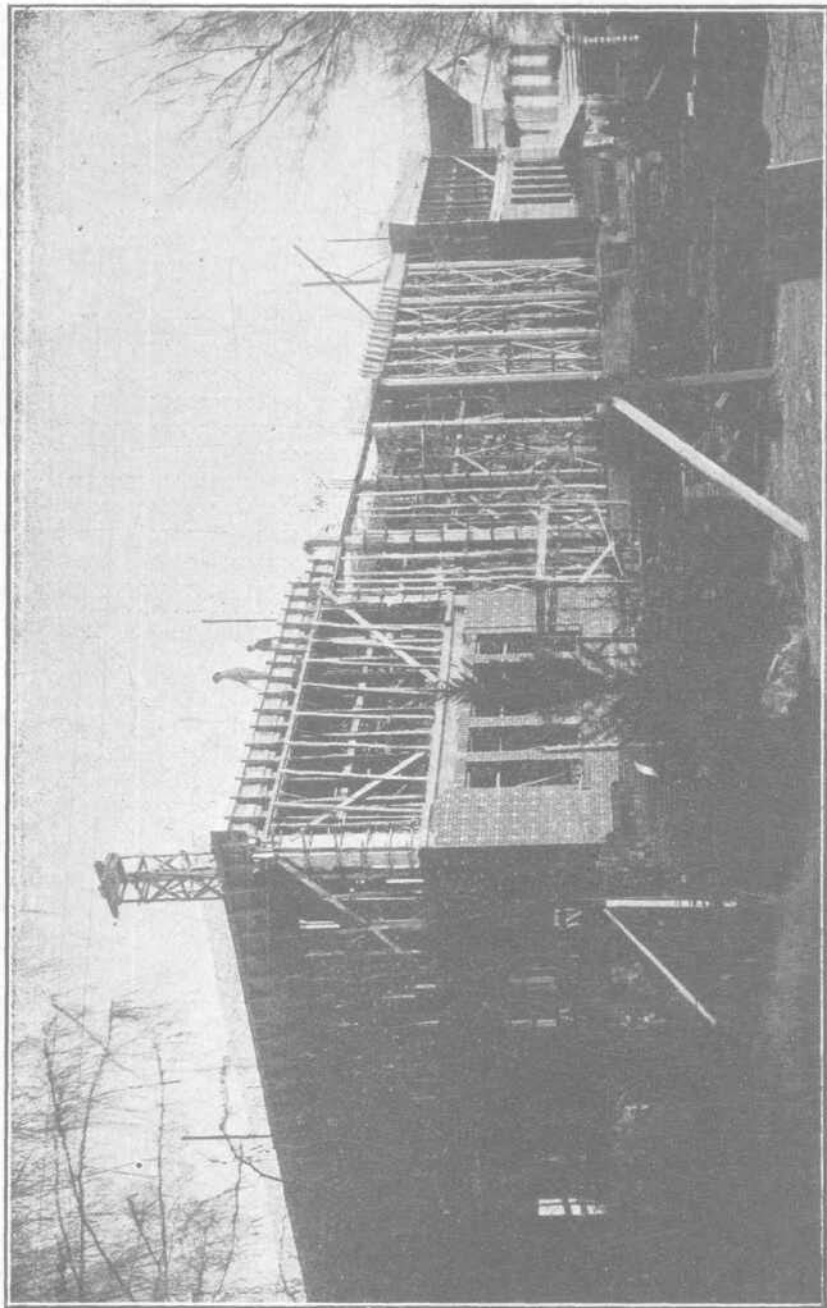
Very respectfully,

R H. FORBES,
Director

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The new Agriculture Building, under construction, University Campus, December 29, 1914

Twenty-fifth Annual Report

ADMINISTRATION

Agriculturally the year has been a prosperous one for Arizona. Climatic and rainfall conditions throughout the State have been, on the whole, favorable. The winter of 1913-1914 was mild and the somewhat greater than usual rainfall afforded good irrigating water supplies, while the combination of rainfall and mild temperatures resulted generally in good grazing range conditions. Irrigated areas under the Yuma project on the Colorado River have steadily increased, amounting to a total of 16,750 acres in December, 1914. A threatened shortage at one time of irrigating water from the Roosevelt Dam resulted in a general effort towards the more economical and effective use of irrigating water, with an actually beneficial result upon the irrigating practice of the region. The cultivated area in the Salt River Valley project, including town sites, now amounts to a total of 191,714 acres. In the northeastern part of the State, on the Little Colorado, notable progress is being made by private irrigating enterprises. Considerable additional areas dependent upon the combination of flood and seepage waters, are still being opened up at the lower end of the Upper Gila and Salt River Valley districts. Along the Santa Cruz River and tributaries, private enterprise has made advances in developing water and in reclaiming alluvial lands. Where, according to data collected by the writer in 1909, there existed but 6000 acres under cultivation, we now have a total acreage of approximately 13,000 acres of farmed lands. Throughout the State elsewhere many small enterprises in water development and in irrigation are in evidence. Pumping developments, particularly, have been very considerable, the new types of improved engines using cheap slop distillates for fuel, being in large part identified with this phase of agricultural progress.

A reconnaissance during the year by a member of the Station Staff, of the considerable region lying between Grand Canyon and the southern boundary of Utah has unexpectedly revealed interesting agricultural possibilities. Colonists from Utah have been dry farming in portions of this region for the last thirty years, long before the idea was even suggested for other parts of the State. It is

Interesting to record also that one of the very few herds of buffalo yet remaining in the United States is privately owned near Fredonia in this section.

The eager search for lands is continually in evidence through the numerous inquiries of land-hungry colonists, and in many instances leads to almost desperate efforts towards the reclamation of semi-arid tracts. The problems presented by many of these ventures are difficult ones as to water supply, methods of cultivation, hardy crops, and suitable lines of animal industry. While many of these ventures seem foredoomed to failure, the writer, as a result of many reversed judgments, is usually reluctant to state that this or that agricultural problem cannot be solved, inasmuch as the diversity of conditions available in Arizona, the multitude of plant introductions possible from similar regions of the Old World, and the ingenuities at the command of the modern farmer, often result in a degree of success which would be impossible for a less resourceful people.

NEW DEVELOPMENTS

Following the passage of the Lever Act, May 8, 1914, the most important development of the year has been the organization of the extension service of the University College of Agriculture. This includes not only field demonstrations and advisory service in agricultural and home economics, but also farmers' institutes, demonstration trains and related work as carried on for years past. For the current year the first annual federal appropriation for this work amounts to \$10,000 and will be increased from year to year until in 1922-23 the maximum amount of \$21,730 will be received for this purpose. This must still further be duplicated to the amount of \$11,730 by the State, making a forthcoming total of \$33,460 under this new endowment. With such additional sums as may be appropriated by the State for special purposes, not provided for under the Lever Act, and by private agencies, this will provide a sum which it is believed will be adequate for extension purposes in Arizona.

The appointment of additional members of the extension staff, as rapidly as they can be found, is under way. An important feature of this work is the installation of resident county farm advisors in those parts of the State most needing such service, and a cooperation involving still further funds has been entered into with the U. S. Department of Agriculture in connection with this branch of the service.

Incidentally, a very considerable advantage to be derived from the extension service should consist in taking away this distracting line of activities from among the duties of the investigating staff, the members of which, it is hoped, will be less interrupted in their proper lines of work by demands for extension information formerly made upon them by the public.

As stated more at length in another part of this report, educational progress, considering the exceedingly limited facilities that it has been possible to assemble in cramped and inadequate quarters, has been satisfactory. The bringing together of all agricultural work within the University into one organization, is proving a material advantage because of the administrative means which consequently exist for the coordination of experimental, educational and extension activities.

CONSTRUCTIVE WORK

Following the receipt of endowments granted by the first State Legislature, a good deal of constructive work has been initiated and additional facilities secured during the year. The chief item of new equipment is the new Agriculture Building, the business incidental to which has devolved upon this office. In order to secure, if possible, the best architectural advice in planning and constructing this building, a competition was initiated and thrown open to the architectural profession. Fifty-five programs were distributed early in 1914 to possible competitors and twenty sets of plans were finally received. From these twenty sets of plans, first four and then two were selected for further consideration. Finally, on May 8th, 1914, Messrs. Bristow and Lyman of San Diego, California, were selected as architects for the building, the plans were perfected, and July 13, 1914, contracts for construction were let to the Winget Construction Company of Los Angeles, California, and for heating, plumbing and ventilating to the Elliott Engineering Company of El Paso, Texas. Since that time very satisfactory progress has been made with the building, which will be storm proof, fire proof and earthquake proof, as well as architecturally beautiful. It will be completed in June, 1915; but additional time will be required for furnishing. It will be ready, in large part, for occupation at the beginning of the next college year.

The Sulphur Spring Valley dry farm at Cochise, Arizona, was entered upon, a dwelling house for the foreman constructed, a well put down, a foamfouilCand about sixty acres of land brokea. Experi-

mental work was begun by planting a number of winter crops, followed by an assortment of summer crops in 1914. This farm, which is located directly on the Southern Pacific R. R. within view of overland travel is already presenting an attractive appearance and will without question prove interesting and instructive to many thousands of people who will view the work done there.

Another important item of business for the year was the selection of a new Experiment Station Farm in Salt River Valley. Following years of dissatisfaction with the present farm a painstaking effort was made, after having secured legislative appropriation therefor, to select a permanent and satisfactory location for this important branch of the work. Proposals were received for this farm in the vicinity of Glendale, Phoenix, Tempe and Mesa, and the Board of Regents of the University, acting under the authority of law, viewed the different sites suggested for the farm and finally selected the tract measuring 162.02 acres, in Section 20, T. 1, N. R. 5 E., lying between the Arizona Eastern R. R. and the State highway, and between the towns of Mesa and Tempe, Arizona. This tract is composed of Maricopa sandy loam, which is the prevailing soil in Salt River Valley, it is composed of Class A land, having the best water rights under the Salt River project, and ground water is about forty feet from the surface. The location is in the edge of the citrus belt, well situated with reference to the culture of somewhat frost-resistant citrus varieties. Its position between the Arizona Eastern Railroad and the State highway makes the tract easy of access to the large number of people traveling between Phoenix and Tempe on one hand, and Mesa and Chandler on the other. The shape of the tract—one-quarter of a mile wide and one mile long, is favorable for the exhibition of experimental and other work which may be carried out upon it in time to come. Moreover, this farm is situated conveniently accessible to the agricultural students of the Mesa Union High School and of the Tempe State Normal School, and is easily reached from Phoenix by both rail and highway.

Additions of 11 acres of land have been made to the Yuma Date Orchard, as meditated in the appropriation therefor. This very fruitful and interesting area now totals 18 acres.

Incidentally, considerable time has been spent, in collaboration with the Board of Supervisors of Cochise County, in the selection of the most hopeful site for the boring of an artesian well in Sulphur Spring Valley, and subsequently by the Director in letting the contract for the boring at the well. Although unavoidably delayed in

beginning actual operations, an excellent contract was secured that calls for a well 14 inches in diameter at the top, 10 inches in diameter at the bottom and 1500 feet in depth. The site chosen is in the west $\frac{1}{4}$ of Section 36, T. 16 S., R. 24 E., about one mile from Servoss Station on the Arizona Eastern Railroad. A derrick was erected in November and actual drilling operations begun January 2, 1915.

In addition to the separate administrative items enumerated above, a heavy program has been maintained throughout the year, including the continuation of the usual lines of cultural work at the outlying stations; of scientific experimentation in field and laboratories; publications; extension work, including Demonstration Train, Farmers' Short Course and institutes; and in the development of college class work within the institution.

THE PHYSICAL EQUIPMENT

The agricultural equipment now consists of the following general items.

1. The Agriculture Building (under construction) at Tucson, will house the administrative and scientific activities of the College of Agriculture and the Agricultural Experiment Station.

2. Other equipment at Tucson, consisting of gardens, greenhouses, poultry yards and the University Farm, affords facilities for instruction and experimentation.

3. The Experiment Station Farm and the cooperative date orchard in Salt River Valley, represent cultural conditions in Salt River Valley.

4. The dry farms in Sulphur Spring Valley, near Prescott, and near Snowflake, represent the lower and intermediate altitudes at which dry farming is now attempted.

5. The date orchard at Yuma affords most valuable ground for plant introduction and breeding work within the State.

This equipment, together with facilities for observation elsewhere in the State, is now fairly adequate and complete, affording ample office and laboratory room for the research, educational and extension activities of the institution, and representing nearly all types of agriculture within the State, excepting possibly the agriculture of the higher altitudes. By making the final and permanent location of the northeastern dry farm at an altitude of 6000 feet or thereabouts, this can also be arranged for at practically no additional expense, and will then leave little to be desired in the way of further cultural facilities.

The Experiment Station is frequently asked to consider the addition of new farms to its present equipment for experimental purposes. Considering what we now have, this is highly inadvisable for the reason that such tracts of ground are costly to maintain, and in the majority of cases represent nothing essentially new in soil conditions or in climate. The agricultural staff, also, is fully occupied with the care of the farms now owned, and an addition to the number, with the present personnel, would necessarily result in a depreciated character of the work throughout. It is therefore earnestly recommended that at the present time no more cultural areas be added to the equipment. A far stronger and more fruitful policy at this time is to appropriate adequate maintenance for the buildings and farms now operated by the Agricultural College and Experiment Station,

Fortunately, for the satisfaction of an insistent demand from our agricultural communities for farm demonstrations, the Federal government has recently enacted the so-called Smith-Lever Act which provides an appropriation, the object of which is the conduct of demonstrations in crops and agricultural methods, lessons in household economy, and the dissemination of useful information within agricultural communities. This, in part, is really in the nature of what is expected from an "Experiment Station" as the term is ordinarily understood by our farmers, and the work contemplated is of that flexible character which will make it possible to reach a much greater number of people than can be served by any one station, located, however centrally, in a community.

The Smith-Lever fund is already in operation, the organization for its use has been created, four extension staff men have been appointed and are available for field work and others are in process of selection and initiation into the work. Operations under the federal Smith-Lever fund, therefore, are relied upon as a means towards the satisfaction of this demand for additional field crop demonstrations and methods of culture in various parts of the State.

PERSONNEL

During the year several additions have been made to the Agricultural staff. Mr. G. W. Barnes, recently of the Agricultural College of Oklahoma, has been appointed Farm Advisor, specializing in livestock. Mr. S. B. Johnson, from the same institution, has been appointed Assistant Horticulturist. Dr. R. H. Williams, recently from the University of Illinois, has assumed charge of the Department

of Animal Husbandry, assisted by Mr. W. S. Cunningham, from the New Mexico Agricultural College. Miss Helen M. A. Miller has returned to her former duties as librarian and Mrs. R. Murphy has been added to the stenographic force.

