University of Arizona College of Agriculture

Agricultural Experiment Station

Twenty-Ninth Annual Report

For the Year Ending June 30, 1918

(With subsecuent items)

Consisting of reports relating to

Administration,
Agronomy, Botany, Horticulture,
Plant Breeding, Animal Husbandry,
Entomology, Chemistry,
Irrigation Investigations.

Tucson, Arizona, December 31, 1918

GOVERNING BOARD

(Regents of the University)

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His Excellency, The Governor of Arizona

The State Superintendent of Public Instruction

Appointed by the Governor of the State

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Agricultural Staff

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Robert H. Forbes, Ph.D.....Research Specialist
John J. Thornber, A.M.....Botanist
Albert E. Vinson, Ph.D.....Biochemist
George E. P. Smith, B.S., C.E.....Irrigation Engineer
Richard H. Williams, Ph.D.....Animal Husbandman
Walter S. Cunningham, B.S.....Dairy Husbandman
Charles T. Vorhies, Ph.D.....Entomologist
G. E. Thompson, B.S.A.....Agronomist
F. J. Crider, M.S.....Horticulturist
Clifford N. Catlin, A.M.....Assistant Chemist
*Arthur L. Enger, B.S., C.E.....Assistant Irrigation Engineer
Walker E. Bryan, M.S.....Assistant Plant Breeder
C. O. Bond, B.S.A.....Assistant Plant Breeder
W. E. Code, B.S.....Assistant Irrigation Engineer
A. F. Kinnison, B.S.A.....Assistant Horticulturist
R. S. Hawkins, B.S.A.....Assistant Agronomist
Austin W. Morrill, Ph.D.....Consulting Entomologist
D. C. George.....Consulting Plant Pathologist
Leland S. Parke, B.S.....State Leader Boys' and Girls' Clubs
Mary Pritner Lockwood, B.S.....State Leader Home Demonstration Agents
W. M. Cook, A.B.....State Leader County Agricultural Agents
A. B. Ballantyne, B.S.....County Agent, Graham-Greenlee Counties
C. R. Fillerup.....County Agent, Navajo-Apache Counties
De Lore Nichols, B.S.....County Agent, Coconino County
J. R. Sandige, B.S.....County Agent, Gila County
C. R. Adamson, B.S.A.....County Agent, Cochise County
H. C. Heard, B.S.....County Agent, Maricopa County
J. W. Longstreth.....County Agent, Yuma County
Leo L. Laythe, B.S.....County Agent, Pima-Pinal Counties
Agnes A. Hunt.....Assistant State Leader Boys' and Girls' Clubs
Edward B. Oxley, B.S.....County Club Leader, Maricopa County
Hazel Zimmerman.....Home Demonstration Agent, Pima-Pinal Counties
Florence D. Sandige, B.S.....Home Demonstration Agent, Gila County
Amy L. Dinsmore, B.S.....Home Demonstration Agent, Maricopa County
Flossie D. Wills, B.S.....Home Dem. Agent, Graham-Greenlee Counties
Grace I. Tufts.....Home Demonstration Agent, Yuma-Yavapai Counties
Louise Sporléder.....Home Demonstration Agent, Cochise County
Nora Lamoreaux.....Home Demonstration Agent, Apache County

The Experiment Station offices and laboratories are an integral part of the University at Tucson. The Salt River Valley Experiment Station Farm is situated one mile west of Mesa, Arizona. The date palm orchards are three miles south of Tempe (co-operative U. S. D. A.) and one mile southwest of Yuma, Arizona, respectively. The experimental dry-farms are near Cochise and Prescott, Arizona.

Visitors are cordially invited, and correspondence receives careful attention.

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*On leave.

OMISSION

GEORGE F. FREEMAN, Sc.D ....Plant Breeder

Dr. Freeman was head of the Department of Plant Breeding during the period covered by this report, but the report was written after his resignation. His name should also appear on page 321.

LETTER OF TRANSMITTAL

To His Excellency, The Governor of Arizona,
Executive Department, Phoenix, Arizona.

SIR: I have the honor herewith to transmit to you the Twenty-ninth Annual Report of the Arizona Agricultural Experiment Station, of the College of Agriculture, University of Arizona, for the fiscal year ending June 30, 1918.

This report is made in accordance with the Act of Congress, approved March 2, 1887, establishing Agricultural Experiment Stations, and the Act of Congress, approved March 16, 1906, known as the Adams Act.

Faithfully yours,

R. B. VON KLEINSMID,
President.

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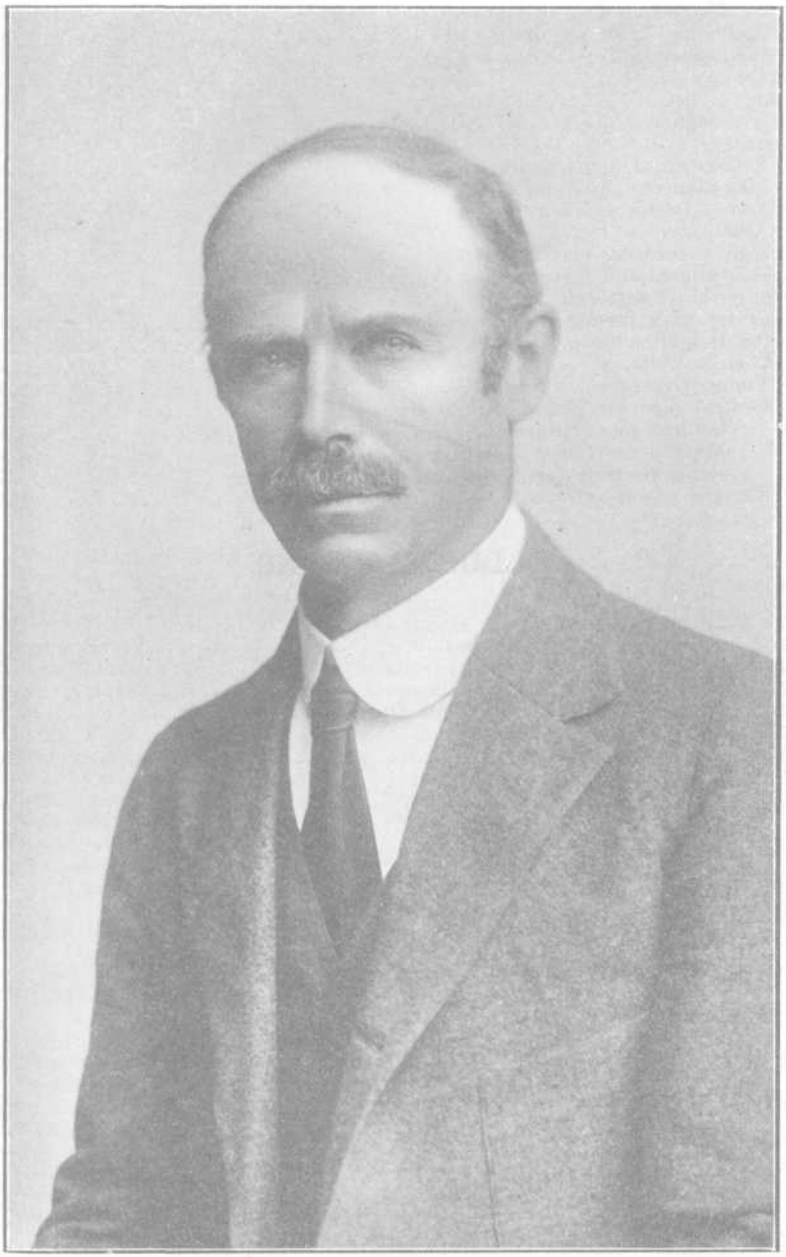
ILLUSTRATIONS



ROBERT HUMPHREY FORBES

Chemist of Experiment Station, September 1, 1894 to May 6, 1899; Director May 6, 1899 to February 15, 1918; Research Specialist, on leave, February 15, 1918,—

Twenty-ninth Annual Report

ADMINISTRATION

The period covered by this report is one of particular interest from an agricultural standpoint for it was during this time that our country was engaged in the war

Never before were farmers and stockmen of Arizona spurred on for increased production as during this time The dire need of food and supplies for domestic consumption, for our troops abroad and for our Allies, made agricultural effort a pleasure from a patriotic standpoint. Prices of agricultural products have never been better

A rapid adaptation to the needs of the war period was effected by those engaged in agricultural production in Arizona. The very definite program of production outlined and advised as a result of the Agricultural Mobilization Conference called by the College of Agriculture of the University of Arizona, and held at Tucson on April 20 and 21, proved to be the guiding plan of the farmers, stockmen, and housewives during the year following

Arizona farmers first set about the production of crops to support local mining industries which were producing war materials. Agricultural and livestock products were also adopted which were in greatest demand under the conditions of war and which were peculiarly adapted to the State In this class came Arizona wool and cotton. Advantage was taken of the double cropping possibilities of southern Arizona districts and a greater utilization of the farming land was secured than ever before

Wheat, the great war crop, has been liberally grown as well as the grain sorghum crops so well adapted to the Southwest for silage and emergency human food Potatoes, beans, fruits, and vegetables have entered largely into the year's agricultural output during the war period.

Livestock, including beef, mutton, dairy products, pork, and poultry products, have been produced in quantity in spite of a continuation of the drouth period which has made feed for livestock scarce and expensive. The loss of livestock upon the range due to shortage of forage has been serious with many and has greatly emphasized the need of better range livestock management and the growth of supplemental feeds and silage

This period of continued drouth has also affected the dry

farmer who is dependent partially or wholly upon rainfall. It has also reduced the amount of storage water and stream flow for irrigation and made greater economy of water necessary.

During the period of this report, the most notable change by farmers and housewives in methods has been in the direction of economy and conservation. Remarkable agricultural achievements mark the period in spite of the handicap of serious labor shortage. Arizona agriculture, thus put to the test under the pressure of war, has achieved results which would have been impossible otherwise. The doing of things in new and better ways by farmers will bring permanent good to our agriculture.

THE AGRICULTURAL EXPERIMENT STATION FARMS

A very complete description of the Experiment Station farms, accompanied by maps of the properties, was published in the Twenty-eighth Annual Report Since that time various minor improvements have been effected but no large developments have taken place, due to the exigencies of war work and numerous changes in the personnel of the Agronomy Department. Cultural operations, as usual, have been pursued on the farms and are reviewed in the report of the Agronomist.

Several of the farms were inspected and reported upon by committees of the Board of Regents. A resume of the reports of these committees follows:

TEMPE COOPERATIVE DATE ORCHARD

This property was visited by Member William Scarlett during the harvest season of 1918. Mr. Scarlett found that no particular improvement in the way of buildings had been made; that the crop of dates had been profitable: and that the farm was becoming able more and more to take care of itself. Certain experiments looking largely toward the production of seed from which dates can be grown were progressing.

The conditions which some time ago threatened the existence of the farm and a large section of the farming community round about, in the rise of the water level of the valley, were being corrected by a drainage ditch and, apparently, that danger had largely passed. The date crop appeared not to have been affected.

SALT RIVER VALLEY FARM

The University Experiment Farm near Mesa also was visited by Mr. Scarlett. He reported that extensive experiments in the growing of peas and beans for fodder and as renewers of the soil

had been carried on in the course of the year. Valuable experiments regarding the spacing of cotton plants had led to conclusions that will be of great benefit to the future cotton industry of the Valley. The people of the Valley more and more had been making use of the farm. Every day numerous telephone calls had been received and visitors averaged three or four daily. The farm was found to be answering more and more the purpose for which it had been created—a demonstration-experiment farm for the Valley. In the course of the year there had been several improvements on the farm. A 120-ton capacity silo had been erected; a new metal grain bin had been installed; new wagon scales purchased, and a small cottage erected. Much new machinery had been bought in the course of the year and the mechanical side of the farm was first class.