Professor F. W. Wilson, for eight years Animal Husbandman of the Experiment Station Staff, has assumed a similar connection at the University of Nevada; and Professor R. W. Clothier, for seven years with the institution, has assumed a connection with the U. S. Department of Agriculture.

PUBLICATIONS

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

Bulletin 71, July 1, 1913. Gasoline Engine Troubles and The Care and Operation of Gasoline Engines (with chart). —By G. E. P. Smith.
Bulletin 72, July 1, 1913, Geology and Water Resources of Sulphur Spring Valley, Arizona.

O. E. Meinzer in collaboration with Messrs. Forbes and Kelton.
Bulletin 73, June 1, 1914. Alfalfa in the Southwest. —By Geo. F. Freeman.

Twenty-fourth Annual Report, December 31, 1913. —By the Station Staff

Timely Hints for Farmers:

No 101 January 10, 1914. Asparagus Culture. —By R. H. Forbes.
No 102. January 20, 1914. Apple Culture. —By W. H. Lawrence.
No 103 March 1, 1914. Johnson Grass Control. —By R. H. Forbes.
No. 104 May 1, 1914. Grasshoppers. —By A. W. Morrill.
No 105. June 30, 1914, Three Arsenical Insecticides and How to Use Them. —By A. W. Morrill.

Papers published in scientific and technical journals*

Variations in Composition and Concentration of Water of Salton Sea, 1912 and 1913. —By A. E. Vinson.

The Salton Sea, by D. T. McDougal and collaborators,

Published by The Carnegie Institution, Washington, D. C., 1914.

Physiological Correlations and Climatic Reactions in Alfalfa Breeding.
American Naturalist, 1914. —By Geo. F. Freeman.

Discussion of Weir Measurement of Stream Flow. —By G. E. P. Smith.
Transactions American Society of Civil Engineers. Vol. LXXVII, pp. 1300-1313, 1914.

Report on Tucson Water Supply System, —By G. E. P. Smith.
Arizona Daily Star, August 27, 1913.

The Practical Application of the Kent Grazing Bill to Western and Southwestern Grazing Ranges. —By J. J. Thornber.

Proceedings Seventeenth Annual Convention, American National Live Stock Association, pp. 1114-19, January, 1914.

Climatic Conditions Affecting Dry Farming in the Southwest.—By R. H. Forbes.
Dry Farming, pp. 9-11, Aug. 1914.

FINANCIAL

Financially, the year has been a busy one, the program of expenditures initiated by the appropriations of 1913 having resulted in a greatly increased amount of business passing through the office. The business methods and bookkeeping forms employed have however, proved sufficiently expeditious and elastic to receive the added work imposed, conveniently and satisfactorily.

Financial resources for the year 1913-14 were as follows:

Hatch Fund, from the U. S. Treasury.	\$15,000.00		
Adams Fund, " " " " "	15,000.00		
Farm Sales, Station Farm.	\$1,375.65		
Sales, Tempe Date Orchard	1,055.55		
Produce, Yuma Date Orchard	803.65		
Miscellaneous receipts	139.33	\$3,374.18	
Balance brought forward from 1912-1913.	\$1,769.46		
Balance forwarded to 1914-1915.	1,524.65	244.81	3,618.99
E. P. & S. W. Fund			482.50
Southern Pacific Fund			2,000.00
First State Legislature, Dry farming.	\$10,165.57		
(Including balances) Institutes	4,355.21		
Date Palms.	6,500.00		
Publications.	2,418.88		
Horticultural Experiments.	3,179.59		
Plant Int. and Breeding	1,895.08		
Underflow Investigations.	22.75		
New Salt River Valley Farm.	\$30,000.00		
Office expense.	2,500.00	\$61,037.08	
Grand Total.			\$97,138.57

The usual detailed statement of expenditures by schedules, by departments and by funds is also submitted herewith.

R. EL FORBES,
Director.

EXPENDITURES BY FUNDS, SCHEDULES, AND DEPARTMENTS FOR THE YEAR ENDING JUNE 30, 1914.

	Admin- stration	Agricul- ture	Animal hus- bandry	Horticul- ture	Botany	Chemis- try	Entomol- ogy	Irr. and meteor- ology	Tempe- rate orchard	Yuma date orchard	Miscel- laneous	Totals	
Tech Fund \$1,000.00	Salaries.....	3207.57	802.50	504.96	14.85	700.00	1608.07	300.00				7137.95	
	Labor.....	126.21	50.13	656.95	742.69	48.00	561.83		76.87		31.39	2294.07	
	Publications.....	290.23	25.00						3.88			319.11	
	Postage, stat'y., tel & tel.	1128.67	24.37	82.80	48.21				1.25	34.90	10.00	1330.20	
	Freight and express.....	222.77	37.88	36.51	11.73	2.47	2.69	.70	1.25		1.70	317.70	
	Heat, light and water.....	67.07		7.72	8.20		43.75					126.74	
	Chemical supplies.....			1.90	.50	1.70						4.10	
	Seeds, plants, sundries.....	87.96	113.35	103.42	129.91	56.11			.77	12.60		504.12	
	Fertilizers.....		28.20	41.79	37.16					4.04		111.19	
	Feeding stuffs.....		1.50	242.30	14.15	74.80				4.40		337.15	
	Library.....	173.69										173.69	
	Tools, imp'ts., mch'y.....	.95	.65	202.43	102.35	4.50						310.88	
	Furniture and fixtures.....	412.14		17.25					50.50			479.89	
	Scientific apparatus.....	28.17	2.30	29.96								60.43	
	Live stock.....	7.00		122.50								129.50	
Traveling expenses.....	973.72	44.80	166.71	13.16	26.92				.95		1226.26		
Buildings and land.....	79.15	7.17	33.78	7.87		4.25			4.80		137.02		
Totals.....	6805.30	1137.85	2250.98	1130.78	914.50	2220.59	300.70	57.65	138.56	11.70	31.39	15000.00	
les Fund, \$1,816.99	Labor.....	208.30		1096.46	710.10	70.00	60.17		285.00			2429.97	
	Contingent expenses.....	1043.85	1.15	117.82	.35	5.95			6.10	13.80		1189.02	
	Totals.....	1252.15	1.15	1214.22	710.45	75.95	60.17		291.10	13.80		3618.99	
P. & S. W. Fund \$482.50 Southern Pacific Fund 2,000.00	Salaries.....							40.50				40.50	
	Labor.....												
	Seeds, plants, sundries.....							32.95				32.95	
	Tools, imp'ts., mch'y.....		125.50					9.25				134.75	
	Freight and express.....							50.72				50.72	
	Scientific apparatus.....							63.98				63.98	
	Traveling expenses.....							283.80				283.80	
	Postage, stat'y., tel & tel. Buildings and land.....							1.30				1.30	
Totals.....		2000.00						482.50				2482.50	
Laws of 1913 Institutes \$355.21	Salaries.....		Institutes 1616.86									1616.86	
	Spec. temporary services												
	Labor.....		199.74									199.74	
	Traveling expenses.....		1793.45									1793.45	
	Printing.....		265.74									265.74	
	Freight and express.....		7.25									7.25	
	Postage, stat'y., tel & tel.		121.19									121.19	
	Seeds, plants, sundries.....		204.60									204.60	
	Furniture and fixtures.....												
	Feeding stuffs.....		78.20									78.20	
Scientific apparatus.....		68.18									68.18		
Totals.....		4355.21										4355.21	
Laws of 1913 Dry-farm- ing \$10,165.87 Horticul- tural Experi- ments \$3,179.59 Date Palms \$6,500.00 Miscel- laneous Office Expenses \$2,500.00	Salaries.....		4670.59		1766.57				804.88	382.00	1908.34	9532.38	
	Labor.....		1124.16		386.56				375.40	531.47	46.84	2464.43	
	Seeds, plants, sundries.....		262.40		102.77				339.44	55.73		760.34	
	Tools, imp'ts., mch'y.....		1153.51						6.75	60.25		1220.51	
	Freight and express.....		162.72		58.41				26.19	2.23		249.55	
	Buildings and land.....		1329.00						6.48	3717.75		5053.23	
	Furniture and fixtures.....		18.00		150.27				9.00	9.00		186.27	
	Traveling expenses.....		737.39		525.26				89.55			1352.20	
	Postage, stat'y., tel & tel.		22.90		17.79				11.00	20.35		72.04	
	Feeding stuffs.....		660.49							36.80		697.29	
	Scientific apparatus.....		4.16		171.96				5.20		544.82	726.14	
	Irrigation waters.....								3.23	5.30		8.53	
Horses and harness.....		20.25							2.00		22.25		
Totals.....		10165.57		3179.59				1677.12	4822.88	2500.00		22345.16	
Laws of 1913 Printing \$2,418.88	Ann. Rpt. and bulletins.....	2013.43										2013.43	
	Timely Hints.....	350.70										350.70	
	Sundries.....	54.75										54.75	2418.88
Plant Introduc- tion and Breeding \$1,895.08 Underflow Investiga- tions \$22.75	Salaries.....		265.75					21.25				287.00	
	Labor.....		1245.75									1245.75	
	Travel.....		37.60					1.50				39.10	
	Freight and express.....		40.19									40.19	
	Postage, stat'y., tel & tel.		2.96									2.96	
	Tools, imp'ts., mch'y.....		69.45									69.45	
	Seeds, plants, sundries.....		229.53									229.53	
Pumping and irrigating		3.85									3.85		
Totals.....		1895.08						22.75				1917.83	
New Salt ver Val- ley Farm \$1,000.00	Buildings and land.....	30000.00										30000.00	

EXPENDITURES BY FUNDS, SCHEDULES, AND PROJECTS FOR THE YEAR ENDING JUNE 30, 1914.

	Saltbush and cactus	Plant diseases	Toxicity of copper	Date ripening	Under- flow in- vestigat'n	Olive products	Alfalfa investi- gations	Bean investi- gations	Irr. and meteor- ology	Wheat	Miscel- laneous	Totals	
Adams Fund \$5,000.00	Salaries.....	487.80		807.50	1794.11	3919.72	2044.46	1844.47				10898.06	
	Labor.....			12.00	1.00	94.05	836.34	836.87				1780.26	
	Postage, stat'y., tel & tel.					3.48	16.35	16.36				36.19	
	Freight and express.....				21.61	50.66	13.66	9.50				95.43	
	Heat, light and water.....					3.50	2.45	4.86				10.81	
	Chemical supplies.....				42.73	3.90	6.58	6.61				59.82	
	Seeds, plants, sundries.....		.50	4.90	18.33	63.77	85.31	83.69		.99		257.49	
	Fertilizers.....						52.88	52.90				105.78	
	Feeding stuffs.....						12.47	12.48				24.95	
	Tools, imp'ts., mch'y.....					63.25	52.95	71.69			144.52	332.41	
	Furniture and fixtures.....												
	Scientific apparatus.....				461.20	65.57	211.44	106.81				845.02	
	Traveling expenses.....				81.05	210.39	109.79	129.78				531.01	
Contingent expenses.....													
Buildings and land.....							21.89	.88			22.77		
Totals.....	487.80	.50	824.40	2420.03	4478.29	3466.57	3176.90			145.51		15000.00	

AGRICULTURE

THE EXPERIMENT STATION FARM AT PHOENIX

Activities on this farm may be grouped under five general heads as follows (1) Projects in Animal Husbandry, (2) Horticulture, (3) Alfalfa Breeding, (4) Agricultural Crops, and (5) Extension Service, administered for those members of the Station Staff concerned in these subjects

ANIMAL HUSBANDRY

The work in Animal Husbandry is confined almost wholly to sheep breeding with the Tunis, Hampshire, Shropshire, Native and Rambouillet breeds. Work is progressing along the lines of fixing the $\frac{H}{2} \frac{N}{4}$ ideal valley type, and $\frac{H}{2} \frac{N}{2}$ ideal Arizona range type. The long continued drought and high temperatures of the summer just past, severely tested the vitality of the sheep, and caused high mortality among them. Further details may be found in the Animal Husbandry report

HORTICULTURE

In Horticulture, the work of assembling data already available on grapes, occupied the chief attention of Professor W. H. Lawrence. He also found material here for the study of leaf and fruit bud characters in the date palm. Further work consisted in collecting data on the productiveness of various varieties of figs. The small number of *blastophaga* wasps imported during the spring of 1913, proved sufficient to fertilize our Smyrna figs on the farm this year, and also to supply the few people who have Smyrna trees in this section with profiche figs. With bearing trees of capri No. 1 and capri Nos. 2 and 3 coming into bearing this year, it is very probable that the insects are permanently established here. It is also of importance for the growers of this section to know that the Smyrna fig is very productive, and of high quality when fertilized in this way. The fig industry will become of great importance here, as it is better

understood. The routine work of keeping cultural records of the olive, peach, apricot, plum, etc., was continued.

ALFALFA BREEDING

The work in alfalfa breeding was modified by taking out the alternate rows of the Peruvian in each plot, and thereby leaving No. 17 in a solid block of rows three feet apart. It was suggested, by reason of the quicker growing habits of the Peruvian, that it tended to retard No. 17, pedigreed strain, by shading. Results showed, however, that it made little difference with respect to the yield, as the Peruvian continued to produce more heavily and required fewer days for making each crop, than did No. 17. The plots were finally allowed to make seed, and subsequently broken. This project is finished on this farm.

AGRICULTURE

The agricultural crop projects were mostly organized last year, and have been continued along the same lines.

Cereals. Additions were made to the varieties of cereals, and although the summer was exceedingly unfavorable, some of the best milling wheats were very satisfactory. Two winter oats were introduced, and show some promise of adaptability to this section.

Corn: Many more introductions of corn were made, chiefly of Indian varieties. On account of the lack of our usual summer rains during July and August, the dry heat caused the drying out of the silks, and prevented proper fertilization of the earlier varieties, materially reducing the yields. One planting of Mexican June corn made the middle of August, was fertilized much better than the same variety planted a month earlier. Indian corns were most seriously affected, and all except Pima Indian gave disappointing returns.

Sugar beets: The mild winter of 1913-14 was exceedingly well suited to sugar beets, and this, supplemented by the absence of the leaf hopper, gave excellent yields of this crop. The farmers of this section should stay more closely to staples, and plant a certain acreage of these crops, consistently each year. This would prevent much haphazard farming.

Sugar cane: The interest in sugar cane is increasing, plantings having been very much increased throughout the valley. The experiments so far with this crop, indicate that it may be grown profitably in this section. The Mexican cane borer was observed in many of the stalks. One more variety was added to our collection.

Sorghums Work with the sorghums continued, and some special tests with Sudan grass were undertaken. Plots were laid off in series as follows: Series 1, time of planting, series 2, rate of seeding; series 3, method of planting, series 4, legume mixtures, series 5, seed production, series 6, water requirements, series 7, food value. Valuable data have been secured from all these tests. It was observed that the seed tends to run to the black and not the cream hull variety, which tendency should be corrected by growers making head selections. It may also be possible that this crop will cross with Johnson grass, although our observations along this line have been very careful, no such cross seems yet to have occurred. The extent and effect of such a cross on the Sudan will be studied the coming year. The yields of hay under irrigation exceed eight tons to the acre from two cuttings. The hay is of good quality, and eaten readily by all classes of livestock. One hundred farmers in Arizona were supplied with one-pound lots of seed for trial. These farmers were distributed at elevations from 500 to 7500 feet. Reports thus far received, show the grass to be a heavy and persistent producer under these varied conditions. The work of the corn flea beetle retarded the growth of the young grass during May.

Potatoes. Many more introductions of Irish potatoes have been made. Some from northern and others from southern sources of the United States. There seems to be a slight preference in favor of the northern seed. Plantings were made at four periods: first, early in November, second, early in December, third, late in January; and fourth, the middle of February. Highest yields from most varieties, were from the November and January plantings, with the advantage slightly in favor of January. The White Pearl indicates some superiority in the earlier planted plots, and the Early Triumph in the February series. Methods of keeping home grown potatoes for seed were tried: first, in a closed pit; second, in a pit with screened sides and shaded roof; third, on a dry shaded floor, and fourth, by cold storage. Very interesting and valuable results were obtained.

Legumes for cover and forage crops: The deficiency of nitrogen and faunus in Arizona soils leads to the need of determining cover crops best suited to supply these elements. Material assembled for a *Timely Hint* on "Alfalfa as an Orchard Cover Crop" was prepared for publication. This indicates in brief, that alfalfa retards the growth of young trees, but if planted after the trees are bearing, the effect is much less injurious, although at this latter stage it has an appreciable negative effect on the production of fruit. It is also detrimental to ornamentals when planted with them. Other legumes

seem better suited for cover crops. Of these, Canada field peas, Colorado stock peas, and both yellow and white flowered sweet clover are recommended for fall planting in southern Arizona, while Whippoorwill peas and Tepary beans are suggested for spring and summer planting. On the Station Farm soils all of these were supplied with nodules.

Soy beans were tried but made small growth, and produced a scanty yield.

Teparies for forage were again tried against millets, Whippoorwill and black eyed peas, and used in a mixture with Sudan grass. A yield of 3720 pounds an acre of dry tepary hay indicates the performance for this new crop. In an endeavor to test the value of these beans under varied climatic and soil conditions, 25,000 pounds were collected for the Office of Seed Distribution, Washington, D. C., and were sent by them in small Jots to various parts of the United States. In addition to these, the writer has distributed seed for trial to farmers of 28 states and foreign countries, from which reports show that the Tepary may have a wide distribution. Nematodes were noticed working vigorously on this crop this year.

Sainfoin, winter vetch and spring vetch were added to these tests. The Sainfoin failed completely the first year, but the vetches show some promise,

Millets Millets were tried in a test for seed production and hay, as compared with Sudan grass. Several varieties were tried, and they are found to mature very quickly, and to make good yields.

Flax: Three varieties of flax of European and Asiatic origin were planted in rows three feet apart, the seed having been furnished by Mr. Charles H. Clark of the Bureau of Plant Industry, Washington, D. C. Very restricted growth of the plants was the general rule, although some seed was matured. The matured seed was plump and had a good color*

Teosinte: Many requests for information concerning this annual grass, led to a planting. Although planted April 8, and allowed to grow until December 5, when it was hit by a frost, only about half matured seeds were formed. Forage yield was as follows: first cutting, July 17, made 954 pounds of green forage; second cutting, December 6, made 440 pounds, or a total of 1394 pounds from a row 290 feet long by four feet wide. This is at the rate of about 52,296 pounds of green forage to the acre. Due to the high cost of seed, and the fact that none may be matured here, It is not recommended to farmers of this section. At other stations trials of this

grass have been made against milo, orange sorghums, etc., and found to produce no more.

Eucalypts: The south eucalyptus grove was deforested January 19, 1914, and the north grove, February 9, 1914, the former was dried until April 7, 1914, and the latter until April 9, 1914, then weighed, and gave yields of ties, posts, stovewood, and brush as follows:

Variety	No of trees	Area	Age	Yields in pounds			
				Ties	Posts	Stove-wood	Brush
Rostrata	3	48 sq ft	12 yrs	1,550	875	600	550
Rudis	South grove 113	33,327 " "	12 "	16,175	17,125	4,450	3,421
Rudis	North grove 91	16,465 " "	6 "	10,145	16,190	6,125	3,590

Weight of average tie, 250 lb.; of average post 55 lb.; size of average tie, 8 inches in diameter, 8 feet long; size of average post 5 inches in diameter, 7 feet 6 inches long.

The south grove with twelve-year-old trees seems less productive than the north grove with six year olds, but some wood was removed from the former as a result of limbs breaking during high winds, yet the results still favor the earlier deforestation,

EXTENSION SERVICE

Under this head may be included news articles, milk testing, visitors, and special calls.

News articles: Timely articles on different crops and soil treatments have been published in the "Great Southwest Farmer," "The Stockman-Farmer," the daily papers of Phoenix, and other periodicals of the State.

Milk testing: Occasionally farmers bring their milk and cream to the farm to be tested. About forty tests have been made in the year.

Visitors: Most of the people who come to look over the Station Farm are local farmers who come for definite information. It is very gratifying to note that the number who come for this purpose, is **increasing each year**. Besides these, visitors from different Agricultural Colleges throughout the United States and foreign countries **come to look** over the special agricultural conditions of this section. Basing **our** estimates on a two **week's** calculation, during which 31 **visitors** came, we would have a total for 52 weeks of about 1600.

Special calls: It is found necessary at times to make trips in answer to requests to look into some matter that requires personal attention. For example, an orange grower was troubled by the slow death of his trees. Upon careful examination of the soil, it was found that "caliche" underlaid the portion of the grove thus affected, at two feet from the surface. The planter of the grove had not blasted or dug through the impervious stratum when the trees were set out, and as a result the roots were collected in a mass in these upper two feet of soil. Neither roots nor water were able to penetrate the hardpan. Such difficulties can only be ascertained by personal examination, and many of these trips were made during the year.

THE DRY FARMS

Over most sections of the State, the dry farmers have witnessed an exceptionally favorable season, and report profitable crops from the various districts.

SULPHUR SPRING VALLEY DRY FARM

At present some sixty acres have been broken on this place. It is divided into four sections, for investigational purposes. One portion is devoted to tests under dry farm conditions, that is, no flood water is allowed to run over it, and no supplemental irrigation is applied. The second portion is used for demonstrating the use of flood water. For this purpose an earthen dam has been thrown across a small arroyo which diverts the water over the land selected for these tests. A third portion is used for trials with supplemental irrigation from a pumping plant. In this work it is hoped to develop a high duty of water. A fourth portion is utilized for pasture, on which records are kept as to the carrying capacity of native grass pasture in connection with a farm in this section.

Under each of these various systems of farming, variety tests, time and method of planting, mulching tests, time and depth of plowing, cover crops, special forage and grain crop tests, etc., are being compared. This year, very successful crops of beans, corn, and of the grain and forage sorghum, and also some cereals, were produced under each condition. Black winter emmer, deserves special mention among the grain crops for its drought-resisting character.

The buildings have all been completed, and supply ample accommodations for the livestock of the farm, and for the comfort of the foreman in residence. This farm is attracting very favorable com-

ment, and drawing many interested farmers to it from all over Sulphur Spring Valley. Mr. Fillerup has made many calls by request, and been of material aid to settlers in supplying information.

PRESCOTT DRY FARM

The third year of operation here indicates more definitely the lines of farming that will succeed in this district. The bean crop gave promise of being very heavy, but was attacked not only here, but also at the Sulphur Spring Valley Farm and at Snowflake, by a fungusroot rot, probably *ozonium*, and also by a blight on the leaves, until the crop yield was cut in two.

Forage and ensilage crops: Marked success was in evidence with Sudan grass, club top cane, red sumac cane, bloody butcher, and yellow white dent corns, as forage and ensilage crops.

Potatoes: The potato crop, although showing a good top growth, failed to produce an average amount of tubers.

Cereals: The cereal trials were enlarged by the introduction of several winter oat and barley varieties. Rye shows promise of a dry farm hay crop, yielding slightly more than two and one-half tons of dry hay to the acre.

Silos: The pit silo was lined with a wall of concrete four inches thick and enlarged until its capacity is now forty tons. The material was cut by a small hand cutter attached to an old horse power machine, secured from a neighboring rancher. It was filled with milo, corn, and club top and sumac sorghums.

This farm has also grown in popularity through the earnest work of Mr. Bates, who has served the few farmers of the district with timely suggestions.

SNOWFLAKE DRY FARM

Fully as good crops were obtained on this farm this year as on either the Prescott or the Sulphur Spring Valley locations. Crops were as good or better than those grown by the farmers of that section. Peach blow potatoes yielded at the rate of 1400 lb. from a $\frac{1}{4}$ -acre plot, or 5600 lb. to the acre. They weighed 60 lb. to the bushel, and were smooth, clean potatoes. They were produced at a cost of \$10.21 on the $\frac{1}{4}$ -acre plot, with a market price in that section of 3c. a pound, giving a gross value of \$42, and a net value of \$31.80 from the plot.

Indian beans: A newly acquired Indian bean gave the highest yield of any of the beans tried out. It shows a yield from a $\frac{1}{4}$ -acre

plot of 180 lb. of clean seed, or 620 lb. per acre. The $\frac{1}{4}$ -acre crop was produced at a cost of \$3.61 and sold at \$10.80, leaving a net profit of \$7.19 from the plot. White Tepary beans failed.

Corn: Hickory King corn produced 4330 lb. green ensilage, but did not mature any grain. Colorado yellow dent produced 58CO lb. of green silage corn, but did not produce any grain. Blue Moqui produced 4500 lb. of green material to the acre, and matured 1840 lb. of seed, with a weight of 60 lb. to the bushel.

Kursk millet: Kursk millet produced at the rate of 1800 lb. of dry material to the acre, 800 lb. of which was seed, and 1000 lb. of hay.

Sudan grass: Sudan grass gave a yield of 8700 lb. green material, which weighed dry, 3800 lb. Dwarf milo yielded 32 bushels of threshed grain to the acre, and made the best showing of any grain sorghums tried.

Material from the three dry farms was displayed at the State Fair, and later transferred to the Demonstration Train. The Prescott Farm also had a display at the Northern Arizona Fair held at Prescott, and the Sulphur Spring Valley Dry Farm had a display at the Willcox Fair.

General observations: Small grains, corn, potatoes, beans, and vegetables were produced in commercial quality and quantity by the dry farmers in the timber sections throughout northern Arizona generally. Near Flagstaff, one potato grower harvested 2200 sacks with average weight of 110 lb. per sack from 16 acres. One farmer near Williams produced 650 bushels of Swedish Select oats from a 10-acre field.

Exhibits: Material from Navajo, Coconino and Apache Counties at the State Fair, drew many of the prizes. A single grower from Navajo County had on display 37 varieties of produce, mainly vegetables, corn, pumpkins, squash and grain. Some silos have been built in Navajo County, and are proving very satisfactory in utilizing the corn of that section.

An exhibit supplied by Yavapai, Coconino and Maricopa Counties, was sent to Wichita, Kansas, to the International Dry Farming Congress and Soil Products Exposition, where it was awarded the grand prize, a trophy cup, for the best state or provincial exhibit.

THE "ARIZONA STRIP"

A reconnoissance trip made in July into the country north of the Grand Canyon, known as the Arizona Strip, revealed a vast tract of desirable land that awaits the settler. The people around Fredo-

nia have been dry farming for many years, and are at present producing very good crops of grain, corn and sweet clover without irrigation. The duty of water for the whole 1000 to 1500 acres of irrigated land is 1 acre-foot. With this amount of water the farmers produce about five to six tons of alfalfa to the acre, and paying crops of potatoes, grains, etc. Vast areas of this section are devoted to and are suitable only for grazing. Some 200,000 sheep are ranged on it annually, and more than 50,000 head of cattle. We found here the buffalo, which seem to do as well or better than on the open range in any other part of the United States. Some 43 head, mostly hybrids, are ranging on the Kaibab National Forest in the summer, and in Houserock Valley in the winter. The country possesses great undeveloped wealth in the timber of its forests, the largest of which contain many billion feet of merchantable timber.

Mineral possibilities, in copper especially, are evident in several locations.

The greatest needs of the "Strip" are people and suitable transportation.

A. M. McOMIE,
Assistant Agriculturist.

BOTANY

The rainfall on the small range reserve for the year ending June 30, 1914, was 9.77 inches, or two inches below the average. Of this amount 2.46 fell during the summer rainy season, July to October inclusive, and 5.71 inches in the winter rainy period, November to April inclusive. On account of the scant summer rainfall, practically no growth matured on this area during this season. The fine stand of seedlings that began with the heavy showers of the middle and the latter part of July dried up in August. The rainfall all over southern Arizona during this summer season was generally below the average, except, perhaps, at the higher altitudes. On the desert or lower ranges it was "patchy" in character, while in the foothills and on the higher mesas it came mostly in light showers.

Most of the winter precipitation took place in November and December, and the latter half of March. With seasonable distribution this rainfall would have resulted in good growth. As it was, however, such forage plants as Indian wheat, alfalfa and the various borages made a poor growth. The splendid showers in May and June were too late to be of any use for this winter growth, though they favored very much the scattered bunch grasses which followed. On the higher mesas and in the foothills, the winter annual growth was better than at the lower altitudes, due to the growing season extending later. Besides this, there was a good growth of the bunch or root grasses, including grama grasses, triple awn grasses and early mesquite, by the first of May. This resulted largely from the heavy March rainfall. The present summer and fall seasons have been very favorable, and hence range stock are in much better condition than they were one year ago. Large amounts of seed have matured, particularly on the better class of ranges, and it has been possible to cut some hay.

On the small range reserve, notwithstanding the recent droughty years, there has been a slow increase in the growth of such arid, perennial grasses as silver-top blue-stem (*Andropogon saccharoides*), cotton-top (*Panicum lacnanthum*), Texas poverty grass (*Aristida divaricata*), purple-top (*Aristida purpurea*), spike grass (*Pappophorum apertum*), galleta or cracker grass (*Hilarimutica*), and crowfoot

or mesa grama (*Bouteloua Rothrockii*). The last mentioned grass is less drought resistant than the others, though quicker to recuperate during favorable periods by virtue of its heavy seed production. Once established in the deeper and heavier soils of the lower mesas, particularly those subject to occasional flood waters, and also protected from overgrazing, the above grasses succeed well under our growing conditions, and yield from one-half to a ton of hay to the acre, according to the season. They can be used to advantage in establishing arid meadows, such as were common over these lower mesas 25 and 30 years ago.