The needs of the farm were a central cottage for the foreman, a barn for machinery, and a shed for storing hay. Otherwise, the farm was in excellent condition and numerous experiments of various kinds were going on. It was suggested that all experiments bordering the highway be clearly marked so that people going by might understand exactly what was taking place.

YUMA DATE ORCHARD AND HORTICULTURAL STATION

This property was visited December 14, 1918, by Member Bettie White. Mrs. White reported a marked degree of efficiency in the management of this station. Not only the date orchard, but various other phases of work, such as the winter garden, rotation of crops, etc., showed ability, energy, and foresight. The station was admirably located, having fine Warrenite roads on two sides. The work was proving of great value to the surrounding country as numbers of persons seeking information call at the station almost daily. The improvements were in good condition with the exception of a shed used as a barn. This was reported to be of little value as a means of protection to stock and detracted materially from the otherwise pleasing appearance of the grounds.

The limited acreage seemed unfortunate to the committee, there being but 13 acres in the tract. The purchase of additional land was recommended.

THE SULPHUR SPRING VALLEY DRY-FARM

This farm was also visited by Member White December 21, 1918. Seventy of the 160 acres were found in cultivation. All land provements were found to include a comfortable, seven-roomed was enclosed with barbed wire and rabbit-proof fences. The im-

residence and other necessary farm buildings; a well, equipped with a splendid pump and pump house; two silos of 47 tons capacity each, one built in 1916, the other in 1918. The farm was well equipped with stock and implements. Tests were being made in growing wheat, barley, oats, and sweet clover. About three acres were in orchard, 3 years old, containing apples, pears, peaches, apricots, nectarines, and six varieties of grapes. The culture of tepary beans was found to be, perhaps, the most successful test that has been made on the farm. This crop was planted July, 1916, harvested October, 1916, and yielded a net profit of $37.89 per acre. Mr. Spaulding, who had been on the farm about three years, informed the committee that thus far no experiments in dry-farming, unaided by some irrigation, had proved sufficiently profitable to warrant advising prospective farmers to rely on dry-farming as a means of support; however, he called attention to the fact that the well on the farm was only 100 feet deep and had been drilled to the third stratum of water. The supply of water was sufficient for domestic purposes and with the rainfall would irrigate ten acres.

The number of visitors at this farm was limited. This was believed to be due to two facts; the thinly populated section in which the farm is located and the narrow limits within which experiments have been carried on.

On both the Yuma Date Orchard and the Sulphur Spring Valley Dry-farm failures as well as successes had been met in experimental work. This was forcibly illustrated by an immense date palm in the Yuma Orchard. The tree was large and laden with fruit, but the quality rendered is of no value. In closing, the committee reported:

We believe that failures demonstrate facts of as much value as the successful work. The "danger signal" is as necessary as the "sign board" that points to the path of safety; hence, we consider the work on the experimental farms, under efficient management, of inestimable value and believe the money thus spent by the State is a wise investment.

PERSONNEL

The Administration and Staff of the Experiment Station has suffered numerous changes during the fiscal year. Director R. H. Forbes, after more than twenty years efficient and devoted service as Chemist, Director of the Agricultural Experiment Station, and Dean of the College of Agriculture, has been appointed Research Specialist on leave so that his wide experience and exact knowledge

of semi-arid, subtropical agriculture might be made available to one of our Allies. Director Forbes has taken charge of experimental work for the Société Sultanienne D'Agriculture at Cairo, Egypt. Without doubt this cooperation between two countries with almost identical cultural conditions will result in great mutual benefit.

Following the resignation of Director Forbes, the President of the University assumed the duties of Dean and Director of the College of Agriculture.

The Department of Agronomy has lost Mr. H. C. Heard, Assistant Agronomist, who has conducted the work of the department since the resignation of Dr. Macfarlane. Mr. Heard has been appointed County Agricultural Agent for Maricopa County. In May Professor G. E. Thompson was appointed Agronomist in charge of the department. The Department of Horticulture has lost Mr. S. B. Johnson, Assistant Horticulturist, who has entered commercial work. June 1 Professor F. J. Crider, Horticulturist, took charge of the department..

Minor changes have taken place in other departments and at several of the Experiment Station farms. Mr. H. E. Webber, assistant in Plant Breeding, resigned to enter military service, and Mr. C. O. Bond has been appointed to the position. Mr. C. R. Adamson, assistant in Animal Husbandry, has resigned to become County Agricultural Agent for Cochise County. After the resignation of Mr. F. H. Simmons, foreman of the Tempe Date Orchard, Mr. W. O. Hodgson was placed in charge to market the crop. Mr. G. F. Williams succeeded Mr. Hodgson in this position when Mr. Hodgson was appointed foreman of the University Farm at Tucson, left vacant by the resignation of Mr. J B. McGuffin. This position he later resigned to enter Y. M C. A. war work. Mr. G. J. Darling succeeded as foreman of the University Farm. At the Prescott Dry-Farm, Mr. T. F. Wilcox was appointed foreman Changes in the personnel of the Extension Service are noted in the report of the Director.

PUBLICATIONS

Publications by the Experiment Station Staff for the year, including Annual Reports, Bulletins, Timely Hints for Farmers, and Scientific and Technical Papers are as follows:

Bulletin 81, November 15, 1917. How to Combat Rabbits, Gophers, Prairie Dogs, Coyotes, Ants, and Grasshoppers —By Arthur L. Paschall

Bulletin 82, December 1, 1917. Johnson Grass Control. —By H C. Heard

Bulletin 83, December 20, 1917. Poisonous Animals of the Desert.
—By Charles T. Vorhies
Twenty-eighth Annual Report, December 31, 1917. —By the Station Staff
Bulletin 84, February 1, 1918. Dry-Farming in Arizona
—By A. M. McOmie and Others
Bulletin 85, March 1, 1918. A Study of Marketing Conditions in the Salt River Valley. —By J. H. Collins

Timely Hints for Farmers:

No. 127. July 15, 1917. Raising Dairy Calves. —By W. S. Cunningham
No. 128. August 15, 1917. Head Lettuce Growing in Southern Arizona.
—By S. B. Johnson
No. 129. September 15, 1917. Curing Meat on the Farm.
—By R. H. Williams
No. 130. October 15, 1917. How Much Seed to Sow. —By S. B. Johnson
No. 131. November 15, 1917. Sanitary Water Supply for the Home.
—By J. J. Thornber
No. 132. December 15, 1917. Hairy Peruvian Alfalfa. —By W. E. Bryan
No. 133. January 1, 1918. A Little Farm Well-Tilled. —By R. H. Forbes
No. 134. January 15, 1918. Unproductive Soils, Their Cause and Management.
—By A. E. Vinson
No. 135. February 1, 1918. Soapweed or Palmilla (*Yucca elata*) as Emergency Forage. —By J. J. Thornber

Scientific and Technical Papers:

Notes on the Fauna of Great Salt Lake.
American Naturalist, August, 1917. —By Charles T. Vorhies
Grading Land for Furrow Irrigation. Western Engineering, IX, 1 Jan. 1918.
—By G. E. P. Smith

PROJECTS

The projects listed in the Twenty-eighth Annual Report for the year 1917-1918 have been continued, or completed and several new projects have been approved. The list of projects approved for the year 1918-1919 follows.

1. Groundwater supplies and pump irrigation in the Casa Grande Valley.
State fund. G. E. P. SMITH.

2. A study of pumping machinery to determine fundamental facts relating to the action and efficiency of various types of pumping machinery.
Adams fund. G. E. P. SMITH.

3. The relation of evaporation rate to the duty of water; and the study of the factors controlling evaporation.
Adams fund. G. E. P. SMITH.

4 A study of the culture and management of date orchards with special reference to the improvement of the yield and quality of the fruit and the rooting of offshoots.
State fund. F. J. CRIDER.

5. A study of the cultural methods with citrus fruits.
Hatch fund. F. J. CRIDER.

6. A study of the effect of different methods of orchard management on the growth, yield, and size of the fruit of the olive.
Hatch fund. F. J. CRIDER.

7. A study of conditions affecting the production of fall Irish potatoes in southern Arizona.
State Horticultural and Hatch funds. F. J. CRIDER.

8. A study of spinach as a market garden crop for southern Arizona.
State Horticultural fund. F. J. CRIDER.

9. A study of cultural and storage methods of the sweet potato.
State and Hatch funds. F. J. CRIDER.

10. Miscellaneous horticultural studies including stone fruits, citrus fruits, vine fruits, small fruits, pomes, nuts, nursery stock, ornamentals, vegetables, etc.
State and University of Arizona Maintenance funds. F. J. CRIDER.

11. Student practice garden and greenhouse laboratory, University Campus.
State Maintenance fund F. J. CRIDER.

12. An intensive quarter acre garden plat at Yuma Experiment Farm.
State Horticultural fund. F. J. CRIDER.

13. The same as Project 9. At Cochise Dry-Farm
Cochise Dry-Farm and General Farm fund. F. J. CRIDER.

14. The same as Project 9. At Prescott Dry-Farm.
Prescott Dry-Farm and General Dry-Farm fund. F. J. CRIDER.

15. The production by plant breeding methods of a superior variety of alfalfa, free, if possible, from the hairiness and stemmy character of Peruvian alfalfa. Methods of determining the water requirements of different varieties of alfalfa; and the biological analysis of alfalfa into its hereditary units with manipulation of these units in constructive breeding, is within the scope of this study.
Adams, State Plant Introduction and Breeding funds. W. E. BRYAN.

16. The hybridization and selection for Arizona conditions of a superior grain sorghum combining, if possible, the following characters: large, upright head; uniform ripening; upright stalk; dwarf habit; earliness; drought resistance; and large individual grains.
State Plant Introduction and Breeding fund. W. E. BRYAN.

17. A physiological and biological study of southwestern varieties of Indian corn to determine heat and drought resistant characters; and biological analysis of these corns with a view to the use of hereditary characters in constructive plant breeding operations.
Adams fund. W. E. BRYAN.

18. The biological analysis of the genus Phaseolus and the improvement of varieties of beans by selective breeding. This project includes the improvement of Tepary beans.
Adams, and State Plant Introduction and Breeding funds. W. E. BRYAN.

19. A study and comparison of durum, poulard, and bread wheats with biological analysis and constructive breeding operations for the purpose of developing a bread wheat which will retain its hardness under southwestern conditions.
Adams, and State Plant Introduction and Breeding funds. W. E. BRYAN.

20. The production by crossing, selection, and inbreeding of Deglet Noor dates which will be of high quality and ripen naturally under Arizonan conditions.
State Date Orchard funds. W. E. BRYAN.

21. Study of rodent control on grazing ranges.
Adams fund. C. T. VORHIES.

22. Development of a collection of economic insects.
Hatch fund. C. T. VORHIES.

23. Economic study of grasses and grass-like plants.
Hatch fund. J. J. THORNBER.

24. Botanical and economical study of poison range plants.
Hatch fund. J. J. THORNBER.

25. A study of range grass improvement through fencing.
Hatch fund. J. J. THORNBER.

26. Tamarisks for growing in alkaline soils.
Hatch, and State Plant Introduction funds. J. J. THORNBER.

27. A study of certain mulberries with reference to fruit production, the quality of fruit and its possible use in the home or in the yard.
Hatch, and Plant Introduction and Breeding funds. J. J. THORNBER.

28. To determine the practicability of growing pistach trees and nut trees in the Southwest.
Hatch, and Plant Introduction and Breeding funds. J. J. THORNBER.

29. Native wild fruits and nuts as stock for grafting purposes.
Hatch, and Plant Introduction and Breeding funds. J. J. THORNBER.