On the large range reserve lying northwest of, and adjacent to the Santa Rita mountains, there has been a gradual spread, both of the annual and the perennial grasses over the lower two-thirds of the pasture. As is usual, the six-weeks grasses mostly appear first in abundance, after which scattered bunches of perennial grasses become established. These latter include the grasses just mentioned on the small range reserve and in addition, rabbit grass (*Aristida californica*), and black grama (*Muhlenbergia Porteri*). The spread of black grama from shrubs, where it grows under open range conditions, to the open ground in fenced areas is becoming very noticeable. Forage yields have not increased appreciably over the higher and more favorable parts of the large range reserve, since here the land is already well seeded with grass, and producing about as much growth as is possible with the rainfall.

SPINELESS CACTI

Study has been begun on a minor Adams' Fund project relative to hardiness in spineless cacti. Already there is a considerable number of varieties of spineless cacti on the market, some of which are apparently far more resistant to frost than others. The object of this work, in brief, is to determine whether hardiness in these plants is due to external factors, as cultivation and irrigation, or is inherent in the plant.

POSSIBILITIES OF WALNUT GROWING

Numerous inquiries have been received during the year relative to growing French and English walnuts in Arizona, when grafted on native walnut stocks. Heretofore, the difficulty has been to graft successfully the English walnut on the Arizona stock. Through careful work with many experiments, Mr. C. R. Biederman of Garces, Arizona, has worked out an ingenious plan which enables him to graft

at almost any season of the year, at least as concerns his conditions, French and English walnuts on our hardy Arizona walnut. After a personal interview with Mr. Biederman and a brief examination of his work, the writer was convinced of the possibilities of growing successfully English and French walnuts in our mountain canyons and also in the deep alluvial soils of many Arizona valleys. English walnuts grafted on Arizona stocks by Mr. R. A. Smith, Safford, Arizona, have fruited now for upwards of 15 years in the Upper Gila Valley, and the trees are in excellent condition at this time. Mr. Biederman's method consists, in short, of top-working native walnut trees with French walnuts. He can use to advantage rather large trees, and bring them into a bearing condition at an early date. Through Mr. Biederman's generosity, this method of grafting will be explained in full, together with practical suggestions for walnut growing in Arizona, in a publication soon to be issued by this Station.

PLANT INTRODUCTION

In the plant introduction garden, a rather poor stand of the seedlings of the native Arizona walnut (*Juglans major*) was secured; these made growths ranging from one to three feet, which was less than was expected. A larger number of these nuts will be planted during the coming winter season. It is planned to grow several thousand young native walnut trees for use in grafting by the Biederman method with hardy French, German and English walnuts. In this way, valuable information may be had concerning the future success of this method of grafting together with knowledge of the varieties of walnuts best adapted to our climatic conditions. The native currant plants (*Ribes aureum* var.) set out last spring, have made splendid growth. Besides these, a small number of currant plants of apparently this same variety has been received from two other localities in Arizona. Some of these are said to have red and others yellow fruits. About 100 plants of a currant shrub similar to the one above, were secured from South Dakota. These also have done well. As yet, however, none of these plants have produced any fruit.

Russian oleasters (*Elaeagnus hortensis* var.) have grown from small seedlings to plants 3 to 5 feet high in a single season. The planting of this species was recommended in the Twenty-third Annual Report of this Station. This plant should succeed above altitudes of 3500 feet in dry farming areas, and also below this altitude with occasional irrigation. It can be grown either as large shrubs or

small trees, the plants making excellent windbreaks, and in addition being ornamental. Cuttings of various native elderberries that were planted failed to make any growth. Under our conditions, these plants have a value both as ornamentals and for the abundant fruit they produce over a long season. This has some value to the home, and as birds are fond of it they may thus be kept from eating valuable fruit crops.

TREE TROUBLES AT DOUGLAS, ARIZONA

An examination into the causes affecting the growth of ornamental trees and shrubs at Douglas, Arizona, has been begun. Though as yet incomplete, it has resulted in finding a number of conditions affecting tree growth unfavorably, among which are bad drainage and soil aeration due to poor methods of planting, selection of varieties of plants poorly suited to our conditions, damage to foliage from smelter smoke and fumes, and also black alkali in the irrigation water. The black alkali in the water can be neutralized at nominal expense with gypsum or with water impregnated with gypsum, both of which are abundant in the vicinity. With the black alkali removed, with the selection of varieties well adapted to our conditions of growth, and the proper methods of planting and care afterwards, trees and shrubs can be grown as successfully in Douglas as in most parts of the State. Smelter fumes and smoke, will, perhaps, always be a factor, but with other matters corrected, there will be a minimum of trouble from this source. Below are given two lists of the trees commonly planted at Douglas. Those in list No. 1 grow well with reasonable care, and generally they are successful over the State; those in list No. 2 grow unsuccessfully at Douglas, even with good care, and likewise, generally, throughout the State. The importance of planting trees that are suited to our conditions is apparent from a study of these lists.

LIST No. 1.	LIST No. 2.
Arizona ash (<i>Fraxinus Toumeyi</i>)	Balm of Gilead (<i>Populus candicans</i>)
Chinese sumach (<i>Ailanthus glandulosus</i>)	Common catalpa (<i>Catalpa bignonioides</i>)
White mulberry (<i>Morus alba</i>)	White elm (<i>Ulmus americana</i>)
Weeping mulberry (<i>Morus alba</i> var)	European plane (<i>Platanus orientalis</i>)
Texas umbrella (<i>Melia azedarach</i>)	White ash (<i>Fraxinus americana</i>)
Common elderberry (<i>Sambucus mexicana</i>)	European ash (<i>Fraxinus excelsior</i>)
Native cottonwood (<i>Populus mexicana</i>)	Weeping elm (<i>Ulmus</i> sp)
Black locust (<i>Robinia pseudacacia</i>)	Eastern box-elder (<i>Acer Negundo</i>)
Arizona cypress (<i>Cupressus arizonica</i>)	Common basswood (<i>Tilia americana</i>)
Italian cypress (<i>Cupressus sempervirens</i>)	English walnut (<i>Juglans regia</i>)*
Oriental arborvitae (<i>Thuja orientalis</i>)	

*Grafted on foreign stock

MISCELLANEOUS

During the past year, the writer was relieved from teaching duties and was also given more assistance. This makes possible the completion of valuable pieces of work that have been under way for some time, but that have been necessarily delayed. It is planned now to publish from time to time in advance of the completion of the work on the Arizona flora, parts which are of particular economic or scientific value to the State. Among these may be mentioned a study of our native cacti, or native trees and shrubs, also native grasses and other forage plants. In addition to the above, a bulletin on hardy trees, shrubs and vines for southwestern planting, which has long been under consideration, will soon be completed for publication.

Considerable time has been given to study of miscellaneous plant collections from various parts of the State. Numerous trips, also, have been made to mountain ranges in southern Arizona, including two weeks spent in the study of the flora of the Pinaleno or Graham Mountains. This latter work was done in conjunction with the Desert Botanical Laboratory of the Carnegie Institution. This study has resulted in adding numerous interesting species to our collections and in greatly extending the distribution of others. Among the more interesting of these plants was the discovery of the wild tepary bean (*Phaseolus acutifolius* var *latifolius*) in lower Stone Cabin Canyon, Santa Rita Mountains, in August. Heretofore, this plant had been known only from Sonora, Mexico. Western buckthorn or gum elastic (*Bumelia rigida*) of the family Sapotaceae has also been found in two localities in southern Arizona during the past year. It may be of value as a stock for grafting certain of the economic members of this family. A handsome species of acacia was also found for the first time in the Huachuca Mountains. This is *Acacia myriophylla*, and it should be hardy for ornamental planting.

In January, the writer read a paper before the American National Live Stock Association at its annual meeting in Denver, on the subject "The Practical Application of the Kent Grazing Bill to Western and Southwestern Grazing Ranges." This paper was published in the Proceedings of the Seventeenth Annual Convention of this association.

J. J. THORNBUR,
Botanist.

PLANT BREEDING

A summary of the work in plant breeding for the past fiscal year may be divided as follows alfalfa, sweet corn, dates, beans, and wheat.

ALFALFA

Varieties Of the 44 regional varieties of alfalfa tested at the Phoenix Station during 1909 and 1910, only 7 have been deemed worthy of retention. A seed crop was secured from these during the summer of 1912. Together with a sample of "Baltic" alfalfa, these were planted on the Station at Yuma in February, 1914, and their yields compared during the present summer. The following table gives the average of four cuttings

YIELDS OF ALFALFA VARIETIES AT YUMA

No of plot	Name of Alfalfa	Yield in lb per acre
39a	Peruvian (hairy type)	3898
11	Italian (shows <i>falcata</i> cross)	3719
	"Baltic" (from Colorado)	3077
22	Algerian (Bagdad)	3340
24	Algerian (Oued Rirh)	2659
39b	Peruvian (hairy type)	2659
27	Turkestan	2599
35	Siberian (Turkestan type)	2792
41	French (European type)	2841
39c	Peruvian (hairy type)	3179

In this season's tests the Peruvian (hairy type) has again demonstrated its excellence. The high yields, good quality of hay when cut early, and tenacity with which it maintains its stand commend this variety to general planting in the State.

Plot 11 has also shown a promising yield. A seed crop will be taken from it at the earliest possible date in order to give it further trial. The high yield obtained from Plot 22 is interesting. This plot is of the third generation from seed brought originally from Algeria. The plot grown from the seed originally imported and sown at Phoenix in November 1905, soon lost stand and gave relatively very poor yields. A seed crop was taken from it in 1906 and a new plot planted in the fall of the same year. This new plot held its

stand much better than the parent plot and in 1910 yielded on an average about forty percent more hay. These facts taken together with the good prospects of the third generation plot form a significant suggestion of the value of natural climatic selection or acclimatization in the improvement of crops.

PURE RACES

The first elimination test of the 144 pure races of alfalfa planted in the fall of 1911, has been completed. A seed crop was taken during the present summer. Out of these strains 35 of the best were selected, and there were sufficient seed of each for planting plots under field conditions. These were planted at the Evergreen Nursery in November, 1914, and during the coming summer they will be tested in comparison with the same strain of high yielding Peruvian alfalfa which was used as a check at Phoenix. No. 17, the only race saved from that first test, was again sown for comparison with this lot.

Five years of work in breeding for yield and quality of hay may be summarized as follows: Forty-four regional varieties of alfalfa and 224 pure races have been given the first elimination test. For the second elimination test all were discarded except the best 7 regional varieties and 40 pure races. Four of these pure races were discarded after the test at Phoenix during 1911 and 1912. This leaves 36 pure races and 7 regional varieties out of the original lot of material. These are being tested under field conditions on the experimental plots at Tucson and at Yuma. As a practical outcome of this work, the department has begun the distribution of improved alfalfa seed by putting out among interested farmers its available supply of Peruvian seed (raised on the check plots at Phoenix), and is recommending the planting of this high yielding strain. Seeds of several other promising strains are also being distributed in limited quantities.

As a beginning of a third series of pure races, 33 regional varieties of alfalfa were grown at the Evergreen Nursery plots during 1913 and 1914. From these plots individual plant selections were made and a seed crop taken during the present summer. Forty-three plots for the first elimination test of the pure races thus originated, were planted in December, 1914 at the Evergreen Nursery.

Physiological studies concerning the nature of drought resistance and water efficiency in alfalfa have been continued. Experimental results suggest a distinct relation between the transpiration rate and the number of stomata on a given area of teal surface.

The relation between transpiration and the thickness of the different tissue systems, the density of the tissue, and the percentage of dry matter in the leaves is being studied. The data at hand offer many interesting suggestions and indicate that this work should be followed vigorously in the future.

Studies concerning the affect of wind movement, temperature, and humidity upon the transpiration of alfalfa have been made, and, as a result, interesting facts have been obtained concerning the power of the alfalfa plant to adapt itself to different environic conditions and the rate at which this adaptive change may be accomplished. The details of this work will be reserved for later publication.

SWEET CORN

The first phase of the work has now been completed. A variety of hardy, drought and heat-resistant sweet corn has been produced from the few grains originally found among the native corn grown by the Papago Indians. The ears and grains of this corn are still somewhat smaller than those of the larger varieties such as Country Gentleman and Stowell's Evergreen; but the greater hardiness and resistance to worms of this new variety enable it to produce, on the average, better ears than either of the varieties mentioned. Comparative tests between the Papago sweet corn and nine of the leading eastern varieties made on three different series of plots have shown the Papago to greatly outyield any other variety. In fact, it was the only variety to give satisfactory yields. Table and chemical tests made during the present summer indicate that the Papago sweet corn is slightly below the other sweet corns tested in sugar content, but is higher than field corn in this respect. However, this character is so dependent upon the stage of maturity at which the corn is gathered that an error of a day or two in judging the exact time at which the corn is in prime roasting ear condition, may reverse the order of quality and sweetness between varieties which are rather wide apart when true comparisons are possible. In the watery stage both field and sweet corn are very high in sugar content. As the milk and dough stages are approached the content of sugar rapidly falls. Decreases during the progress of these stages are reported by Straughn and Church¹ as follows; From 49.71 percent to 19.54 percent in Crosby Sweet Corn and from 31.81 percent to 12.58 percent in Stowell's Evergreen. In the watery stage, though the sugar content is high,

¹ Straughn, M. N., and Church, C. G. Influence of Environment on the Composition of Sweet Corn, U. S. Dept. of Agr., Bu of Chemistry, Bul. No. 127, (1909).

the grain is not palatable. Sweet corn differs from field corn in the fact that the palatable milk stage is reached with a higher sugar content in the former than in the latter. Our results indicate that although the Papago is somewhat inferior to the high-bred eastern sweet corn in this respect, it is superior to field corn. However, since the eastern sweet corns are always practically a failure in Arizona, there is an important economic place for the Papago corn in supplying our tables with a higher grade roasting ear than is now available in the Southwest.

A publication setting forth the details of the experiments with this corn, together with its history and description, is now being prepared. Physiological studies to determine the reason for the greater hardness of this new variety continue.

DATES

The seedling plants forming the first generation of the date breeding project were transferred to their permanent places in the orchard at Tempe in June, 1914. December 20, 1914, there were 318 plants alive and for the most part in healthy growing condition.

BEANS

Work with beans has been continued along the lines previously outlined. The 17 pure races of tepary beans retained as the most promising out of the 105 pure races in the plant-row test of last year, were given their second elimination trial during the present season. The best of these will be planted in a large increase plot next summer preparatory to their distribution one year hence. The wild form of the tepary (*Phaseolus acutifolius* var. *latifolius*) has been definitely located in two places within the state of Arizona. It was first found by Professor J. J. Thornber in the lower part of Stone Cabin Canyon on the northwest slope of the Santa Rita Mountains, July, 1914. This plant was also reported by Mr. A. J. Menager as growing in abundance in sandwash thickets south of the Santa Rosa Mountains near the Mexican border. The locality reported by Mr. Menager was visited by the writer in November, 1914. Here the typical form of *Phaseolus acutifolius* var. *latifolius* was found in abundance growing in thickets and climbing in great profusion upon the surrounding brush. Many of the vines ascended to a height of 10 to 12 feet and bore a bountiful crop of pods as high as 6 and 8 feet from the ground. In this locality only one variety was found. It has pink flowers and small, strongly flattened, gray speckled seeds. This is the same variety as that found in Stone

Cabin Canyon. The luxuriant vegetative growth of this wild variety strongly suggests that it may have value as a hay plant. A quantity of seed has been obtained and a plot will be planted next summer to test this point.

Domesticated varieties were sown broadcast on the Experiment Station Farm at Yuma in order to again test their value as a hay or green manure crop. Sown at the rate of 60 pounds to the acre in July and harvested in the latter part of October, they yielded on a two-acre plot, air-dry hay at the rate of 5075 pounds to the acre.

Genetic studies concerning the inheritance of certain characters in this species have been continued. Details of this work are not yet ready for publication.

WHEAT

The average yield of wheat on the substation at Yuma was 88 bushels to the acre. Low night temperatures which continued late into the spring growing season caused an excessive amount of dew, which, in turn, favored the growth and distribution of rust. This disease was exceptionally severe during the present season. The several varieties grown, exhibited great differences in respect to their rust resistance. Algerian macaroni wheat was almost perfectly resistant, as was also the Poulard (California Club). Of the bread wheats, Early Baart and Algerian Red Bread were most resistant, but these suffered much more from rust than the Durum and Poulards. Turkey Red and White Sonora were most susceptible. The White Sonora, however, was injured much less than the Turkey Red on account of its earlier ripening.

The following table gives acreage and yield per acre of the seven field plots:

YIELD OF WHEAT VARIETIES, 1914

Variety	Acreage	Yield in bushels per acre
California Club (Poulard)	.4548	4?
Red Algerian Macaroni	.0918	44
White Algerian Macaroni	1.2900	40
Red Algerian (bread)	.7436	38
Kubanka (macaroni)	.1143	29
Turkey Red (bread)	.5281	27
Minnesota Bluestem (bread)	.0995	23
Total acreage	3.3221	Av. yield 38

The high yielding power of the Poulards and Algerian macaroni varieties is again apparent in this year's yields, as it was last year. The macaroni wheats continue hard and show no tendency to become soft under Arizona conditions. The commercial sample of California Club (Poulard) on the other hand is badly mixed, many different types of head and grain appearing. These, however, all apparently belong to the Poulard group. Some of these types made grain of good quality, but the greater part of them are very inferior. This variety, therefore, while promising in yield, must be bred for quality and fixed in this character before it can be recommended for general planting. The high yield and good quality of the Algerian macaroni commend it highly for planting for poultry feeding. It must be remembered, however, that it cannot be milled for bread flour. If, on the other hand, a sufficient amount of it were grown to warrant the establishment of a mill for the manufacture of semolina, the basis for a very promising industry in the State would be laid.

None of the bread wheats tested in this series are of sufficient promise in both yield and quality to displace Early Baart, which is now fast becoming the dominant variety in the State. Early Baart wheat was first introduced by the Experiment Station in 1902.

The 665 pure races of wheat resulting from last year's head selections were tested as to yield, rust resistance, and quality of grain during the present summer. Based upon these tests, 65 of the most promising races were planted in larger plots, and are now undergoing their second elimination tests. A new series of 214 head-rows was planted at the Yuma station. At the same place there was also planted a series of 240 plant-rows of second generation hybrids between macaroni and bread wheats, and between hard and soft bread wheats. The high yielding, hard macaroni wheat was crossed with the likewise high yielding but soft White Sonora for the purpose of securing on the one hand a beardless macaroni, and on the other, a Sonora wheat with harder grain than is now possessed by this variety. The cross between the bread wheats was an attempt to combine the high yielding power of some of the softer varieties with the high quality of some of the lower yielding but harder sorts.

A careful study of the relation between several physiological correlations and the climatic adaptation of wheat varieties has been made. The details and results of this study are reserved for future publication.

GEO. F. FREEMAN, *Plant Breeder.*

J. C. TH. UPHOF, *Assistant Plant Breeder.*

HORTICULTURE

The time of the horticulturist has been divided between teaching, extension and research work. Teaching and extension work occupied the larger portion of the time during the academic year. Research work has been limited to two definite problems, namely, the culture of the grape and the pollination of the date palm. The protection of citrus trees against frosts and freezes by the use of processed fabrics set up as containers of heat supplied by burning kerosene, was also given some attention as a minor problem.

GRAPES

Careful records of the quality of the fruit, the size of the berry, and the yield per hill for 320 plants representing 84 varieties of 4 hills each, have been taken during the past season. This will make it possible to locate for propagating purposes the individuals of varieties producing large yields of well matured fruit of excellent quality. These observations will be duplicated and records made showing the behavior of the plants this season.

POLLINATION OF THE DATE PALM

Unsatisfactory results following the best known methods of pollination for the date palm warrant an extensive inquiry into the relation of atmospheric conditions, alkali, kinds and character of pollen, and methods of application to the setting of fruit. Many important observations have been made and results secured from experimental work done in pollinating more than 1000 blooms. This work will be extended to include a number of minor problems.

PROTECTING CITRUS TREES FROM FROST

A commercial supply company of Arizona at an earlier date announced the processing of cotton fabrics with materials rendering them mildew-proof, gas, water and air-tight, only slightly resistant to sunlight, and both heat absorbing and heat retaining.

At the request of the company and with the loan of four tree covers, or tents, and a supply of kerosene lamps with tin chimneys, an attempt was made to determine the value of the cloth and the apparatus in protecting citrus trees during cold weather.

The four tents were of equal dimensions and constructed to enclose trees 10 feet wide and 10 feet high exclusive of

the length of the trunk. Two of these tents were made of light and two of medium weight fabrics. No. 1 was medium weight, not treated; No. 2, medium weight, treated, No. 3, light weight, not treated; and No. 4, light weight, treated. The following statements summarize the results obtained during this preliminary investigation.

Lamps with tin chimneys: The rapid accumulation of heat by the tin chimney and the heating of the burner cause the flame to strike back and go out or to burn in the reservoir. No. 2 lanterns and lamps were used as substitutes.

Mildew resistance: Observations proved that fungi will grow upon the processed cloth.

Air and water-tightness: Air, which does not possess the penetrating properties of many gases passes readily through the fabric.

A light weight 6 x 6 inch square of the fabric was weighed, handled roughly, reweighed, washed in tap water, dried and reweighed. Rough handling reduced the weight 8.8 percent, and a further reduction of 7.7 percent occurred during washing.

Strips of light and medium weight fabrics were weighed, placed in water for a period of 44 hours, allowed to hang in a current of air until excess moisture had escaped and were then again weighed, dried and reweighed. The amounts of water absorbed were 63 percent for light and 58 percent for medium fabric, and the loss of weight was 9.6 and 9.9 percent, respectively.

On making small depressions in fabrics of light, medium and heavy weight and pouring a quart of water in each, dripping began in 25, 10 and 5 minutes respectively. A second test gave immediate results for the light and medium weights, and a five-minute delay for the heavy, a third trial producing immediate results in all cases. There was a reduction of weight during each percolation with a total loss of approximately 9 percent for each fabric. These cloths were given a second washing in tap water with a further reduction in weight of 7, 8, and 4 percent for the light, medium and heavy grades.

Semi-transparency: Trials with an actinometer, and with light sensitive solutions, for various lengths of time, showed tent No. 1 to have the greatest light resistance, Nos. 2 and 3 slightly less resistance, and No. 4 the least resistance.

Heat absorption: With the maximum temperatures of the air varying from 62° to 77° F. during a period of nearly two weeks, the maximum in each of the four tents ranged from 1° to 18° P. higher, giving an average of about 16° F. for clear days irrespective of wind. Tent No. 2 showed the least change in temperature and was the slow-

est to lose heat At sunset or a little later there was a rapid and total loss of accumulated heat from each tent.

Retention of heat Two series of tests were made with each of the four tents. At 22°F. in an atmosphere devoid of air currents and with no possible absorption of heat from external sources, when supplied with a constant amount of heat for a period of one hour and ten minutes, they showed a gain of 5° to 9°F. in the first ten minutes, and an additional average increase of 15°F. during the remainder of the period. Furthermore, the tests showed that the heavier fabrics hold the heat much more effectively during the first ten minutes, but after that the loss of heat is about one-half as fast through the treated cloths of both light and medium weights as through the untreated cloths.

Five tests conducted during the nights of January 28 and 31, and February 1, 2 and 4, gave interesting results. When the minimum air temperatures ranged from 32° to 24°F., the medium temperatures in those tents in which approximately 6000 large calories were liberated during the night, did not fall below the danger point. The cost of heating varied from 3 to 8 cents per tree for an average of 12½ hours. The cost of fuel could be greatly reduced since injurious temperatures varied in duration from ½ to 7 hours. Evidence of the greater value of tent No. 2 was again noted.

Summary of tests: With reference to the work above described, it appears in a general way that the heavier processed fabric employed retains heat to an extent practicable for the protection of trees, at a reasonable cost for fuel. Lamps with tin chimneys overheated quickly, and the fabrics were not found mildew resistant or gas and water-tight as claimed.

PUBLICATIONS

A study of prevailing conditions has been made with reference to the adaptability of important commercial varieties of apples, and the best methods of culture and orchard management, including pruning, thinning and spraying. The results were published in *Timely Hint for Farmers*, No. 102, entitled "Apple Culture."

Results of a similar study of the grape have been published in *Timely Hint* No. 107, entitled "Grape Culture."

W. H. LAWRENCE, *Horticulturist.*

ANIMAL HUSBANDRY

SHEEP BREEDING

The breeding flock has been maintained through the year and operations carried on along the general plan outlined in the Twentieth Annual Report of this Station. At present there are 388 head of sheep in the flock, consisting of a few pure breeds and various crosses. A small band of dry ewes has been used to keep the Johnson grass and other weeds in check along the ditches at the Station Farm. Table I gives a detailed account of progress in the making of the final crosses contemplated, with other crosses for comparison; also the number, sex, and age of each member of the flock:

TABLE I.—SUMMARY OF SHEEP IN BREEDING FLOCK

Breeding	8 yr. old		7 yr. old		6 yr. old		5 yr. old		4 yr. old		3 yr. old		2 yr. Old		1 yr. old		Lambs		Total
	ram	ewe	ram	ewe	ram	ewe	ram	ewe	ram	ewe	ram	ewe	ram	ewe	ram	ewe	ram	ewe	
T ⁺ T							1		1		1		1		3	2	0		12
N T				1							3								4
S f									1	1	1							1 1	5
H T								1						1					2
R I													1						1
T ^N 2 2		1		9		6		18		12		13		6					65
S ^N 2 2								3		7		3							13
H ^N 2 T								5						8					13
R ^N 2 2																		1	1
R ^O 2 2																			1
T ^{TN} 2 4 4									1		5		1		1	4			12
T ^{SN} 2 4 4											2		2		9	9	3		25
T ^{HN} 2 4 4											4		2		2	0	7		21

*T—Tunis, N—Native, S—Shropshire, H—Hampshire, R—Rambouillet, O—Oxford
D—Dorset, Na—Navajo

Breeding	8 yr. old		7 yr. old		6 yr. old		5 yr. old		4 yr. old		3 yr. old		2 yr. old		1 yr. old		Lambs		Total
	ram	ewe	ram	ewe	ram	ewe	ram	ewe	ram	ewe	ram	ewe	ram	ewe	ram	ewe	ram	ewe	
TON 2 4 4											2		1						3
SIN 2 4 5											7		19	1	20	25	25		97
SSN 2 4 4															1	1	2		4
SHN 2 4 4											1				1	2	2		6
HTN 2 4 4							7						1				2		10
HSN 2 4 4													1			1			2
ONT 2 4 4							1												1
TTTN 2 4 8 8																1			1
IHN 2 4 8 8											2					1	2		5
STIN 2 4 8 8															1	1	2		4
STHN 2 4 8 8													1			1	2		4
STOM 2 4 8 8																	1		1
SNTN 2 4 8 8											1				2		1		4
SSIN 2 4 8 8																2			2
SHIN 2 4 8 8											1				1	4	2		8
HTSN 2 4 8 8															1		4		5
HTHN 2 4 8 8																1	2		3
HNIN 2 4 8 8							1												1
HSTN 2 4 8 8															2	9	6		17
STHTN 2 4 8 16 16															1		2		3
SHNTN 2 4 8 16 16														1					1
INTNNN 2 4 16 16 16 16														1					1
Unknown							1								1		14	14	30
Total.....	1		9	1	6	2	85	1	22	1	46	1	45	3	45	86	84	388	

During the entire period of the experiment, dating from May, 1906, until the present, 1627 sheep have been under observation, of which 230 have died from various causes, 1011 have been discarded as undesirable, and 388 are still in the flock. Later about 75 head will be sold to make room for a new crop of lambs. The first generation — $\frac{N}{2}$ is the most promising cross to date, although the $\frac{T}{8} \frac{N}{8} \frac{N}{4} \frac{N}{2}$ cross with a few sheep shows a much better animal than the Tunis Native. Some of the later crosses have not done so well, owing to the late lambing season and the rather crowded conditions on the Station Farm during the past year and a half. During the last two years a large percentage of our lambs has been dropped late in the spring, and the hot summers have been exceedingly trying on the young lambs. The weight at six months and at one year hardly gives a correct idea as to their worth. This applies particularly to the young lambs born as late as April and May, which do not recover their normal growth until after they are one year old. However, large numbers of Tunis-Native lambs have been born at the same time, and the average for this cross still remains higher than that of the next generation. Table II gives the cross, the average weight at birth, at six months, and at one year, and the weight of fleece for all crosses numbering six or more individuals.

Many crosses have been made for comparison with those contemplated in the general outline. For the most part they have not proved satisfactory. With a few exceptions all have been discarded. Forty-nine of the unknown sheep given in the table of crosses were due to the young rams breaking into the breeding flocks. The remaining twenty were lambs that were purchased in dam and are designated as natives, for their dams were purchased on the range and had been bred when received at the Farm.