30. Experiments in the growing of jujube nuts under our conditions.
Hatch, and Plant Introduction and Breeding funds. J. J. THORNBER.

31. A study of trees and shrubs suitable for ornamentation, wind-break, and shade at the following locations:
(a) Prescott Dry-Farm, Prescott.
(b) Cochise Dry-Farm, Cochise.
(c) Tempe Date Palm Orchard, Tempe.
(d) University Farm, Tucson
Hatch fund. J. J. THORNBER.

32. Identification and studies of the life histories of certain fungi causing rot in date fruits.
Adams fund. J. G. BROWN.

33. Feeding dry farm silage to range cattle to study the effectiveness of this ration for carrying cattle over short range
Hatch fund. R. H. WILLIAMS
W. S. CUNNINGHAM

34. Economic combinations of high and low-priced feeds for meat production.
Hatch fund. R. H. WILLIAMS
W. S. CUNNINGHAM

35. A study of livestock management on the range; the present status of livestock production on the range.
Hatch fund. R. H. WILLIAMS,
W. S. CUNNINGHAM.

36. Systems of livestock farming; the coordination of livestock farming into units best suited for results, including: (1) Sheep raising on irrigated farms in Arizona; (2) Hog raising on Arizona farms; (3) A combination of hogs, beef cattle, and poultry on irrigated land; (4) Special cattle and sheep feeding operations.
Salt River Valley Farm Maintenance fund. R. H. WILLIAMS,
W. S. CUNNINGHAM.

37. Lambing ewes on irrigated farms; to ascertain the ration best suited for feeding range ewes during the lambing period in irrigated valleys.
Salt River Valley Farm Maintenance fund. R. H. WILLIAMS,
W. S. CUNNINGHAM.

38. Supplements to silage for wintering range cattle at the Cochise Dry-Farm. Cochise Dry-Farm fund. R. H. WILLIAMS,
W. S. CUNNINGHAM.

39. Cooperative crop experiments on farmers' lands, dry-farming fund.
G. E. THOMPSON.

40. A continuation of study at the Sulphur Spring Valley Dry-Farm.
Sulphur Spring Valley Dry-Farm fund. G. E. THOMPSON.

41. A continuation of study at the Prescott Dry-Farm.
General Dry-Farm and Prescott Dry-Farm funds G. E. THOMPSON,

42. A study of culture and varieties of legumes adapted to southwestern conditions.
Salt River Valley Farm and Hatch funds. G. E. THOMPSON,

43. A study of the varieties and methods of culture of Indian corn and the various sorghums.
Salt River Valley Farm and Hatch funds. G. E. THOMPSON,

44. The culture and field management of Egyptian cotton.
Salt River Valley Farm, Yuma Date Orchard, and Hatch funds.
G. E. THOMPSON.

45. The culture and management of winter and spring grains, including wheat, oats, and barley.
Salt River Valley Farm and Hatch funds. G. E. THOMPSON.

46 Effect of dynamiting field soil on field crops.
General Dry-Farm fund. G. E. THOMPSON.

47. A varietal and cultural test of grain and forage crops and of grasses and miscellaneous crops.
Salt River Valley Farm fund. G. E. THOMPSON.

48. Grasshopper control.
Hatch fund. A. W. MORRILL.

49. Cotton square stainer or tarnished plant bug control.
Hatch fund. A. W. MORRILL.

50. Ozonium root disease of cotton and other crops. Occurrence, life history, and methods of control of the disease.
Adams fund. D. C. GEORGE.

51. Gummosis of stone fruit trees. Occurrence, causes and methods of control of this disease.
Hatch fund. D. C. GEORGE,

52 Effect of weather conditions on processing and pasteurizing dates.
State, Hatch, and Date Orchard Sales funds. A. E. VINSON, C. N. CATLIN.

53. Alkali soil studies. Concomitant soil conditions that affect the toxicity of black alkali and means for the amelioration of the effects of alkali on soil and plant.
Adams fund. A. E. VINSON, C. N. CATLIN.

54. Miscellaneous routine chemical analyses.
Adams fund. A. E. VINSON, C. N. CATLIN.

55. Reclamation of alkali land at the University Farm.
University Farm Maintenance Fund A. E. VINSON, C. N. CATLIN

56. Meteorological observations.
Hatch funds. C. N. CATLIN,

FINANCIAL

Increased costs incident to our entering the war have necessitated extreme economy and the curtailment of much work that had been planned. The resources of the Station for the fiscal year, 1918-1919, remain the same as reported in the Twenty-eighth Annual Report for the biennium beginning July 1, 1917, as follows:

College of Agriculture and Experiment Station	1917-18	1918-19
Instruction	$ 3,650.00 i.	$ 3,650.00 i.
Administration	7,500.00 i.r.	7,500.00 i.r.
Improvements	5,450.00 i.r.	5,450.00 i.r.
Greenhouse for agriculture		2,500.00 i.r.
Extension Service (not Smith-Lever)	1,000.00 e	1,000.00 e
" " (with " ")	4,574.59 e	6,004.15 e
University of Arizona Farm—Maintenance	11,850.00 i.	11,850.00 i.
" " " " —Improvements	2,300 00 i.	2,300.00 i.
Dry-Farming Investigations—Maintenance	10,140.00 r.	10,140.00 r.
" " —Improvements	500.00 r.	
Plant Introduction and Breeding Investigations	3,000.00 r.	3,000.00 r.
Tempe Date Orchard—Maintenance	2,330.00 r.	1,770.00 r.
" " " —Improvements	600.00 r.	600.00 r.
Underflow Investigations	2,400.00 r.	2,400.00 r.
Yuma Date Orchard and Horticultural Station —Maintenance	2,600.00 r.	2,600.00 r.
—Improvements	675.00 r.	400.00 r.
Salt River Valley Farm Fund—Maintenance	10,000.00 r.	10,000.00 r.
Agricultural Printing	4,000.00 i.r.	4,000.00 i.r.
Total	$72,569 59	$75,164.15

Those items marked *i* are intended primarily for instructional purposes; those marked *r* are intended for the research work of the station; while those marked *e* are for extension purposes.

Available resources for the year ending June 30, 1918, are as follows:

Hatch Fund from U. S. Treasury		$15,000.00
Adams Fund from U. S. Treasury		$15,000.00
Sales funds 1917-1918 as follows:		
Salt River Valley Farm		$ 9,768.66
Yuma Date Orchard		1,153.79
Tempe Date Orchard		4,860.45
Prescott Dry-Farm		294.50
Sulphur Spring Valley Dry-Farm		73.57
Northern Arizona Dry-Farm		25.50
Hatch Sales Balance 1916-17	$2,609.01	
" " Collections	2,518.99	5,128.00
Dry-Farming Fund (Supervision)	$ 3,000.00	
" " (Prescott)	3,690.00	
Date Palm Orchards	2,630.00	
Yuma Horticultural Station	3,275.00	
Salt River Valley Farm	10,000.00	
Underflow Water Investigation	2,400.00	
Sulphur Spring Valley Dry-Farm	3,700.00	
Maintenance	11,150.00	
Plant Introduction and Breeding	3,000.00	
Printing	4,000.00	46,845.00
		$98,149.47

EXPENDITURES BY FUNDS AND SCHEDULES FOR THE YEAR ENDING JUNE 30, 1918

Abstract	State appropriations	Sales fund	Hatch fund	Adams fund	Total
Salaries	$14,243.36	$ 1,838.91	$11,192.81	$11,940.59	$39,215.67
Labor	10,009.00	9,749.54	133.17	749.39	20,641.10
Publications	3,986.55	173.89	1,051.51		5,211.95
Postage and stationery	340.96	956.83	765.51	79.80	2,143.10
Freight and express	238.14	337.45	71.47	333.85	980.91
Heat, light, water, and power	301.40	183.80	1,073.17		1,558.37
Chemicals and laboratory supplies	.76	25.10		125.62	151.48
Seeds, plants, and sundry supplies	1,035.11	1,242.56	96.41	146.89	2,520.97
Fertilizers	584.61	75.38			659.99
Feeding stuffs	103.70	220.39		40.92	365.01
Library		10.95	138.70	10.23	159.88
Tools, machinery, and appliances	3,333.20	1,089.74	12.25	73.46	4,508.65
Furniture and fixtures	11.80	65.75	23.99		101.54
Scientific apparatus and specimens	36.50	17.50		882.53	936.53
Livestock		675.00			675.00
Traveling expenses	2,598.99	1,211.00	441.01	607.72	4,858.72
Contingent expenses	242.33	63.09			305.42
Buildings and land	2,872.62	2,297.98		9.00	5,179.60
	$39,939.03	$20,234.86	$15,000.00	$15,000.00	$90,173.89

A. E. VINSON,

AGRONOMY

During the fiscal year ending June 30, 1918, experimental work in Agronomy has been carried on the Salt River Valley Farm near Mesa, on the Prescott Dry-Farm near Prescott, on the Cochise Dry-Farm near Cochise, and on the grounds of the Yuma Date Orchard and Horticultural Station. Demonstration work along agronomic lines on plats used for teaching purposes has been carried on the University Farm near Tucson.

SALT RIVER VALLEY FARM

The experimental work with Johnson grass reported upon in the Twenty-eighth Annual Report has been completed and results summarized and published in Bulletin No. 84 by Professor H. C. Heard. During the year covered by this report the work of the Salt River Valley Farm has been more varied than in previous years. Corn, long staple cotton, wheat, oats, barley, kafir, milo, hegari, darso, sumac sorghum, feterita, Sudan grass, alfalfa, cowpeas, soy beans, velvet beans, field peas, and several varieties of table beans have been among the crops tested. In order to handle this large variety of crops it has been necessary to double crop a considerable portion of the land of the experiment farm. Practically all of the acreage given to wheat during the winter and spring was planted during the early summer to some one or more of the various legumes mentioned above. A small portion of the wheat and barley land was planted to kafir, milo, and other sorghum crops. We realize that such a system of double cropping means a severe drain upon the soil fertility, and provision has been made to maintain the soil in good tilth and in a fertile condition by plowing under green manure and by rotating the crops in a careful manner. Some long time experiments covering this feature are now being arranged, which in course of time will become valuable demonstrations for the Salt River Valley and the State at large.

During the season covered by this report one difficulty of unusual severity has been encountered. This difficulty was the extremely destructive work of the lesser corn stalk borer. Practically every variety of beans planted on the experiment farm during the season was destroyed by this insect. Most of the varieties of cowpeas were attacked to a lesser degree. All of the sorghums were injured and in some cases the stand materially lessened. Apparently due to the weakening of the stalks, a considerable portion of the milo fell down and lodged badly just previous to harvest

time. Examination of the stalks that had fallen down showed that in nearly every case these stalks had been injured by the lesser corn stalk borer when the plants were small.

Unless a practical method of controlling this insect can be worked out soon it promises to become a serious menace.

LEGUMES

With the exception of tests made with cowpeas previous trials with annual legumes have resulted largely in negative results. As a basis for further work 17 varieties of cow peas and the same number of soy beans were tested on plots of ground ranging in size from 1/20 acre to 1 acre. These varieties were as follows:

COW PEAS	SOY BEANS
Brabham	Mammoth Yellow
Groit	Virginia
White Crowder	Arlington
Brown Crowder	Chiquita
Wonderful	Manchu
Early Ramshorn	Biloxi
Potomac	Peking
Arlington	Early Brown
Monetta	Tarheel Black
Early Buff	Lot 3 Manchuria
Early Catjang	Hollybrook Early
Two Crop Clay	Fancy Yellow
Clay	Ito San
Blackeye	Wilson Early
Cream	Wilson No. 5
Red Ripper	Tokio
Taylor	Blackeyebrow

Careful observation throut the growing season and at harvest time indicates that the soy beans are decidedly inferior in value to the cow peas for the conditions of the Salt River Valley. Altho some varieties of the soy beans made a creditable growth practically every variety produced an inferior quality of beans. The beans shrivelled badly and for the most part are unmarketable. It is possible that this shrivelling is due to the very dry atmosphere, since the ground was kept in first class condition thruout the time that the soy beans were growing and maturing. The three varieties of soy beans giving most promise this year are the Biloxi which is a rather large late growing and upright variety, the Wilson No. 5 which is a medium sized and medium early maturing variety but which has the disadvantage of shattering rather badly, and the Ito San. The latter is a small, early maturing variety but one of the few that produced a good quality of beans.