Table III gives the cross and the number of individuals of the cross, since the institution of the project

TABLE II—AVERAGE WEIGHTS OF SHEEP AT BIRTH, SIX MONTHS, ONE YEAR, WITH THE WEIGHT OF THE FLEECES FOR ALL CROSSES NUMBERING SIX OR MORE INDIVIDUALS

Cross	Weight at birth		Weight at six months		Weight at one year		Weight of wool	
	No	Average	No	Average	No	Average	No of fleeces	Average
$\frac{T}{1}$	23	7 141	10	68 900	12	86 625	37	4 932
$\frac{S}{1}$	9	7 166	4	64 000	4	84 125	29	6 344
$\frac{N}{1}$	14	7 392	12	64 708	6	85 666	416	7 144
$\frac{T}{2} \frac{N}{2}$	240	7 703	179	66 980	137	81 682	312	8 002
$\frac{S}{2} \frac{N}{2}$	89	7 696	57	62 245	34	72 325	75	6 638
$\frac{H}{2} \frac{N}{2}$	50	8 895	25	63 120	17	77 353	46	5 684
$\frac{O}{2} \frac{N}{2}$	6	9 666	3	75 000	3	93 666	6	7 645
$\frac{T}{2} \frac{T}{4} \frac{N}{4}$	47	7 182	27	60 925	19	73 815	31	6 024
$\frac{T}{2} \frac{S}{4} \frac{N}{4}$	64	7 148	37	59 338	22	65 272	30	5 591
$\frac{T}{2} \frac{H}{4} \frac{N}{4}$	36	7 028	19	64 369	14	69 714	28	5 485
$\frac{S}{2} \frac{T}{4} \frac{N}{4}$	210	7 690	99	63 424	54	65 713	88	5 818
$\frac{H}{2} \frac{T}{4} \frac{N}{4}$	20	8 8	14	71 284	12	93 166	41	5 872
$\frac{N}{2} \frac{T}{4} \frac{N}{4}$	19	8 355	15	69 733	5	69 2	12	7 062
$\frac{N}{2} \frac{N}{4} \frac{N}{4}$	6	8 083	4	51	1	82	2	3 5
$\frac{T}{2} \frac{H}{4} \frac{T}{8} \frac{N}{8}$	14	6.607	6	56 333	5	67	4	4 187
$\frac{S}{2} \frac{T}{4} \frac{S}{8} \frac{N}{8}$	10	7.325	3	58 666	1	55	.	.
$\frac{S}{2} \frac{T}{4} \frac{T}{8} \frac{N}{8}$	23	7 75	7	65 642	5	74 2	..	..
$\frac{H}{2} \frac{S}{4} \frac{T}{8} \frac{N}{8}$	33	7.916	5	54	1	69.	..	.
$\frac{T}{8} \frac{N}{8} \frac{N}{4} \frac{N}{2}$	8	7.875	8	74 25	2	91.5	....	.

TABLE III—SUMMARY OF ALL SHEEP PRODUCED IN THE TUNIS BREEDING EXPERIMENT

Cross	Number of individual sheep	Cross	Number of individual sheep	Cross	Number of individual sheep
$\frac{T}{2} \frac{I}{4}$	23	$\frac{STN}{244}$	210	$\frac{ST3N}{285}$	1
$\frac{R}{2} \frac{I}{4}$	2	$\frac{SSN}{244}$	4	$\frac{HSNTN}{2481616}$	2
$\frac{H}{2} \frac{I}{4}$		$\frac{HTN}{244}$	20	$\frac{SHNNT}{2481616}$	2
$\frac{D}{2} \frac{I}{4}$	5	$\frac{SHN}{244}$	5	$\frac{TSTN}{2488}$	3
$\frac{Na}{2} \frac{I}{4}$		$\frac{OND}{244}$	1	$\frac{TNNNTNN}{448881616}$	1
$\frac{S}{2} \frac{I}{4}$	9	$\frac{NNT}{244}$	19	$\frac{STON}{2488}$	2
$\frac{O}{2} \frac{I}{4}$	1	$\frac{HSN}{244}$	2	$\frac{SNNT}{2488}$	3
$\frac{N}{2} \frac{I}{4}$	14	$\frac{OTN}{244}$	5	$\frac{TTNN}{2488}$	3
$\frac{TN}{2} \frac{I}{8}$	240	$\frac{TTTN}{2488}$	1	$\frac{STSN}{2488}$	1
$\frac{SN}{2} \frac{I}{8}$	89	$\frac{THNTN}{2481616}$	1	$\frac{NaN}{22}$	6
$\frac{HN}{2} \frac{I}{8}$	50	$\frac{SOTN}{2488}$	1	$\frac{STOH}{2488}$	1
$\frac{NaN}{2} \frac{I}{8}$	1	$\frac{NaN}{244}$	6	$\frac{SN7T}{1616}$	2
$\frac{TD}{2} \frac{I}{8}$	2	$\frac{THTN}{2488}$	14	$\frac{RTN}{244}$	1
$\frac{ND}{2} \frac{I}{8}$	4	$\frac{STHN}{2488}$	10	$\frac{NNNTT}{2816416}$	3
$\frac{NO}{2} \frac{I}{8}$	6	$\frac{STTN}{2488}$	9	$\frac{NNTN}{2488}$	8
$\frac{fNa}{2} \frac{I}{8}$	1	$\frac{SHTN}{2488}$	23	$\frac{HTHN}{2488}$	3
$\frac{TTN}{2} \frac{I}{4}$	47	$\frac{STN}{88}$	1	$\frac{HNTN}{2488}$	1
$\frac{TSN}{2} \frac{I}{4}$	64	$\frac{HSTN}{2488}$	33	Unknown	69
$\frac{THN}{2} \frac{I}{4}$	36	$\frac{RHTN}{2488}$	1		
$\frac{TON}{2} \frac{I}{4}$	5	$\frac{SSTN}{2488}$	2		

UNIVERSITY FARM DAIRY

Aside from the uses of the dairy herd at the University Farm for instruction work, several short experiments have been conducted which have been helpful in connection with the general management of the herd.

PASTURE VS. DRY FEED

The general idea advanced by many Arizona dairymen is that alfalfa pasture is not only the most economical ration but also the best milk producing feed available. In order to get data on the subject four cows were selected and their milk carefully weighed. The results are shown in Table IV.

TABLE IV.—MILK PRODUCTION ON PASTURE AND ON DRY FEED

Name of cow	Production 1st week on pasture	Production 2nd week on pasture	Production 3rd week on dry feed	Production 4th week on dry feed
Anna Inka ..	271 5	280 3	282 3	284 3
Molhe .	201 3	214 3	232 3	223 6
Nettie .	268 0	275 5	294 5	289 2
Shepherders .	301 3	316 0	321 6	300 5
Total ...	1042 1	1089 1	1130 7	1097 6

The first and third weeks were used to prepare the cows for the test. The second and fourth weeks indicate the comparison of alfalfa pasture *vs.* dry feed (alfalfahay at the rack, wheat bran 7 pounds and rolled barley $1\frac{1}{2}$ pounds daily.) Three of the four cows fed on dry feed made a gain in milk yield, one lost 15.5 pounds. The total gain for the week was 8 pounds. A comparison of the second and third weeks shows a gain of 50.6 pounds of milk in favor of the dry feed for the four cows, with a gain for each cow except Anna Inka, who lost one pound.

DRIED BEET PULP VS. DRIED BEET PULP AND WHEAT BRAN

Eighteen cows of uniform breeding were selected and divided into two equal lots for a feeding trial of dried beet pulp *vs.* dried beet pulp and bran. Each lot had access to all the alfalfa hay that it could economically consume. The average daily ration of hay for the herd was 25 pounds. During the first week of the trial both lots were fed parallel rations to study the milk production of the indivi-

duals before the test began. The trial was of very short duration, but the results obtained since that time seem to fully justify the conclusion.

Lot 1: Total yield of milk for nine cows on a ration of dried beet pulp, bran, and alfalfabay, February 4 to 17, was 2710 pounds. This lot was continued on the same ration for two weeks more, February 18 to March 4, with a yield of 2554 pounds. The loss in milk yield was 156 pounds. Total cost for Lot 1 was \$17.85 as follows: beet pulp, 548 pounds at \$28.50 a ton, \$7.78, bran, 576 pounds at \$35 a ton, \$10.08.

Lot 2: Total yield for nine cows on a ration of dried beet pulp, bran, and alfalfa hay, February 4 to 17, 3129 pounds of milk. Later the cows were continued on a ration for two weeks of beet pulp and alfalfa hay, February 18 to March 4, with a yeild of 2813 pounds. The loss in milk yield was 316 pounds. Total cost for Lot 2 was \$8.18 as follows: beet pulp, 574 pounds at \$28.50 a ton, \$8.18.

The cows in Lot 1 lost 156 pounds in milk during the last two weeks and this figure may be taken as the normal loss due to the advancement of the period of lactation and other natural causes. Hence, to reduce the loss of Lot 2 to normal we have the simple proportion, 2554 156 :: 2813:171. The normal loss for Lot 2, therefore, if continued on the ration of beet pulp and bran would have been 171 pounds, instead of 316 pounds. The loss in milk produced then equals 145 pounds for the two weeks, which, at 35c. a gallon, would have amounted to \$5.95, against an increased cost in feed of \$9.87. The actual saving by feeding beet pulp instead of beet pulp and bran was \$3.72 in 2 weeks, which amounts to \$96.72 for the herd of 9 cows in one year.

GAIN IN WEIGHT OF ARIZONA WOOL IN STORAGE AND TRANSIT

Data supplied by Mr. Thomas E. Pollock, Flagstaff, Arizona, one of the largest shippers of sheep and wool in the State, show that 15 shipments made in February and March, 1914, and weighing a total of 448,223 pounds when shipped, weighed 452,852 pounds when sold on the Boston market, a gain of 4629 pounds, which at 22 cents a pound gave an increase in value of \$1018.38. Arizona produces annually about 4,200,000 pounds of wool, which according to these figures would increase 43,334 pounds in storage and transit to the eastern market. The increased value of the dip due to gain in moisture, therefore, would be \$9535.68.

F. W. WILSON,
Animal Husbandman.

ENTOMOLOGY

It proved impracticable to take up the alfalfa seed chalcis fly investigation in the spring of 1914 as planned. Since the field work outlined would require a complete season, and since fragmentary results which might have been secured later in the season would have been of comparatively little value, the entire subject was postponed.

THE HARVESTER ANT

Efforts to perfect a practical method of utilizing carbon bisulphide in combating the harvester ant (*Pogonomyrmex barbatus* subspecies *rugosus*) have continued. A high pressure pump which volatilizes the carbon bisulphide has been thoroughly tested in the attempt to force the fumes into the insects' underground tunnels in an effective manner, but so far the results have been unsuccessful. Mound building varieties of the harvester ant occur in parts of Arizona, particularly in the northern half of the State. These can no doubt be destroyed with carbon bisulphide by the method demonstrated in experiments against a closely related species at the Kansas Experiment Station. Fortunately, these mound building varieties have not proved very destructive in this State.

The principal work of the season against the harvester ant has consisted in a large scale experiment with London purple to determine the cost of material and labor and to perfect the methods of this treatment. A ten acre field located near Phoenix has been practically cleared of the ants by a series of five applications of the poison. In this field there were 168 nests with bare areas estimated to average 330 square feet, making a total approximately of $1\frac{1}{4}$ acres or $12\frac{1}{2}$ percent of the ten acre field. Twenty-eight and a half pounds of London purple costing \$8.40 were used during the season. The labor cost, figured at 30 cents an hour and allowing for the extra time actually expended in making notes and miscellaneous observations, has amounted to \$3.30. The total cost per acre has been \$1.17. This work has been conducted with the assistance of Mr. George Acuff, Crop Pest Inspector at Phoenix, for the Arizona Commission of Agriculture and Horticulture.

During the summer of 1913 certain drug stores in the Salt River Valley secured a stock of London purple which was ineffective, and a considerable amount was sold to ranchers for use against the harvester ant. The material was readily distinguished from the ordinary London purple by its very dark color. Field tests proved that ants were not injured by it when used in the ordinary manner, even in excessive doses. In the laboratory a water mixture was made of a sample of the ineffective material for comparison with a water mixture of an effective sample. The result was that after the insoluble matter had settled the water remained a deep purplish color in the case of the lighter colored sample. The ineffective material was thus proven to contain a considerable amount of coloring matter. It would be impossible to say whether or not this was added with the intention of deceiving the purchaser but this would not appear to be the case since the color of the material as marketed was not a good imitation of the color of ordinary London purple. Samples were submitted to the chemical laboratory of the Station and were analyzed by Mr. Catlin, with the result that the effective London purple was found to contain 27.81 percent arsenious oxide (As_2O_3) whereas the sample of the ineffective material was found to contain only .35 percent arsenious oxide.

THE WESTERN GREEN JUNE BEETLE

In the lower elevations in Arizona the Western Green June beetle (*Allorhina mutabilis*) is a troublesome pest of nearly all kinds of fruits, peaches, figs and grapes being the principal crops to suffer. Investigations of this pest have been conducted with the view to gaining a knowledge of its habits and life history and methods of control. As a result, a plan for control is being formulated and after another season a report with definite recommendations will be issued. Drowning of the grubs in the soil by flooding the infested areas, plowing infested areas to enable turkeys and chickens to clean up the grubs, and hand picking, or otherwise collecting the beetles in the orchard or vineyard, are the main lines of control which are available. Poisoning the adults offers little hope of success. For the collection of adults in an orchard, a device originated by Professor W. H. Lawrence and the Entomologist has been tested with good results. A design has been made for an improved form of this device which will be perfected during the coming season.

COTTON INSECTS

Circumstances have required some attention to acquiring a knowledge of southwestern cotton pests, including the insects which attack the Arizona wild cotton plant (*Thurberia thespesiodes*). During July and August, 1913, insect pests of cultivated cotton in the Salt River Valley and near Tucson were investigated with the view to learning what cotton pests exist in these sections and the extent of their injury. In August, cooperating with the Bureau of Entomology of the U. S. Department of Agriculture, attention was given to the insects found on the Arizona wild cotton plant. The results of the first year's studies of the insects attacking the cultivated and wild cottons were published in connection with the report of the State Entomologist in the Fifth Annual Report of the Arizona Commission of Agriculture and Horticulture¹. A more complete report concerning the insects found on wild cotton was published elsewhere² under the joint authorship of Mr. W. D. Pierce of the Bureau of Entomology, and the writer.

In the summer of 1914 the value of cowpeas and corn as trap crops in the protection of Egyptian cotton against the boll worm was tested near Glendale. The insects were not present in sufficient numbers to cause appreciable damage, but the detailed examinations showed that this method is fully as adaptable for the protection of Egyptian cotton in Arizona as it is for the protection of Upland cotton in the southeastern states.

One of the native insects found attacking wild cotton in the Santa Rita Mountains was a small moth species of the genus *Bucculatrix*. The larva of this insect is a leaf miner until nearly full grown. Specimens collected by Mr. Pierce of the U. S. Department of Agriculture, and the writer were determined by Mr. Busck of the U. S. National Museum as a new species which he has named *Bucculatrix thurberiaella*. A small amount of leaf miner work was noted by the writer on cotton growing on the grounds of the office of the State Entomologist at Phoenix during the summer of 1913. During the season of 1914 leaf miner work became prevalent throughout the Salt River Valley but not sufficiently early in the season to cause appreciable damage. Unless the insects are controlled by parasites or other natural means, however, artificial control measures will be required and in this connection a knowledge of the life of the insect is necessary. Some attention has been given to this

1. Pages 38 to 48.

2. Proceedings Entomological Society of Washington, vol. XVI, p 14-23. 1914.

subject, and the main features of the life history and habits of the insect worked out,

THE HOUSE FLY

No insect pest in Arizona is of more direct and universal interest than the house fly. Its relation to human health as a disease carrier has been well established and practically every family both in the city and in the country finds some form of protection against the house-fly nuisance necessary. The use of fly poisons and traps is becoming more and more common and while it is generally accepted that as a rule the most practicable means for the control of the house-fly is the prevention of breeding, work directed against the adult insects, particularly in rural districts, must be relied upon to a considerable extent as a protection against this disease-carrying pest. There are many situations where fly traps, fly poisons and even sticky fly paper are the only practicable means of protection, and many more where such means are valuable accessories to the more desirable methods of protection. In December, 1913 an opportunity presented itself for an investigation of house-fly baits and poisons. A series of experiments was conducted which developed considerable information of value in the household problem of fly control.¹

PUBLICATIONS

Of the total 42 articles written by the Entomologist for publication during the past fiscal year² five are of special interest in connection with this report. Two of these are "Timely Hints," Nos. 104 and 105, the first entitled "Grasshoppers" and the second "Three Arsenical Insecticides and How to Use Them." Two publications relating to cotton insect investigations and one to house-fly experiments have already been referred to,

A. W. MORRILL,
Entomologist.

1. *Journal Economic Entomology* vol. 7, June, 1914, p. 265-273
2. For complete list see Sixth Ann. Rept. Am. Comm. of Agri. and Hort.

CHEMISTRY

The dependence upon the chemists for analytical work necessitated by the various projects being carried out by the Station has increased noticeably during the past year. Cooperation has been sought in nearly every project now under way, and the chemists have responded as far as possible, especially in those cases that were immediately urgent. A number of water analyses have been made for the United States Geological Survey in connection with the study of the groundwater supply of certain Arizona valleys. The various dry farms have also required several hundred moisture determinations in soils. The free analyses of irrigating water and determinations of alkali in soils for the farmers of the State are increasing in importance and utility, as attested by the demand for this service. The establishing of the Agricultural Extension Service by the Station has further stimulated the interest of Arizona farmers in the quality of their soils and irrigating waters, and many abnormal conditions met with in field and orchard by the farm advisors require the services of the chemist in determining their cause. While much of this work is of value only to the farmer served—and frequently the installation of expensive pumping machinery depends entirely upon the report of the chemist—nevertheless, we are accumulating much valuable data relative to the soils and water supplies of Arizona, as well as to the alkali resistance of various crops under field conditions. In this connection may be mentioned a series of soils examined and reported upon for the Arizona Land Commission. Only in a few rare instances where complete information regarding samples was not furnished, or where the requests were excessive and not in the immediate interest of prospective settlers or established residents, has this service been, or should it be, curtailed. The result of these outside demands, which must further increase with the growth of the State and the expanding activities of the Station, has been to impede progress with our own more purely investigational work, which had been previously outlined. Thus, the department stands in need of additional assistance for analytical work.

The sample for the eighth annual complete analysis of the Salton Sea water in cooperation with the Carnegie Desert Laboratory, was taken by the biochemist at the usual time near Mecca, California.

Other samples for study in connection with the natural concentration of this great body of saline water were also secured. Indications are that certain facts of considerable interest will be established by this investigation, especially regarding the concentration of potassium from very dilute solutions of that element in stronger saline solutions. The establishing and interpretation of this phenomena has direct bearing on a more complete knowledge of the conservation of potassium in agricultural soils, A complete discussion by Dr. W. H. Ross and Dr. A. E. Vinson of the work done in this laboratory on the Salton water has been published during the year by Dr. D. T. MacDougal in a volume entitled *The Salton Sea*, and published at Washington by the Carnegie Institution.

Aside from the work of the laboratories proper, the activities of the department have extended into other fields. The biochemist has been actively interested in the educational work of the College of Agriculture and the University. On two occasions invitations have been accepted to deliver addresses outside the State; and In February the biochemist acted as a member of the Annual Assay Commission at the Philadelphia Mint, to pass on the weight and fineness of the gold and silver coins made at the United States Mints in 1913.

SALTON SEA WATER

The eighth annual sample of Salton Sea water was collected June 12, 1914, over deep water about $1\frac{1}{2}$ miles from shore near Tavertine Point. The water was very clear and did not show as many organisms as were present in the sample taken the previous year. The lime deposit on the mesquite below water level did not seem as heavy as that brought to the laboratory by Dr. MacDougal in 1913.

During 359 days (June 18, 1913 to June 12, 1914) the total solids have increased from 1002.56 to 1179.6 parts per 100,000, an increase of 17.5 percent. When calculated for the year ending June 3 by the method used in previous years, (Ariz, Agr. Exp. Sta. 22nd Annual Report, p. 559) the annual concentration for 1913-14 is found to be 18.1 percent (1912-13, 17.7%; 1911-12, 17.5%; 1910-11, 19%; 1909-10, 21%; 1908-9, 16%; 1907-08, 17%). The accompanying table gives the results of the eighth annual analysis, and from it the concentration of the various constituents may be traced.

The concentration of the total saline matter for each succeeding 365 days is fairly regular, as may be seen from the percentages noted in the preceding paragraph. The percentages of concentration for the separate constituents, however, show variation from the

COMPOSITE ANALYSES OF THE SALTON SEA WATER, Parts per 100,000

	May 25, 1908	June 5, 1909	May 22, 1910	June 3, 1911	June 10, 1912	June 18, 1913	June 12, 1914
solids (at 110° C.), plus water of occlusion and hydration	884.80	519.40	603.80	718.00	846.55	1002.56	1179.6
Water of occlusion and hydration	.....	17.50	22.56	20.84	23.9	32.6	38.2
Sodium, Na	111.05	160.33	189.28	227.81	270.71	823.08	381.47
Potassium, K	2.80	3.24	3.53	3.81	3.81	3.45	4.01
Calcium, Ca	9.95	12.70	13.67	15.62	17.28	19.75	22.22
Magnesium, Mg	6.43	8.96	9.84	11.68	13.62	16.22	19.08
Aluminum, Al	.030	.062	.040	.089	.100	.125	.140
Iron, Fe	.005	.010	.008	.036	.042	.038	.012
Manganese, Mn	none	none	none	none	none	none	none
Zinc, Zn	none	none	none	none	none	none	none
Lead, Pb	none	none	none	none	none	none	none
Copper, Cu	none	trace	trace	trace	.....	.....	trace
Lithium, Li	.....	.13	.021	.025	.....	.....	.....
Chlorine, Cl	169.75	240.90	280.93	339.42	395.44	473.89	579.66
Sulphuric, SO ₄	47.80	65.87	76.36	91.67	106.83	124.65	143.10
Carbonic, CO ₂ (in total solids)	6.58	7.34	6.38	5.78	.....	.....	.....
Carbonic, CO ₂ (total)	.....	.....	.....	.....	12.09	11.28	10.68
Bicarbonic, HCO ₃ (volumetric)	.....	.....	.....	.....	16.85	15.74	15.22
Silicic, SiO ₂	1.41	1.59	1.55	1.83	1.79	2.18	2.42
Phosphoric, PO ₄	.009	.01	.013	trace	trace	trace	trace
Nitric, NO ₃	.18	none	none	none	trace	none	none
Nitric, NO ₂	none	.0006	none	none	none	none	none
Oxygen consumed	.093	.088	.045	.063	.072	.110	.110
Boric acid	.....	trace	trace	trace	trace	trace	trace
Total constituents	855.39	501.10	581.67	697.83	.....	.....	.....

general rate of concentration, due, undoubtedly, to the disturbing effects of drainage and seepage water received by the lake. Three constituents—calcium, potassium and carbonic acid—are showing variations clearly not due to these causes. Calcium and carbonates, as in previous years, have not concentrated as much as the other constituents, carbonates again showing an actual decrease. It is now well established that this loss of calcium carbonate is due to the formation of new travertines similar to those formed when the ancient Salton Sea dried up. Potassium, however, instead of decreasing, has concentrated this year in about the same ratio as the other constituents. This may be accounted for in part by the apparent decrease in animal and vegetable organisms in the water.

A. E. VINSON, *Biochemist*.

C. N. CATLIN, *Assistant Chemist*.

IRRIGATION INVESTIGATIONS

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During the past year, as previously, the activities of this office have been divided about equally between general studies of groundwater supplies and the development of groundwaters with pumping machinery. A considerable number of farmers and incoming settlers have been assisted in the solution of their pump irrigation problems. In many cases they have visited this office for the purpose of consultation and in other cases they have been aided through correspondence.

GROUNDWATER STUDIES

The intensive investigations of groundwater hydrology in many valleys, both in Arizona and in other states, during the past few years have increased the knowledge of groundwaters to such an extent that it is possible to formulate general principles concerning them. It is now recognized that, excepting certain cases, the rock trough of each valley is practically water-tight, and the valley fill, therefore, is in each case an entity in its relation to groundwater. A valley fill receives increments to its water supply from various sources, chief of which in arid regions are percolation from stream flows and from flooded areas, and it is subject to losses of groundwater through springs, river drainage, evaporation and transpiration, percolation into lower valleys through the outlet gap of the rock basin, and by artificial means. Each valley fill contains a fairly definite quantity of stored water, but the total amount thus contained is of minor importance. The object of investigations should be to determine how much water can be made available for man's uses without depleting the main supply, that is, to determine the average annual "safe yield." For, to withdraw a larger amount for municipal service or for irrigation, would result in a constantly increasing pumping lift and an ultimate exhaustion of the supply.

The loss of groundwater through transpiration has attracted the writers' attention during the past year, for it is believed to be the largest and most important factor of loss in many Arizona valleys. A discussion of transpiration in its relation to groundwater supplies has been prepared and contributed to technical literature.¹

1 Proceedings Am. Soc. C. E., XL, 6, p 1949, Aug 1914

SULPHUR SPRING VALLEY

During this, the third year of irrigation investigations in the Sulphur Spring Valley, the principal accomplishments have been the sinking of another reinforced concrete caisson well,¹ and the study of the flood discharges from Leslie Canyon.

The caisson well was sunk on the ranch of George Giragi, about five miles northwest of Douglas. Although the depth to the water table was 41 feet, Mr. Giragi chose the 8-foot size. This is the larger of the two sizes used by the Experiment Station. A pit was first dug to within a foot of the water level and the caisson was started there. An exceptionally good curb was built extending to the surface, meanwhile being sunk to a depth of 53 feet, where it rests upon a stratum of hard caliche. A good supply of water has been developed and the drilling or digging of a small opening through the caliche will augment the supply.

The construction of a concrete submerged dam in Leslie Canyon made it possible to measure the flood discharges as a basis for studying the disposal of the floods after they debouch upon the broad valley slope. Advantage was taken of this dam during the summer of 1914.

The plan of the campaign was to observe and record the location, intensity and character of each storm and the resultant flood; to measure the discharge over the dam; to estimate the gain or loss in the Canyon below the dam; and to ascertain in each case what became of the flood flow, how much was diverted into irrigation ditches, how much was spread out over wild grass lands, how much reached the Whitewater River, and how much was contributed to the groundwater supply of the valley. The data obtained was of necessity roughly approximate, and much of the computations are assumptive. But the results point to a number of important deductions, as follows; Flood flows of great size originate occasionally from storms on the valley slopes; flows in the Canyon begin suddenly and are of short duration; the rate of loss by seepage in a sandy stream bed is high; comparatively little water from the Canyon reaches the river; most of the water spreads out over grass lands and sinks into the heavy soil; a minor portion of the flow (difficult to estimate) sinks through the stream beds to the main body of groundwater, and a small amount, also, reaches the groundwater through gopher holes and joints in the soil. Most of the water flooded over the draws does not sink below the reach of the grassroots.

710 description see Bul 60, Ariz Agr Exp. Sta., p. 404; and 25rd Ann. Rept., 1912, p.

WATER SUPPLY NEAR TUCSON

A comprehensive report was made during August, 1913, to the City of Tucson covering the groundwater supplies and possibilities of water development on the lands owned by the city, and covering, also, the plans proposed by the city engineer for extensive changes and improvements. The report states: "The best groundwater supply is in the Recent gravels, which underlie the bottomland only. The drainage of the valley rising through the Pleistocene deposits enters the Recent gravels, thus feeding the underflow which these gravels carry. The underflow moves slowly and much of it is lost by evaporation and transpiration. The underflow should be developed as though it were an extended storage reservoir rather than as a moving stream. The present supply of one billion gallons per year, with a maximum consumption of 4,670,000 gallons per day, can be trebled without acquiring any additional land or water rights." The plans of the city engineer were approved with a few minor exceptions, the most important ones being the location of the proposed new wells and the construction of the main conduit, it being considered that reinforced concrete should be used instead of redwood stave-pipe.

The general study of the fluctuations of the water table in the Santa Cruz Valley is being continued. This work is now being done cooperatively with the city engineer.

A gaging station was established on the Rillito River at the Oracle road bridge in 1908. The station was transferred to the U. S. Geological Survey in June, 1912, but on January 1, 1914, this office assumed responsibility for it again. The Rillito is an exceedingly difficult stream to gage, the floods being very erratic and the stream bed shifting and subject to scour. A nilometer is maintained on one of the bridge piers and usually records the first part and maximum height of the flows. Effort is made to get one or more gagings on each flood. The unprecedented flood of December 20, 1914, washed out the north approach to the bridge and made it impossible to obtain anything more than rough estimates of the flow for the following week. Nevertheless, such estimates were attempted and are used to give the total discharge for 1914. The Santa Cruz River has been gaged since 1905, the station being located on the West Congress St. bridge. This station was transferred to the U. S. Geological Survey in June, 1912, and responsibility for it was resumed in December, 1914. The discharge data for the intervening time was secured through the courtesy of the district hydrographer, U. S. G. S.