Of the cow pea varieties a number gave indications of being valuable and profitable under average farm conditions of the Salt River Valley. Groit and Brabham cow peas planted after wheat both produced an excellent green manure crop. Groit produced the most seed but Brabham has a little advantage from the green manure standpoint. The Red Ripper variety, tried under a number of conditions, was uniformly good. Two Crop Clay was very promising and a considerable number of other varieties are worthy of further trial. The results secured this year with cow peas would indicate that this crop can be used successfully as a green manuring

Fig. 2. Cow peas—Salt River Valley Farm.

crop following wheat. It is quick enough in growth to allow fall planting and working of the ground to a good seed bed in time for reseeding to wheat or other small grains.

Inoculation tests were made with both cow peas and soy beans. Further tests are necessary, however, before we are justified in publishing the results.

FIELD PEAS

A limited number of field peas were planted in the fall of 1917 and harvested in the spring of 1918. The variety called Warsaur

proved best. It made a good vine growth and also produced seed of marketable quality.

VELVET BEANS

The following varieties of velvet beans were planted on June 14: Early Bird, Yokohama, One Hundred Day, Chinese White, and Osceola. A study of these varieties during the growing season indicated that the Early Bird and One Hundred Day were two names for the same variety. The Chinese White variety failed to make a satisfactory stand and was plowed up. The Yokohama made a poor stand but the few plants that did germinate grew well. The Osceola is a promising variety, and deserves further trial. The results indicate that velvet beans should be planted earlier in the season.

TABLE BEANS

The following varieties of table beans were planted on a field scale: Pinto, Bates, Tepary, and Pink. As mentioned earlier in this report every one of them was severely injured by the lesser corn stalk borer. The only varieties that were not plowed up due to this injury were the Teparies and the Pintos. As was proven later, the Pintos were so badly damaged that they should have been plowed up and the yield of Teparies was probably reduced 60 per-cent. Of all the varieties of table beans tested this year, Teparies were the most promising and they were far from satisfactory.

ALFALFA

There are 26 acres in the Salt River Valley Farm now given over to the growing of alfalfa. Ten of these will be plowed up this winter. This alfalfa has been handled principally as a commercial crop. Its effect in smothering out Johnson grass is being noted, and it is our purpose a little later to grow pure Hairy Peruvian seed for distribution.

CORN

During the season of 1918 all varieties of corn tested were planted after wheat or other small grain, plantings being made the latter part of July. The varieties tested were as follows: Mexican June, Sacaton June, Hammond's Select, Reid's Yellow Dent, Giant Red Cob, Giant White Two Ear, Hasting's Prolific, Frazee's Prolific, Mosby's Prolific, Improved Leaming, and a special unnamed variety the seed of which was secured from Mexico.

Due to some unusual and, so far as we are concerned, un-

explainable condition not one of these varieties was satisfactory this year. The complaint was general thruout the Salt River Valley that it was a poor corn season. The best of the varieties were those planted from carefully selected strains of Mexican June corn. None of the large late growing varieties, such as Giant Red Cob, Giant White Two Ear, etc., were worth while. The Frazee's Prolific, which was sent to us with very high recommendations, proved no better than the others and inferior to Mexican June. The year's results as well as previous results secured would indicate that various varieties of sorghums properly handled are more profitable than corn under the conditions of the Salt River Valley.

SORGHUMS

The variety tests of sorghums were incomplete yet very promising. Of the grain sorghums the varieties tested were dwarf milo, hegari, feterita, kafir, and a variety developed by the Oklahoma Station called "darso." This latter variety has been recommended for a combined grain and forage crop, but this season's results indicate that it is inferior to milo, hegari, or kafir from the grain standpoint, and inferior to kafir, hegari, or sumac sorghum from the fodder standpoint. The only variety of forage sorghum tested was the sumac variety and as the seed was purchased locally the variety was badly mixed and, while promising, the results are not conclusive Hegari yielded 65 bushels per acre, and kafir 40. The milo averaged 72 bushels per acre. The milo and hegari are quick to mature, and were fully ripened some little time before frost. The kafir was somewhat immature when frosted the last of October. The hegari stands up well. The grain is produced on a straight neck while the milo grain is produced on a crooked neck, and this gives a decided advantage to the hegari.

WHEAT

Wheats grown on the Salt River Valley Farm yielded well and were very profitable crops. The Early Baart variety averaged 45 bushels per acre. The principal acreage was devoted to this variety. Various tests as to rate of seeding, date of seeding and quantity of water applied were conducted with this variety, but it seems inadvisable to publish the results until the figures for several years have accumulated. Club wheat made a good yield, but was badly mixed and considerably affected by smut, and of inferior baking quality to the Early Baart. Red Turkey yielded well, being a close second to

Early Baart. Two varieties of macaroni gave very excellent yields but under present conditions there is no established market for this variety in the Salt River Valley and it is not advisable to plant this variety generally at the present time. Sonora wheat proved reasonably good, but the quality of grain was inferior to Early Baart and the yield was also less.

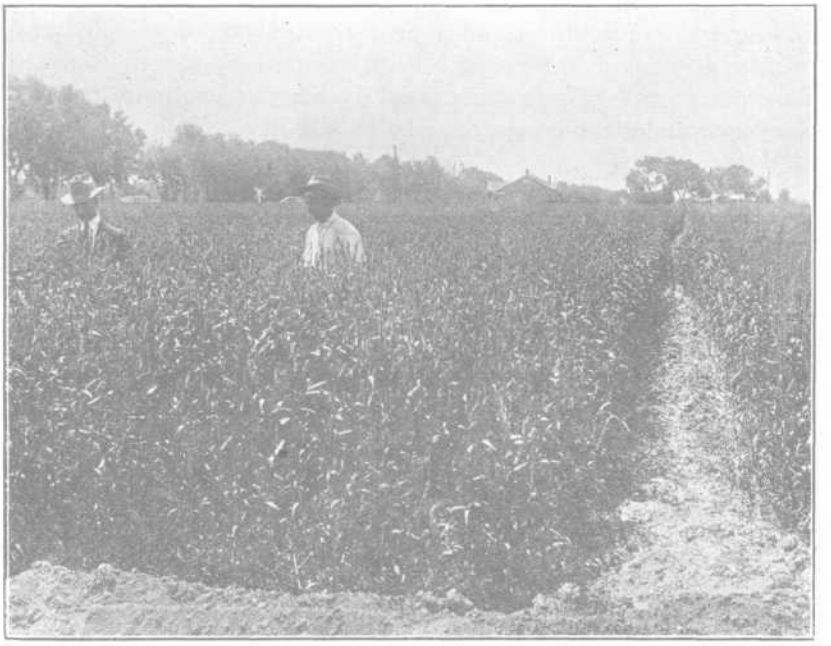


Fig. 3. Club wheat and Early Baart wheat—Salt River Valley Farm

OATS

Two varieties of oats were grown on a commercial basis. The varieties were San Saba, and Red Texas. Red Texas proved the best, the yield ranging between 90 and 95 bushels per acre.

BARLEY

Two varieties of barley were grown, namely, Common Six Row, and Wisconsin Pedigree No. 6. The latter variety produced a heavy yield of grain but the straw just below the head was very weak and many of the heads broke off and fell to the ground before harvest time. Consequently the yield secured was less than on the Common Six Row barley. This is a common fault of the Wisconsin No. 6 barley in this section of the country, and apparently will

eliminate it as a commercial crop. The yield of Common Six Row barley averaged 66 bushels per acre, thus making a very profitable and satisfactory small grain crop.

COTTON

No short staple cotton was grown. Nineteen acres were given over to the growing of Egyptian long staple of the Pima variety. One acre of this was volunteer, that is, it was allowed to grow from the stubs of the previous year's planting. This acre looked very promising during the growing season, producing the first blossoms and open bolls of any cotton on the farm. However, examination of the plants at picking time showed that a considerable number of bolls were moldy or rotten. The fiber is weak and short, and the percentage of lint to seed is small. This year's results would indicate that it is decidedly unprofitable to grow volunteer cotton. Rate of thinning experiments were conducted, also date of planting experiments.

MISCELLANEOUS CROPS

A number of miscellaneous crops were tried on a small scale during the year. These crops include flax, buckwheat, castor beans, rye, rape, and kale. Two or three varieties of flax gave considerable promise. The buckwheat would be considered a complete failure. The castor beans, altho planted late, made an extremely vigorous growth and produced considerable seed. Rye was less valuable than either oats or barley.

PRESCOTT DRY-FARM

The fall of 1917 was extremely dry and it was impracticable to plow the various fields of the Prescott Dry-Farm. Thus the spring planted crops of 1918 were started under a serious handicap. The growing season of 1918 proved less favorable than for a number of years preceding. However, creditable silage yields were secured from Club Top sorghum, darso, kafir, and milo, also from a number of varieties of corn. The grain yields of all were very light and most of the varieties were harvested for silage purposes. A total of 125 tons of silage was secured. Tests with potatoes this year proved a failure. Likewise Canada field peas were a failure and the results secured with beans were of mediocre value.

A considerable number of sweet clover plantings made at intervals of two weeks failed to germinate uniformly, and no results worth while were secured from them. Sudan grass again proved

one of the most promising crops of the farm. Two cuttings of hay were secured and a reasonable seed crop, estimated at 450 pounds per acre was harvested. The season's results substantiate the results of previous years, in that a careful farmer, who is prepared to handle livestock, can grow profitably sufficient forage and silage crops to take care of a reasonable sized herd of livestock, and by this means he will be able to make a good living from a farm of ordinary size.

Fig. 4. Papago sweet corn—Prescott Dry Farm

SULPHUR SPRING VALLEY DRY-FARM

The season of 1918 in Sulphur Spring Valley was extremely dry and followed the dry season of 1917, consequently there was no reserve moisture in the soil. Practically every crop planted under strictly dry land conditions on the experiment farm proved a total failure. The same conditions prevail on the privately owned farms thruout the valleys. Various crops planted with supplemental irrigation gave reasonable yields. Among them may be mentioned kafir, Freed's sorghum, Sudan grass, and cow peas. Soy beans were not satisfactory. Velvet beans made considerable growth, but it is doubtful if they will prove worth while. One plot of sweet clover planted in 1917 made a reasonable growth and a small amount of seed. Yields of wheat, oats, and barley were extremely light. Mexican June corn planted in the early season without irrigation had sufficient moisture to germinate and while it lived thruout the season, at harvest time in the fall much of it was not above 3 feet in height, and the silage yield from the best of it was only

3300 pounds per acre. It did not pay for the time and labor expended on it.

It is planned to change the cropping system on this farm somewhat, omitting the growing of much corn or small grains and depending mainly upon certain of the quickest maturing and most drought resistant sorghums for silage purposes, maintaining the fertility of the soil by the use of legumes plowed under as green manure. Some experiments will be carried to determine the legumes most satisfactory for this purpose, but unless others are found which prove good, tepary beans and cow peas will be used

During the season the Giant Powder Company of Los Angeles furnished dynamite and a supervisor for the work, and one acre of ground was dynamited for the purpose of breaking up the hard strata of subsoil called caliche. This dynamiting was done on 15 feet centers in holes from 2½ to 3½ feet deep, varying with the depth of the caliche, and using one-half stick of dynamite in each hole. It is planned to grow the same crop on this dynamited acre and on an undynamited adjoining acre for a period of three years, comparing the yields of the dynamited and undynamited area. Freed's sorghum was planted for this purpose this year, but due to the dry season neither area made a growth sufficient to be harvested.