DISCHARGE OF RILLITO AND SANTA CRUZ RIVERS, 1912-1914

Month	Rillito			Santa Cruz		
	1912	1913	1914	1912	1913	1914
January.	0	0	1	0	775	No record
February.	0	420	820	0	655	4
March..	3745	650	0	1725	85	18
April....	25	0	0	40	0	0
May.....	0	0	0	0	0	0
June.....	No record	0	12	No record	0	40
July	" "	5	2470	" "	0	762
August. .	" "	5	2920	" "	193	960
September	" "	30	2675	" "	67	0
October. .	" "	0	92	129	0	170
November	0	0	1370	300	18	360
December.	0	0	107640	606	18	55400
Total ...	...	1110	118000	..	1811	....

The flood of December 20-26 was severe and destructive on the Santa Cruz River. A special effort was made to maintain a good record of the discharge, and many gagings were taken. Acknowledgement is hereby made to the Tucson Farms Company for the assistance rendered by their engineers. The daily discharge for the week of the flood, and the maximum for each day, are given in the following table:

DISCHARGE OF SANTA CRUZ RIVER DURING FLOOD OF DECEMBER, 1914

Date	Maximum gage height	Maximum depth observed	Maximum discharge	Discharge
1914	Feet	Feet	Second feet	Acre-feet
December 20.....	3.45	5.6	2500	2250
December 21.....	3.95	8.5	3525	4040
December 22.....	2.20	.. .	2000	1580
December 23.....	9.8	11.3	15000	16860
December 24.....	7.05	12.8	12900	17020
December 25.....	4.08	.. .	7450	7920
December 26.....	2.64	3.1	3170	3850
Total for week.....				53500

For the first time since observations have been taken, the floods of the Rillito and Santa Cruz Rivers reached continuously to the Gila River so that much water, otherwise available for irrigation, was lost. However, the quantity of water lost was but a small part

of the total water which fell as rain. The run-off factor at Tucson was much less than 10 percent and much of the floodwater passing Tucson must have been absorbed into the sandy stream beds and the broad flats lying farther west.

WATER SUPPLY IN THE CASA GRANDE—HIGLEY DISTRICT

Groundwater studies in the vicinity of Casa Grande have been started this year, and studies in the Higley district were inaugurated in 1913. These two districts are contiguous and will be investigated jointly as the next main project of this office.

OIL ENGINES

While groundwater studies are of major importance, the most immediate and insistent demand has been for information regarding pumping machinery. The introduction within the past three years of new types of internal-combustion engines designed to burn low-grade distillates of 30° to 45° B. gravity, heavier than kerosene, and much cheaper in cost, has made it necessary to carry on tests to determine whether these engines are adapted to the use of farmers for irrigation and other farm power, and which types can be expected to give the highest economy, the least trouble and the longest life. The results of these investigations have been prepared as a bulletin, which is complete and awaits publication.

The bulletin contains a chapter on the Cost of Pumping for Irrigation. The conclusions of this chapter are:

1. The use of Tops in place of engine distillate decreases the cost of pumping about 30 percent.
2. The cost of pumping on a 40-foot lift, with 4 feet depth of application, varies from \$8 to \$20 per acre per year, according to whether the plant is used much or little. Under the most favorable conditions the cost of pumped water is no greater than the cost of river water.
3. The cost of pumping on a 100-foot lift, with 4 feet depth of application, varies from \$20 to \$40 per acre.
4. The largest item of cost is the fixed charges. In order to reduce these charges, the plant should be used as much as possible. One pumping plant should, if possible, serve two or more ranches.

PUMPS

Two centrifugal pumps were tested in the mechanical laboratory and their characteristic curves were determined over a considerable range of speed and lift and discharge. One of the pumps was a new horizontal single-stage pump purchased for the University Farm. This pump had two outboard ring-oiling bearings, water-sealed gland, vacuum-proof grease cup, non-overloading enclosed impellor, automatic water balance, and was well machined throughout. The other pump was one that had been in service at the Farm and was an ordinary stock pump. The efficiency of the new pump was one-third higher than that of the old pump.

Many new pumps have been put on the market during the past few years, and are being adopted by Arizona irrigators. Some of these pumps are probably well designed and efficient, others are very poor and will result in failure for the people who depend upon them. They all should be subjected to rigorous tests in a hydraulic laboratory in order that their merits may be established. It is the desire and expectation of this department to test the most important new irrigation pumps as soon as the Agriculture Building is ready for occupancy.

A model pumping plant of 500 gallons per minute capacity was installed on a flat car for the Agricultural Demonstration train, and was operated at each place visited by the Train. Desirable features of oil engines and pumps were pointed out and the method of measuring irrigation water was demonstrated.

G. E. P. SMITH, *Irrigation Engineer.*

A. L. ENGER, *Assistant Engineer.*

EDUCATIONAL

College class work in agriculture has continued on about the same basis as during the preceding year. Further development of the courses of instruction must necessarily await the additional facilities which are being provided in the new Agriculture Building. This will be in large part, ready for occupation at the beginning of the college year in September, 1915. With the excellent facilities thus made available, students concerned in the peculiar agriculture of the Southwest will turn naturally to our State University for the special training required for a proper understanding of the unusually technical agriculture of this region.

AGRICULTURAL COURSES OF INSTRUCTION

During the year the agricultural courses previously offered have been maintained, and courses in Horticultural Crops and Plant Production added. Furthermore, this material has been carefully worked over and systematized with a view to securing desirable adaptation to the needs of agricultural students with various post graduate aims in view. To this end a uniform foundation of required subjects in English, mathematics and the sciences has been provided. These subjects are conveniently available within the general University curriculum and, incidentally, offer agricultural students the advantage of association with the general University student body and faculty. This foundation of required subjects amounts to 73 units in the four-year courses.

The second element in the four-year courses consists of seven groups of electives which lead the student, according to his choice, in the direction of agronomy, horticulture, animal husbandry, chemistry, biology, rural engineering, or rural economics and administration. The group electives, therefore, offer an opportunity for the beginning of a specialization which may be continued to advantage after graduation. The group electives amount to 30 units in the four-year courses.

The third element in the four-year agricultural courses is the free electives which, as their name implies, may be chosen freely from

within the agricultural courses available, or from within the general University curriculum. These free electives amount to 31 units in the four-year agricultural courses, which makes a total of 134 required units for graduation.

The systematization of the courses, governed in its application by prerequisite studies, gives a desirable flexibility to the work in agriculture which in this region is exceedingly diverse in its outlook for the graduate student; and offers opportunity either for intensive specialization as rapidly as the student is ready for it, or through the free electives for a broad, general preparation along agricultural lines.

The total number of students taking agriculture remains practically the same as for the two last years, although the actual number of two and four-year students has steadily increased and the standard of work is gradually being improved as additional instructors and facilities become available.

TWO-YEAR COURSES OF INSTRUCTION

The two-year course is still continued although it has been found that in many cases students beginning the two-year course, which is often regarded as a short cut to agricultural proficiency, soon find that they are in need of some one of the much more complete and satisfactory four-year courses of instruction.

Details of attendance are shown in the accompanying table:

ATTENDANCE IN AGRICULTURE FOR TWO AND ONE-HALF YEARS

	1912-1913 1st and 2nd semesters	1913-1914 1st and 2nd semesters	1914-1915 1st semester only
Students in 2 and 4 year courses	26	20	40
Other students electing agricultural classes	27	9	6*
Total students taking agricultural instruct'n	53	38	46
No of classes in agricultural subjects	21	20	12

*Including one science student majoring in agriculture

In this connection it may be stated that it is not the policy of the College of Agriculture to attract additional students from other departments within the institution, but rather to reach out into rural communities of the State for those young men and women whose interests naturally lie along agricultural lines,

The University Farm is being developed in such a way as to afford as much instructional material as possible. A new centrifugal pump of special design has been added to the equipment during the

past year; the dairy has received several accessions; pigs and sheep, in limited number, have been added to the equipment, and the additional tract of land recently leveled and brought under cultivation, has been graded to varying slopes in order to afford means by which the proper gradients for irrigation with small heads of water may be studied.

Increasing use is being made of these facilities, which are expeditiously reached by means of the automobile service installed the previous year.

The Agricultural Club, a student organization, has done much to stimulate interest and maintain *esprit de corps* among the agricultural students within the institution. It is noteworthy that there exists nothing of the feeling of separation and aloofness between the agricultural student body and the University student body at large that is often complained of in other state universities. This is probably due to the fact that the agricultural students are, on the whole, equal in preparation and personnel to those of other general departments within the University.

FARMERS' SHORT COURSE

The Farmers' Short Course continues to be a very popular feature of agricultural instruction afforded on the college campus. At the January, 1914, session, the enrollment increased to 103 names, and a program of lectures on practical topics, together with entertainments and excursions, was afforded which has undoubtedly resulted in much good to those in attendance. The following is a brief table relating to Short Course work during the two years that it has been offered;

Year	Registration	No lectures	Attendance at lectures	No days	Attendance per day (visitors)	Outside visitors	Additional entertainment and excursions	Outside lecturers
1913	80	45	1944	12	123	36	4	1
1914	103	43	1697	10	147	75	8	5

The cost of the Short Course is very small in proportion to the service rendered. With an attendance of over fifty, the railroads afford 1-3 fares for the round trip. The University furnishes room and cots free, requiring only a roll of bedding to be brought by those in attendance. Meals are furnished at cost at the University Dining Hall.

EXTENSION WORK

Extension work for the year, as heretofore, has been in charge of Professor A. M. McOmie, who, in addition to his other duties has found time to plan and conduct an increased program of extension work. The following data are condensed from his report for the year:

THE DEMONSTRATION TRAIN

The Demonstration Train was increased to four cars—the first car containing exhibits of hogs, cattle, and sheep; the second car, fruits, vegetables, and farm crops; and the third car, various items of farm machinery. The fourth car was used as a lecture room.

The exhibits were educational in character, and with the aid of charts and models were used as texts for numerous lectures and explanations delivered by those accompanying the Train. The practical character of these lectures is indicated by the following subjects: "Building an Orchard," "Dry Farming Methods," "Live Stock," "The Pit Silo for the Dry Farmer," "Dairying," "The Culture of Alfalfa," "Orcharding," "Household Helps," "Supplemental Pumping Plants and Dry farming Methods," delivered at points where they were most applicable.

The Demonstration Train, which was furnished and moved without charge through the courtesy of the Santa Fe, Arizona Eastern, Southern Pacific and El Paso & Southwestern railroads, traveled 2722 miles and made 33 stops. Nineteen lecturers were with the Train at different times, and a total attendance of 35,319 men, women and children was recorded. Of this number, 12,306 were school children above the fourth grade and 2437 women attended the lectures for women. In general, increased attendance and interest was shown in this branch of extension work.

FARMERS' INSTITUTES

As in previous years, a portion of the season was devoted to the conduct of Farmers' Institutes. Throughout the Salt River Valley 11 institutes were held, addressed by members of the Station Staff and by other invited speakers. Twenty-four of these institutes were held with a total attendance of 2544.

In the Upper Gila Valley and at San Simon and Duncan the institutes were 6 in number with a total attendance of 410. In the northeastern part of the State, 11 meetings with a total attendance of 1241 were held. In other parts of the State various meetings were

raising the sum-total for institute work in the State for the year to 60 institutes with a total attendance of 12,756 people. It is of interest in this connection to note that the first institute held in Arizona north of the Grand Canyon occurred on July 16 at Fredonia with lectures by Messrs. A. M. McOmie, O. C. Bartlett and C. C. Jacob, in the course of an exploratory expedition in that little-known region.

Gentlemen of the agricultural staff, also, have served at agricultural fairs in the Verde Valley, at Light, in Cochise County, and at the Maricopa County Fair in Phoenix.

FARM ADVISORY WORK

Anticipating farm advisory work under the Smith-Lever fund, Professor Morse visited about 75 farmers in various parts of the State during the year, and Professor McOmie served about 40 Salt River Valley farmers in a similar way. The Boys' and Girls' Club movement was also begun with results indicating a demand for this work. It was possible to care for a very few of these dabs in Salt River Valley, but interesting competitions were initiated.

Under the provisions of the Smith-Lever Act, the extension service has now been formally organized under the superintendency of Professor S. F. Morse.

SUMMARY

The money expended for Demonstration Train, Institute and Farmers' Short Course work during the year has been \$4355.21 from the State, and railroad transportation to the value of \$408.30. This work has been carried into every agricultural district and into every county in the State. Sixty-six sessions were held with the Demonstration Train, 36 one-day institutes were conducted, 4 fairs were attended, 8 special institutes were held and 28 special lectures and demonstrations for women were conducted, making a total of 142 sessions as against 59 sessions of similar character during the previous year.

The attendance may be summarized as follows:

Second Farmers' Demonstration Train	35,319
One-day institutes	5,040
Special institutes	611
One-day institutes at agricultural fairs	7,105
Farm advisory calls	115
Boys' and Girls' Clubs	100
Grand total	<u>48,236</u>
Grand total for previous year	33,700

R. H. FORBES,

Director.

AGRICULTURAL INSTRUCTION EXPENDITURES FOR YEAR ENDING JUNE 30 1914

		Agriculture	Horticulture	Animal Husbandry	Dairying	Totals	
Morrill Fund	Salaries	1150 82	1254 11	104 13	404 14	3213 20	
	Labor			7 02	1 C3	8 65	
	Postage, stat'y, sundry supplies and misc	4 58	4 57	57 25	22 27	68 67	
	Freight, express and travel	9 30	11 66	137 76	157 76	296 48	
	Educational apparatus and books	81 64	54 98	221 03	08 69	402 14	
	Educational supplies	75 13	54 85	1274 55	1316 13	2720 66	
	Buildings and improvements						
	Totals	1321 47	1410 17	2087 74	1020 62		6710 00
Farm Sales Fund	Salaries	403 30	183 30	130 25	166 60	963 45	
	Labor	356 97	346 00	387 63	389 23	1479 83	
	Postage, stat'y, sundry supplies and misc	168 90	157 43	158 69	394 83	878 85	
	Freight, express and travel	252 01	226 33	301 60	111 34	1924 18	
	Educational apparatus and books	70 32	12 06	28 25	182 10	292 73	
	Educational supplies	312 49	246 26	615 08	110 61	1884 44	
	Buildings and improvements	36 25	40 61	13 94	9 86	100 66	
	Totals	1681 14	1212 01	1635 44	2996 57		\$7525 16
Agricultural Instruction Maintenance and Improvement Fund (State)	Salaries	1541 08					
	Labor	3461 67					
	Postage, stat'y, telephone and telegraph	21 60					
	Travel	14 50					
	Freight and express	50 20					
	Tools, implements and machinery	148 00					
	Seeds, plants and sundry supplies	59 61					
	Buildings and land	7018 15					
	Totals	12314 81					\$12314 81