YUMA DATE ORCHARD AND HORTICULTURAL STATION

A limited amount of experimental work was carried on the Yuma Date Orchard and Horticultural Station. The following varieties of sorghums were tested following wheat: Dwarf milo, hegari, kafir, feterita, Sumac sorghum, Collier sorghum, Honey Drip, and White African. Every one of these varieties made a first class growth. The milo made an excellent grain yield and, as was the case in the Salt River Valley, the hegari was the most promising of any grain sorghum. Of the sweet sorghums Honey Drip made a very heavy growth of forage of good quality and was perhaps the best. Sumac sorghum ranked second altho it fell down rather badly.

Some plantings of flax gave considerable promise and will be carried further next year. Two varieties of buckwheat made a small growth but from the practical standpoint were without value. A most excellent green manure crop of tepary beans was grown. A considerable number of vetch varieties were planted in the fall of

1918 Likewise a small area of five different varieties of root crops was tested during the winter of 1918 and 1919, but the results from these crops were not satisfactory

UNIVERSITY FARM

No regular experimental work was carried on the University Farm, but some demonstration work was conducted and all crops grown upon the farm were utilized for teaching purposes. Several varieties of cotton, several varieties of sorghum, and a few of corn were grown. Cow peas, soy beans, peanuts, hemp, and various other crops were grown on small areas of ground.

ACKNOWLEDGMENT

The experiments with winter grains reported above were outlined and planted under the direction of Dr. R. H. Forbes and Professor H. C. Heard. The summer crop plantings were outlined and planted under the direction of the present agronomist, Dr. Forbes having gone to Egypt, in the service of the British government, in February of the present year, and Professor Heard having left the University to take up County Agricultural work June 1, The present agronomist began work with the Arizona Experiment Station on May 1, 1918.

G. E THOMPSON,
Agronomist.

BOTANY

WEATHER CONDITIONS AND THE GRAZING RANGE

Due both to the shortage and untimely distribution of rainfall, the year ending with June 30, 1918, was a very serious one for the grazing industry. The rainfall for the period, July to September, 1917, was generally above the average over the State. At Tucson it was 7.09 inches, or 66.6 percent of the total precipitation for the year. Following this, there was practically no rainfall thruout the State during the three months, October to December, inclusive. The excellent growth of grasses and other forage plants that began with the summer rains ended by the first of October. This reduced somewhat the forage growth. However, the long dry fall favored the natural curing of the grasses on the ranges. It was remarked during the winter season that, even with short feed, stock were looking well. With average winter and spring rains, grazing conditions would have been satisfactory.

The winter rainy season began with the second week in January and ended in the latter part of March It was of rather short duration and the precipitation was about one-half the average amount for this period. A few light showers of almost no consequence fell during the three months, April to June, 1918 In addition to the above shortage of moisture, the summer rains over much of the State for July to September, 1918, inclusive, were only one-half the average precipitation for this season. Much of the rainfall during the past year came as light showers and hence did not wet the soil to any depth.

On account of the above conditions, losses of stock on the ranges have been necessarily heavy, and, but for the fact that many animals have been shipped out to be sold or fed, the losses would have been heavier. A trip over much of the grazing part of the State in July and August, 1918, showed that the grazing ranges, generally, were in very bad condition, and that large numbers of stock must continue to be shipped out before another season or else be fed. The only grazing districts observed to be in fair condition were those about Flagstaff, Williams, Linden, Lakeside, Showlow, Prescott, Pine, and Payson. The rains in September were light; at best they came rather too late in the season, except at altitudes below 4,000 feet, to result in much additional growth.

Some feeding with native forage and concentrates has been done. In a number of instances singed chollas and prickly pears have been fed in considerable quantity on southern Arizona ranges.

With an increasing number of stockmen, the feeding of soapweed or palmilla *(Yucca elata)* as an emergency forage has become established. This is prepared by chopping in small pieces the succulent stems of the yucca, or soapweed plant, as described in a recent Timely Hint published by this department of the Experiment Station. By means best suited to his local conditions, the successful stockman must plan to carry a reserve feed supply sufficient to tide his herd over an unfavorable period of six months or longer. Until he does this his business is destined to continue uncertain. This may be done by putting up hay or silage, growing forage under irrigation, feeding concentrates, maintaining winter irrigated or range pastures, or thru diversified grazing ranges.

Unfavorable seasonal conditions like the present period, which have now extended over one full year, must make clear to stockmen the value of grazing ranges that have a diversified forage growth over those that have but one type of forage growth, as for example, the bunch grasses Not only have losses of stock generally been less on ranges with a diversified growth of shrubs, grasses, and miscellaneous plants than on ranges with one dominant type of plant growth, but stock have likewise come thru the year in better condition. Such ranges are practically year-round pastures, tho their maximum forage production during favorable seasons may not be as great as that of some of the better perennial grass ranges. During the present droughty period the desert ranges have been of least value, since, outside of the growth of cacti, which alone is not sufficient to sustain animals, they have produced little forage. High mountain ranges, naturally, supply feed for but six or seven months at best, and during the winter period the stock must be moved to the lower altitudes and grazed or fed.

POISON PLANT INVESTIGATIONS

The writer was a member of the squad of livestock specialists that visited the stock raising areas of north central and eastern Arizona during the past summer. Beginning with August 13, three weeks were devoted to this work which was planned by Director Taylor of the Agricultural Extension Service. The subject discussed by the writer was poison plants of our grazing ranges. Prepared specimens of our more important poisonous plants were shown and the commoner poisonous plants of the locality were collected and studied in the field. Eighteen meetings were held and generally a fine interest was shown by stockmen. Particular attention was given towards helping the stockman to know poison plants on the

range, and also the most practical means of preventing losses. The greatest interest was shown in the loco weeds which are widespread, growing both at low and high altitudes, and affecting all classes of stock; larkspurs, of which there are several species, all poisonous to cattle but not poisonous to sheep; pingue, or Colorado rubber plant, which grows at rather high altitudes and causes heavy losses among sheep in the spring and fall; western sneezeweed, which also is a high mountain plant and causes the spewing sickness in sheep; and death camas and water hemlock or wild parsnip, which plants are very poisonous to all classes of stock. Water hemlock is spreading in moist canyons in eastern Arizona about Springerville, Eager, Lakeside, Showlow, and Snowflake.

Information was secured concerning a number of plants that are believed by stockmen to be poisonous, but that heretofore have not been regarded as such. It is planned to continue this work on poison plants during the coming summer and publish the results as a bulletin. On this trip important collections of economic plants were made at various places and opportunity was afforded the writer to study additional types of grazing ranges over the State.

PUBLICATIONS

Timely Hint No. 31, "Sanitary Water Supply for the Home," was published in November. This includes a discussion of wells and surface contamination, contamination of water in wells thru seepage, and small storage tanks, and the pollution of water in them. A study of the commoner algae growing in open water tanks in southern Arizona was made. In some instances a layer of these plants six inches deep was found floating in the water. With partial decomposition of this material, such water becomes unsanitary, having a bad odor and a brackish taste. Open tanks require cleaning every month or two in the warmer part of the year. It was found that by covering tanks with wooden tops this plant growth ceased immediately and did not reappear until the tops were removed. Copper sulphate treatment with one part copper sulphate to 1,000,000 parts of water was successful, but since this treatment should be repeated every sixty days, it is not recommended for small lots of water that are are changed frequently thru pumping.

Timely Hint No. 135, "Soapweed or Palmilla *(Yucca elata)* as Emergency Forage," was published in February. This discusses the distribution and abundance of yucca plants over the State with brief botanical notes, the preparation of yucca forage for stock, and chemical and microscopical analyses of chopped yucca forage. A

study was made of feeding yucca to cattle as practiced at Willcox, Arizona. An improvised yucca feed chopper was described as made at small expense from a discarded pump-jack. With care a silage cutter may be used. There are at this time several yucca choppers, or yucca shredding machines, on the market, which are desirable for use where a considerable number of stock are to be fed.

The chemical analysis of yucca forage as made by the Chemistry Department of the Experiment Station shows that the protein content is little higher than that of native cactus forage; the fiber was somewhat more than double that in cactus forage, and the carbohydrates or nitrogen-free extract averaged 21.94 percent as against 15 percent in cactus feed. Aside from the fact that yucca forage acts as a succulent when fed along with dry range feed, its value as a feed lies chiefly in the carbohydrates. A microscopic study showed that the carbohydrates present were largely in the form of glucose, which explains the sweet taste of the freshly chopped feed.

Circular No. 22, "The Home War Garden," was published in August by the Extension Service. This is a revision of Timely Hint No. 106, "The Home Vegetable Garden," which publication it replaces. This circular attempts a popular presentation of present day gardening under southwestern conditions. The different vegetables are considered in part from their botanical and physiological characters. The first half of the circular discusses the following topics: soil and location; fertilization, irrigation and cultivation; flat culture versus ridged culture, rotation of crops; botanical grouping of vegetables; crop pests; seeds and seed-testing; aids to earliness in the garden; and, altitudes and seasons of planting. The second half discusses vegetables for the winter and spring garden and likewise those for the summer garden.

NOTES ON PLANT INTRODUCTION

Japanese Kudzu vine *(Pueraria hirsuta)*. This herbaceous climber, noted in a recent Annual Report of this station, deserves further mention as an economic plant. It grows from starchy, tuberous roots, increasing in vigor as these become larger. The stems are hairy, and the leaves resemble those of the common bean, but are larger. The flowers are purple, produced in clusters, and pea-like. They are not showy. The pods are flat, hairy, two to four inches long, and contain several small, mottled beans. The plant propagates readily from root cuttings and by layering. It can also be grown from seeds. Being semitropic, the Kudzu vine

grows most rapidly during the summer season. In the introduction garden vines have grown 50 feet in a season. This is the most rapid growing of our herbaceous climbers and with its dense foliage is excellent for shade for poultry yards and fences, sheds, and even for houses. It is much planted in parts of Japan as a covering for homes, and for the forage, which is relished by animals. It is best suited for growing in Arizona below altitudes of 2,500 feet, preferably in rich, well irrigated soils. It blossoms about September 15, and with an early frost will hardly mature seed. The leaves and stems of the season's growth are killed with minimum temperatures of 29 degrees F., and the older woody stems, which ordinarily live over, are killed with temperatures of 6 degrees F. This plant should have value as forage for growing along irrigation ditches or in areas not readily accessible to cultivation.

PLANT DISEASE STUDIES

For the most part, the plant diseases that have been destructive during the recent growing season are the ones that were predominant during the previous year. These include tomato wilt, which has been serious in many sections, cotton sore shin disease, cotton root-rot, alfalfa root-rot, fruit tree root-rot, melon wilt, and crown gall. Besides these, a serious disease of the common pepper has appeared at Tubac and in the Rillito Valley near Tucson. When nearly mature the plants cease growth, gradually turn yellow and begin to die from the roots with a full crop of peppers. In a number of respects the disease resembles tomato wilt. Practically all the plants within an affected area are killed. A study is being made of this disease. A careful rotation of crops will help both in this disease and in tomato wilt.

A serious canker disease of cottonwood and poplar trees caused by *Cytospora chrysosperma** has been found in a number of localities in Arizona. These include Flagstaff, Williams, Prescott, Douglas, Nogales, Continental, and Tucson. This disease attacks both native and introduced poplars, but is most destructive to introduced species, including the Carolina poplar and the Lombardy poplar. A considerable number of these trees have died in Flagstaff from this cause. The disease may be recognized by the presence of sunken, dead areas on the bark of the larger limbs of trees. The inner bark of these areas is blackish and has a pronounced odor. Later, small reddish, pustule-like fruiting bodies appear on the surface of dead areas of bark. On old bark these reddish bodies can

*Long, W. H Journal of Agric. Research, XIII, 6, 1918.

often be seen in the fissures. Affected trees rarely live longer than two or three years and serve to spread the disease. It is recommended that persons who desire cottonwood or poplar trees plant the native cottonwoods, since these are more resistant to the canker disease than introduced species like the Carolina poplar. There are several species of native cottonwood in Arizona which thrive at our various altitudes.

SCIENTIFIC

The work on the herbarium, which claimed so large an amount of time last year, was completed early during the present year. The University plant collections now number 74,000 sheets. Our plant collections are complete enough now to enable one to work to advantage, both on the native and cultivated plants. During the year a collection of biological literature, numbering 2,500 pamphlets and separates, has been classified and arranged systematically for convenience in work in botany. Many of these books and pamphlets were presented to the Botanical Department by the Department of Botanical Research of the Carnegie Institution, Tucson, Arizona. Others have been secured thru exchange of botanical material, including plant specimens.

J. J. THORNBER,
Botanist.

HORTICULTURE

The Horticulturist having entered upon his duties near the close of the present fiscal year, the major portion of his time during the remainder of the period was given to the study of the general horticultural conditions of the State, and in formulating plans for the future development of the work of the department as pertains both to instruction and investigation. Nine distinct station projects have been outlined and accepted, and work on some of them is now under way. The work of the Department of Horticulture falls naturally into three main divisions: Pomology, Olericulture, and Ornamental Gardening. Progress has been made during the past year in these respective branches as follows:

POMOLOGY

Plans have been developed for fruit plantings at the Salt River Valley Farm consisting of a variety orchard of eleven acres, together with additional blocks of three acres each of the standard varieties of such fruits as the fig, olive, and apricot, that have proved themselves particularly adapted to commercial growing in southern Arizona. The plantings of standard varieties will be used as a basis of experimentation in pruning, spraying, and other phases of orchard culture and management. As other varieties demonstrate their worth, block plantings will also be made of them. The first planting in the variety orchard was made with dates in July, 1918, including seventy varieties. The remainder of the orchard will be set during the coming spring.

A three-acre orchard is being developed on the University Farm at Tucson, comprising representative varieties of the leading species of cultivated fruits. This orchard is designed primarily for student instruction in Pomology, but is adaptable as well for purposes of experimentation.

The unplanted portion of the horticultural block at the Yuma Date Orchard and Horticultural Station will be set this fall with citrus and other sub-tropical fruits. The planting of citrus fruits is made with a view to determining an effective method of preventing frost injury, and to testing the adaptability of the Mandarian group of orange to the Yuma Valley.

The deciduous orchard at the Yuma Date Orchard and Horticultural Station is now in its second year. The trees have made a very satisfactory growth, and a few varieties have borne their first crop. The Smyrna and Rea Mammoth varieties of quince, and the

Royal and Newcastle varieties of apricot each produced a small number of fruit this year. The Wonderful and Papershell varieties of pomegranate produced heavy yields for the age and size of the plants.

DATES

The date orchards at the Tempe Date Orchard and the Yuma Date Orchard and Horticultural Station have continued in thrifty condition, and during the past season have produced very satisfactory crops, furnishing additional evidence of the value of the date as a commercial fruit crop for southern Arizona. The blossoming record of the palms was not high at either orchard, but the most excellent weather that prevailed thruout the harvest made it possible to gather a maximum crop from every tree that bore. Even varieties that during ordinary seasons are almost worthless yielded relatively good returns. Another feature of this year's crop was the almost total absence of fungus spots, which have been a source of serious loss of some varieties in the past, particularly during moist weather. These facts considered in the light of losses sustained in the past due to rainy weather point to climate as a most important factor in the harvesting of the date crop.

Considered from the standpoint of yield, size, quality, and appearance, the varieties that did best at the Tempe Orchard are: Hayany, Tadala, Rhars, and Deglet Noor; and at the Yuma Orchard: Deglet Noor, Hellawee, and Kaiby. The following is a summary of the yields and returns at the Tempe and Yuma Date Orchards for the past season:

TABLE I.—YIELD OF DATE VARIETIES AT THE TEMPE ORCHARD

Variety	No. of trees	Harvest season	Average yield per tree	Total yield	Average receipts per tree	Total receipts
			Pounds	*Pounds*	*Dollars*	*Dollars*
Amari	3	Aug 12-Oct. 17	91.16	273½	21.41	64.24
Azerza	2	Sept. 22-Oct. 5	36	72	8.13	16.26
A'oochet	1	Oct. 4-Nov. 17	222	222	55 06	55.06
Arechti	1	Oct. 3-Oct. 31	20	20	4.98	4.98
Apdandon	1	Sept. 5-Oct. 31	75	75	16.79	16.79
Ascherasi	2	Oct. 2-Oct. 12	13	26	3 5	6.10
Amhat	1	Sept. 28-Oct. 28	12	12	2.01	2.01
Amri	2	Oct. 24-Dec. 1	57	115	10.85	21.70
Bent Kebala	1	Sept. 30-Nov. 22	294	294	81 84	81.84
Boo Affar	2	Sept. 28-Dec. 5	15	31¾	3.47	6.94
Burni	2	Oct. 9-Nov. 16	79	159	19 13	38 27
Berhi	4	Sept 30-Nov. 3	148	595	37 52	150.08
Bagam Jurghi	1	Sept. 8-Oct. 15	51	51	11.34	11.34
Besser Haloo	1	Nov. 27-Dec. 1	55	55	6.40	6.40
Bedraihe	2	Oct. 1-Dec. 2	214	428	22.03	44.06
Bajoo	1	Oct. 26-Dec. 5	62	62	6.10	6 10
Dishtari	1	Aug. 31-Oct. 31	96	96	22.29	22.29
Deglet Noor	28	Oct. 11-Dec. 1	108	3043	36.25	1015.10
Deglet Barka	1	Dec. 5-	70	70	7 00	7.00
Gasby	1	Aug. 23-Oct. 5	120	120	27 59	27.59
Gush	1	Sept. 5-Oct. 12	27	27	6.57	6.57
Goondee	1	Dec. 1-	40	40	4.00	4.00
Gaggar	1	Nov 21- Dec. 5	163	163	16.30	16.30
Hayany	9	Aug. 23-Nov. 4	213	1921	51.77	465.98
Hamraia	4	Oct. 5-Nov. 17	63	254	16 49	65.96
Hellawee	1	Sept. 28-Oct. 24	31	31	7.45	7.45
Halloua	2	Nov. 15-Dec. 1	64	129½	6.47	12.95
Horra	3	Nov. 4-Dec. 1	39	119	3.96	11.90
Hurshut	1	Sept. 25-Oct. 19	45	45	9.84	9.84
Halawi	3	Sept. 28-Oct. 28	85	257	21.09	63.26
Itima	1	Oct. 16-Nov. 8	37	37	9.09	9.09
Iteem Joher	1	Oct. 12- Dec. 1	173	173	51.21	51 21
Karooy	1	Sept. 9-Oct. 5	44	44	9 35	9.35
Kustawi	7	Sept. 10-Oct. 31	62	439	14.93	104.51
Khadrawi	2	Sept. 22-Oct. 15	32	64	6.97	13.94
Khedrwee	3	Sept. 5-Oct. 24	73	220	15.15	45.45
Khir	1	Sept. 1-Oct. 16	87	87	20.31	20.31
Kenta	2	Oct. 19-Nov. 21	18	37½	1.87	3.75
Kalara	1	Sept. 9-Oct. 13	80	80	17.12	17.12
Koroch	1	Sept. 9-Oct. 17	125	125	27 66	27.66
Khedrwee	1	Aug. 31-Oct. 26	25	25	5 82	5 82
Kesba	1	Dec. 1-	5	5	.50	.50
Karba	1	Sept. 10-Nov. 15	34	34	7.08	7.08
Kaiby	1	Oct. 15-Oct. 28	34	34	8.24	8.24
M'Kentichi, Degla	2	Dec. 1-	104	208	10.40	20.80

TABLE I.—YIELD OF DATE VARIETIES AT THE TEMPE ORCHARD—*Continued*

Variety	No. of trees	Harvest season	Average yield per tree	Total yield	Average receipts per tree	Total receipts
			Pounds	*Pounds*	*Dollars*	*Dollars*
Maktum	2	Oct 17-Dec 1	113	227	30.10	60 20
Menakher	1	Oct. 17-Oct. 27	40	40	10.71	10.71
Mozati	1	Sept. 9-Oct. 31	51	51	11.29	11.29
Nakkelet Feraoon	1	Oct 10-Oct 31	43	43	10.54	10 54
Nazel	1	Dec 1	100	100	10.00	10 00
Nakiet el Leef	1	Oct. 1-Oct. 30	130	130	28 74	28.74
Lagoo	1	Sept 22-Oct. 30	30	30	3 00	3.00
Nesheem	1	Oct. 1-Nov. 1	182	182	45.10	45.10
Lookzee	1	Oct. 1-Oct. 20	30	30	6 55	6.55
Purdy Seedling	3	Sept 23-Nov. 2	56	169	12.92	38.76
Rhazi	2	Sept 5-Oct. 15	64	128	17.29	34 58
Retbet Regaia	1	Oct. 6-Nov. 11	21	21½	4.55	4.55
Ret Bet Abdella	1	Oct. 4-Nov. 2	62	62	16 27	16.27
Rhars	111	Aug. 17-Oct. 21	87	9685	21.03	2334.17
Roghm Gazal	1	Nov. 17-Dec. 1	98	98½	9.85	9.85
Rogina	1	Sept. 27-Nov. 25	23	23	4 72	4.72
Seedling (West)	2	Oct. 6-Oct. 6	25	5	.50	1.00
Seba Loosif	1	Sept. 23-Oct. 24	94	94	21.27	21.27
Sayer	3	Sept. 11-Oct. 25	101	303	19.01	57.03
Seba Boo Dra	1	Nov. 10-Nov. 28	91	91½	7.05	7.05
Safraia	2	Sept. 11-Dec. 1	50	100	5.10	10.20
Sukeri	2	Sept. 22-Nov. 18	143	287	14.45	28 90
Saydeh	9	Sept 28-Nov. 23	47	427	24.50	220.48
Timdjouert (Yellow)	4	Oct. 4-Nov 20	54	219	13.92	55.66
Tadala	2	Sept 10-Oct. 31	146	293	34.56	69.11
Tennessim	4	Sept. 19-Nov 20	127	511	25.81	103.25
Taflzaomt	1	Oct. 15-Dec. 3	266	266	72.23	72.23
Tentebusht	3	Oct 13-Nov. 2	9	27¾	2.31	6.94
Taurarhet	1	Nov. 4-Dec. 5	67	67	7.45	7.45
Takadet	2	Oct. 4-Nov. 18	82	165	18.93	37.85
Totee	1	Nov. 2-Dec. 3	130	130	34.13	34.13
Tamzoohart	1	Sept. 27-Nov. 17	66	66	15.45	15.45
Toorekhet	1	Nov. 4-Dec. 5	67	67	7.45	7.45
Tozerzaid Khala	1	Oct. 15-Dec. 1	120	120	31.16	31.16
Tazizaoat	1	Oct. 4-Dec. 1	250	250	55.48	55.48
Thoree	5	Oct. 6-Dec.	54	270	5.39	26.95
Toojat	1	Oct. 26-Nov. 3	40	40	3.90	3.90
Taremoont	1	Oct. 16-Nov. 6	124	124	31.09	31.09
Tefezomt	1	Nov. 28-Dec. 1	85	85	8.50	8.50
Zerza	1	Oct. 5-Dec 1	128	128	12.60	12.60
Zehedi	1	Dec 1	14	14	1.40	1.40
Zrai	1	Dec 1	5	5	.50	.50
Zoozia	1	Dec 1	85	85	8.50	8.50
Nagal	1	Dec 1	100	100	10.00	10.00
No Name	7	Sept. 9-Dec. 1	34	239	10.59	74.17
Culls		Aug. 12-Dec. 5		4983½		631.40

TABLE II.—YIELD OF DATE VARIETIES AT THE YUMA ORCHARD

Variety	No. of trees	Harvest season	Average yield per tree	Total yield	Average receipts per tree	Total receipts
			Pounds	*Pounds*	*Dollars*	*Dollars*
Angoo	1	Nov. 19-Nov. 22	91	91	11.37	11.37
Bent el Marad	1	Aug. 31-Sept. 3	12	12	3.00	3.00
Black Seedlings	1	Sept. 9-Sept. 30	12	12	2.80	2.80
Beed Hammon	2	Sept. 20-Nov. 8	66.5	133	15.90	31.80
Boo Fa Goo	2	Sept. 24-Oct. 7	139	278	35 34	70 68
Bread Dates	5	Nov. 13-Nov. 30	63	319	7 43	37.16
Deglet Noor	32	Sept. 21-Nov. 30	50 5	1616	15 14	484.56
Gasley	1	Aug. 26-	31	31	4.65	4 65
Hayany	1	Sept. 4-Sept. 30	10	10	2 57	2.57
Hellawee	8	Aug. 26-Sept. 23	87.12	697	22.92	183.35
Itima	2	Sept. 7-Oct. 22	28 5	57	6.94	13.88
Kaiby	2	Sept. 7-Nov. 22	114.8	229.5	26.77	53.54
Khedrwee	2	Aug. 24-Sept. 13	43 5	87	11.93	23.85
Lagoo	1	Nov. 23-Nov. 26	43	43	5.12	5.12
Rhars	2	Sept. 3-Sept. 13	3.5	7	.90	1.80
Rogina	2	Sept. 9	2	4	.50	1.00
Saba Boo Dra	2	Oct. 5-Nov. 28	54	168	12.48	24 95
Saydeh	4	Sept. 16-Nov. 12	23 25	93	5.68	22.71
Timdjouert (Yellow)	4	Sept. 3-Sept. 9	2 75	11	.81	3.25
Timdjouert (Red)	1	Sept. 13	5	5	1.25	1.25
No Name	1	Sept. 30-Nov. 12	98	98	21.52	21.52
Cul's		Sept. 2-Nov. 30		319.83		37.16

A large number of vacant places in both the Yuma and Tempe Orchards were set with palms during the summer. The off-shoots used in the Yuma Orchard were taken directly from the trees, being too large to place in the propagating house, whereas those used in the Tempe Orchard were rooted. Upon examination in November, 52 of the 81 plants set in the Yuma Orchard were showing signs of growth. The Tempe planting is interesting from the fact that the soil in the orchard is at present extremely alkaline. While the older trees do not appear to be disturbed by the presence of alkali, it was feared that the young plants probably would not fare so well. As a precaution, therefore, about a cubic yard of sweet soil was placed in the holes prepared for the off-shoots and a heavy straw mulch applied to prevent the rise of the alkali. No ill effects from the alkali have yet been observed, as the majority of the plants give evidence of growing.

A rather unusual feature of blossoming was observed at the Yuma Orchard, in that certain varieties failing to bloom during their normal blossoming period in the spring, flowered most profusely towards the latter part of the summer. A number of the blossoms were pollinated in order to study the future behavior of the fruit, particularly as to its ability to stand thru winter.

Progress has been made on definite projects in Pomology as follows

A STUDY IN THE CULTURE AND MANAGEMENT OF DATE ORCHARDS

This project conducted at the Yuma Date Orchard and Horticultural Station was begun in the summer of 1918. The work involves a comprehensive study of a number of features of orchard culture and management, with particular reference to the comparative effect of clean tillage, cover crops, sod, and mulches, together with different methods of fertilizing, on the yield, quality, time of ripening, size of fruit and growth of tree. The orchard contains about four acres, and the trees have been set 10 years. It is divided into six plots with each plot containing two rows of trees. The plots are being handled as follows:

No (1) Planted to alfalfa, cuttings allowed to remain where they fall.

No (2) Planted to sour clover in the fall, followed by cowpeas in summer.

No. (3) Planted to vegetables during both summer and winter.

No. (4) Wide, shallow basin maintained about each tree with a heavy manure mulch.

No. (5) Wide, shallow basin maintained about each tree with a thick straw mulch.

No. (6) Clean culture thruout the year.

The rows are divided crosswise to allow four different treatments with commercial fertilizer.

A STUDY OF CULTURAL METHODS WITH CITRUS FRUITS

These investigations, begun in the summer of 1918, are being conducted on the Yuma Mesa in cooperation with Mr. George W. Hill. The orchard in which the tests are being made contains about ten acres, and the trees composed of the Washington Navel variety of orange and the Marsh Seedless variety of pomelo, were set in the spring of 1916. The area is divided into ten plots, each of which is being given a distinct method of culture, particularly in the matter of cover crops. The plots are divided crosswise so as to allow four trees in each plot being given a different fertilizer treatment. Records of growth and general phenological notes are being made, and it is hoped that during the next few years data may be gathered on the cumulative effect of each cultural method and fertilizer treatment on the growth of tree and the size and quality of the fruit.

DATE PROPAGATION

The results secured in the propagation of the date, have not been as satisfactory as was anticipated, and the matter has become the subject of further investigation. The off-shoots placed in the propagating house at the Yuma Date Orchard and Horticultural Station in the summer of 1917 were a complete failure but this can, however, be attributed to soil conditions. The soil being heavy and not well drained it remained cool, whereas the temperature during summer was very high, making extremely adverse conditions for root development. In the summer of 1918 this house was removed to a location where the soil is sandy and well drained, and as a result the off-shoots are rooting satisfactorily. A careful examination in the latter part of November showed that out of 237 off-shoots placed in the house only 37 failed to show evidence of growth. Several individuals were observed as having developed a good root system, whereas suckers on the outside of the house, although alive, showed no signs of root formation. In the case of suckers placed in an ordinary cutting bench in the green house, where there was a daily range of temperature from 90 to 114 degrees, roots two to four inches long were formed in six weeks.

Following is a summary of the temperature of the atmosphere and soil inside the date propagating house at the Yuma Date Orchard and Horticultural Station as compared with the outside temperature during the months of August, September, October, and November—readings made daily at 12:30 P. M.

TABLE III.—AIR AND SOIL TEMPERATURE IN DATE PROPAGATING HOUSE, YUMA

Month	Temp. inside propagating house		Temp. outside propagating house	
	Atmosphere	Soil	Atmosphere	Soil
	Degrees Fahr.	*Degrees Fahr*	*Degrees Fahr*	*Degrees Fahr.*
August ...	115	90	103	84
September	110	86	100	83
October ...	97	73	90	74
November	79	59	72	61

It will be remembered that while a large number of off-shoots on the inside of the propagating house had rooted by November there was no sign of root development in the case of those planted in an open bed on the outside.

OLERICULTURE

Attention was given during the past year to the maintenance of an all-the-year family garden at the Yuma Date Orchard and

Horticultural Station and on the University grounds at Tucson, with a view to stimulating a greater interest in home gardening as a means of increasing the food supply With good cultivation and ample irrigation, tomato, eggplant, pepper, okra, carrot, and the edible cowpeas were made to produce during the hottest portion of the summer Tomatoes did not yield a heavy crop during this period, but shaded parts of the plants continued to bear some fruit. Further tests will be made with summer vegetables with the hope of adding other varieties to the list that can be successfully grown during the hot weather of this season

Of special interest this year was the fall garden. Notes taken October 25 in the garden at Tucson showed the following vegetables in edible condition snap bean, chard, cucumber, cowpea, carrot, endive, kale, lettuce, mustard, onion, radish, salsify, spinach, tomato, and turnip Other vegetables that were growing nicely at this time, and that will be available for use during winter and early spring are broccoli, cabbage, cauliflower, brussels sprouts, collard, corn salad, kohlrabi, leek, parsley, parsnip, and rutabaga. All of these vegetables were planted during the month of August and in early September, except tomato, carrot, and salsify, which were started in the spring.

IRISH POTATO STUDIES

These investigations, directed towards the accumulation of facts regarding the production and storage of Irish potatoes in southern Arizona, are being conducted at the Yuma Date Orchard and Horticultural Station The varieties Irish Cobbler, Triumph, and White Rose were planted February 25 and harvested on July 5 The yields per acre were as follows·

Irish Cobbler, 10,192 pounds; Triumph, 9,800 pounds; White Rose, 10,976 pounds

Immediately after harvesting a definite amount of each variety was placed under different methods of storage as follows·

No 1 Placed in ventilated bins under shade.

No. 2 Coated with paraffin

No. 3. Spread out thinly on ground under shade.

No. 4. Placed in twelve inches of soil under shade.

No. 5. Placed in a ventilated dugout made three feet deep in a well drained soil

Following is a summary of the storage tests as revealed September 15 when the potatoes were examined:

TABLE IV.—STORAGE TESTS WITH POTATOES

Storage method	Variety	Sound potato
		Percent
No. 1 Ventilated bins	Irish Cobbler	90
	Triumph	90
	White Rose	95
No. 2 Paraffined	Irish Cobbler	None
	Triumph	"
	White Rose	"
No. 3 On ground	Irish Cobbler	75
	Triumph	75
	White Rose	50
No. 4 Dry soil	Irish Cobbler	None
	Triumph	"
	White Rose	95
No. 5 Dugout	Irish Cobbler	95
	Triumph	80
	White Rose	95

In the case of the potatoes that were coated with paraffin the entire lot rotted by the end of four weeks, which indicates that the exclusion of air is absolutely detrimental to the keeping qualities of the potato, and emphasizes the importance of thoro ventilation during storage. As shown in the table, the method of storage in which the potatoes were spread out thinly in ventilated bins, as well as the dugout method of storage, gave a rather high percentage of sound potatoes. While these results are not conclusive, they do indicate that it is easily possible for the home gardener to preserve the spring crop of potatoes thru the summer for culinary use and as seed for a late summer crop.

In tests made to determine the best depth and time of planting for the late summer crop, practically all the potatoes rotted in the ground. This was apparently due to the hot temperature of the soil at planting time, coupled with excessive moisture conditions.

It is believed that modified methods of planting contemplated for trial next season will give more satisfactory results. Plantings are being continued thruout fall, winter, and spring at intervals of ten days in order to determine the best planting date for the spring crop.

SPINACH AS A MARKET GARDEN CROP FOR SOUTHERN ARIZONA

Ranking first in importance among the vegetables grown for "greens" in the United States, and being particularly well adapted

to climatic conditions such as are found in southern Arizona, spinach promises to become a valuable market crop for this section. In view of these facts, a series of investigations was begun in the fall of 1918 for the purpose of securing specific information as to the best cultural practices to be followed in the production of this crop—including methods and time of planting, variety tests, and fertilizer comparisons. The following methods of planting were used:

No. 1. Level planting with flooding—rows ten inches apart.

No. 2. Bedding four rows ten inches apart, made on low, flat beds with irrigation water run between the beds.

No. 3. Row and furrow method—rows two feet apart, and irrigation water run between the rows.

The varieties Savoy, Victoria, Prickly Winter, and Long Standing, typifying as many different groups of spinach, were used in each plot. The first planting was to have been made September 1, with additional planting at intervals of two weeks until November 15, but a delay in the arrival of seed necessitated its postponement until October 1 The plots are subdivided crosswise to permit of fertilizer tests with stable manure, cotton seed meal, nitrate of soda, and acid phosphate. The work has not reached the point where final conclusions can yet be drawn.

ORNAMENTAL GARDENING

The work in Ornamental Gardening has consisted largely in the developing of plans for the beautifying of the grounds at the different branch stations, particular attention having been given the Tempe Date Orchard and the Yuma Date Orchard and Horticultural Station. The central grounds at the Yuma Station have been set to lawn grass, and, during the coming spring, shrubbery and other ornamentals will be added In addition to plantings of tested varieties of trees and shrubbery, other sorts will be set with a view to determining their adaptability to specific localities. A special feature in this connection is the attempt to establish alkali resistant types at the Tempe Date Orchard, the soil of which is very alkaline.

No work has been done in floriculture, but with the added green house and garden facilities, which are soon to be provided, something in this field will be undertaken.

SPECIAL INVESTIGATIONS

The Horticulturist served as a member of a commission appointed by the President of the University of Arizona to investigate

the agricultural possibilities of the Yuma Mesa with special reference to citrus culture. In connection with these investigations considerable time has been spent in studying the climatology, topography, and general features of the soil and in making detailed descriptions of the fruit now being grown in the district and comparing it with that produced in other citrus regions. The entire matter will be treated in greater detail and published as a joint report by the committee.

MISCELLANEOUS

A number of trips were made during the past year to different parts of the State in the interest of extension work in Horticulture. The activities in this field, however, were confined largely to demonstrations in fruit and vegetable conservation by drying, in which the sulphuring process was used.

Considerable time was given to the general supervision of the work at the Tempe Date Orchard and at the Yuma Date Orchard and Horticultural Station.

Very valuable service was rendered the department during the past year by the foremen of the different branch stations in their careful execution of the work as outlined for them. The horticultural work has been given further impetus in the recent appointment of Mr. A. F. Kinnison as Assistant Horticulturist

F. J. CRIDER,
Horticulturist

PLANT BREEDING

Work in the department during the past year has been confined to wheat, beans, alfalfa, and grain sorghums. The wheat work during the year has received especial consideration owing to the increased interest shown in bread wheat varieties.

WHEAT

The breeding work with wheat during the past year has been along four distinct lines: (I) The testing of the promising hybrid macaroni-bread wheat races which have been increased from last year's selections. (II)The growing and comparing of the second seed generation (first plant generation) of new hybrids secured by crossing Turkey and macaroni wheats on the native Sonora. (III) A study of the inheritance of the various characters in the bread wheats, the Poulard wheats, and the macaroni wheats (IV) The field testing of various pure lines of wheat The milling and baking qualities, and also yield received especial consideration

I. The work with the macaroni-bread wheat crosses at Yuma included three series of plots; the plant rows, the small pedigree increase plots, and the tenth acre field plots. There were 540 plant rows grown from plants of good habit and producing grain of apparently good gluten content. Each row of this series was harvested and threshed separately, and the grain worked over in the laboratory for type, texture, and total yield. The seed from about one-third of these rows will be used in planting increase plots next year, so that the excellent strains may be increased as rapidly as possible.

There were 100 pedigree increase plots planted from promising plant rows of 1917. These have been carried thru a severe elimination test from which about 30 will be selected for testing under field conditions in 1919 with the present best milling wheats of the State, such as Early Baart.

There were twenty-five tenth-acre field plots of hybrid wheats which occupied the entire area of the Dyer block of the Yuma Station. Some promising yields were obtained from this series; one produced at the rate of 60 bushels per acre and two others between 50 and 55 bushels per acre. This is about 20 bushels per acre more than was produced by the Early Baart. The quality of these high yielders was fairly good, but neither the grain nor the plants were of sufficient uniformity to be recommended for bread wheat planting, and will require one or two more season's selec-

tions before they will be ready for general planting. However, these wheats are regarded as very promising on account of their high yield and strong straw which stands up well when the wheat is grown on irrigated lands rich in organic matter. One of the worst troubles in growing the present standard milling wheats of the State is that, when they are planted immediately after alfalfa, or other lands rich in nitrogen, they lodge badly.

II. The main object sought in the wheat breeding at this Station is to find, or produce by hybridization, a wheat of high gluten content of superior quality. In an effort to combine the high gluten contents of the hard wheats of Kansas, such as the Turkey Red, with the early, high yielding Sonora wheat, crosses of these wheats were made in the screen garden on the campus in the spring of 1917. Thirty-three hybrids from this cross were grown in the screen garden during the winter and spring of 1917 and 1918. Notes were taken on the earliness of the plants, type of head and other plant characters, and quality of the grain. The first heads of these hybrids appeared between April 16 and April 23, while the first heads of the Turkey parent appeared between April 29 and May 12. It thus appears that there is a possibility of getting an early Turkey wheat selection out of these hybrids when it breaks up into various types in succeeding generations. Earliness in wheat, especially in the irrigated valleys of Arizona, is regarded of prime importance in establishing a wheat with a high gluten content of superior quality. When wheats continue growing in the warm days of late spring abundant irrigation is necessary which always reduces both the quantity and the quality of the gluten in the grain

III. Another series of wheat hybrids was made the past year for the sole purpose of studying the manner of inheritance of the various characters in wheat. Wheats were selected for these crosses in such a way that every visible character was paired with its opposite or its absence. In the succeeding generations a study will be made of the factors controlling gluten content, strength of straw, and the various factors which control yield.

IV. Several selections from each of Early Baart, Turkey Red, Arizona 39, Sonora, Algerian Macaroni, and Alaskan wheats have been under test for several years. As result of these tests one or two high yielding strains have been developed from each of these varieties. In addition to yield, the milling and baking qualities, rust resistance, and strong, non-lodging straw under irrigation have

received attention. Table V gives the yields obtained from these wheats on the Salt River Valley Farm for 1918.

TABLE V.—YIELDS FROM PURE RACES OF WHEAT IN FIELD PLOTS ON SALT RIVER VALLEY FARM, 1918

Plot No	Name	Area planted	Yield per acre	
		Acres	*Pounds*	*Bushels*
34	Early Baart	0 2362	2180	36 33
35 12	Sonora	0 4724	2032	33 86
36-43	Turkey	0 2362	2193	36 55
36-51	"	0 4862	2557	42 62
37- 1	Poulard	0 2224	2549	42 49
38- 1	"	0 2362	2032	33 87
39A- 5	Arizona 39	0 4864	2742	45 70
39A- 9	" "	0 2224	2414	40 24
40A- 8	Selected	0 2362	2616	43 60
40 A-57	"	0 2362	2650	44 17
41A- 1	"	0 2224	2338	38 96
1E-13	Macaroni	0 2224	2315	38 59
1E-88	"	0 2362	2349	39 16

The varieties represented in this table are those which have been selected for several years for either yield, or quality of grain, or both. It is seen from Table V that the highest yielder in the lot is Arizona 39, selection 5 (39A-5) producing at the rate of 45 7 bushels per acre. This is approximately 10 bushels more per acre than was produced by a plot of Early Baart grown in the same field under similar conditions. Section No. 9 of Arizona 39 (39A-9) also produced nearly 5 bushels more per acre than the plot of Early Baart. Baking tests have also been made of Arizona 39, but it is inferior to Early Baart in flour strength, as will be seen from an inspection of Table VI. Table VI. gives the results of the latest baking test with the varieties of wheat listed in Table V.

TABLE VI.—BAKING TEST OF ARIZONA WHEATS

No	Name	Absorption	Maximum volume of dough	Volume of loaf	Weight of loaf
			c. c.	*c. c.*	*Grams*
34-16	Early Baart	63 7	2050	1940	526
35-12	Sonora	63 7	2000	1780	528
36-43	Turkey	70 3	2050	1675	544
36-51	"	69 3	2200	1630	529
37- 1	Poulard	72.7	1750	1400	560
38- 1	"	70 0	1750	1405	554
39A- 5	Arizona 39	63 7	1900	1710	522
39A- 9	" "	65	2000	1725	527
40A- 8	Selected	62	1600	1310	520
40A-57	"	68 3	2050	1715	535
41A- 1	"	68 8	2150	1630	543
1E-13	Macaroni	73 3	1750	1390	560
1E-88	"	78 3	1900	1640	576

From Table VI it is seen that Early Baart (34-16) surpasses every other variety represented in the table in volume of loaf. In all these tests the same quantity of flour was taken for baking the loaf. The column of figures representing loaf volume, therefore, is of primary importance in judging the strength of the flours. Arizona 39 (39A-9) and Sonora (35-12) came nearest to the Early Baart in baking strength, but the difference is great enough to place Early Baart considerably ahead in this quality.

Of all the varieties tested so far by this department, Early Baart outranks all others as a milling wheat. Its yield is about the average of bread wheats in the State, and there is, therefore, room for considerable improvement in this direction. Early Baart has the disadvantage of being awned (bearded). Some farmers object to the presence of awns, for, if it becomes necessary to cut the grain for hay, the hay produced is of an inferior quality. The beards also render the handling of the wheat previous to threshing somewhat unpleasant For this reason the department is bringing forward as rapidly as possible certain other bread wheat strains which, it is believed, will yield, with a few year's further breeding, as well as the Early Baart and which will at the same time be a good millling wheat free from awns.

BEANS

The work of the department with beans this year has been largely along investigational lines related to the various Mendelian genetic factors of the plant. It was anticipated that along with this scientific investigation an economic result might in the end be accomplished. The better the plant is known, genetically, the easier will it be to combine characters in the attempt to produce nearer the ideal.

Particular study was given to the variation of the internodes as affecting the variances in height of the plant and also as affecting the variation in the percentage of supernumerary leaves. In the anticipation of the latter it was assumed that internode length could vary to zero thereby causing a crowding together into within a practically immeasurable zone of the first two or three, or four nodes, each node carrying its leaf, and thus giving a set of supernumerary leaves. The plant having all internodes measurably shows two leaves at the first node and one at each node thereafter. Thus in the case of a zero length of the first internode we would find three primary leaves; zero length of the first and second internodes, four primary leaves, etc. Data covering about three years' work

showed 92 percent of all plants having zero length of the first internode, 66 percent having zero length of the first and second, and 1 percent having zero length of the first, second and third internodes. This leaves 8 percent having two primary leaves. Then 92 percent of 66 percent, or 61 percent, of all plants should have had four or more, thus leaving 92 less 61, or 31 percent, of all plants with three primaries. Also 1 percent of 61 percent, or 0 6 percent, of all plants should have had five primary leaves, leaving about 60 percent with four primaries. Table VII shows how nearly the actual count in one race approaches the theoretically expected.

TABLE VII.—NUMBER PRIMARY LEAVES

	2	3	4	5
No 202 Theoretically expected	8	25	68	2
No. 202 Actual count	9	27	64	0

A number of pure races of teparies were planted in the screen garden on the campus during the last spring and summer with the plan in view to obtain a number of reciprocal crosses in order that a new set of hybrids might be produced. Considerable efforts were expended in developing a practical and effective method of open field cross pollination of beans.

An interesting segregation appeared this year coming from the F_1 seed of a cross between a tame and a wild tepary. A further investigation will be made with the various segregates.

ALFALFA

The work with alfalfa has been with three series of plots. One of these plots is located in the screen garden on the campus, and the other two are on the Salt River Valley Farm

The plot in the screen garden consists of 342 transplanted plants from various sources. Most of these plants were taken from the best plots of the Evergreen Nursery when the work at that place was discontinued in 1916 About twenty-five of these plants were taken from the Hairy Peruvian alfalfa which was growing on the north side of the Salt River Valley Farm in the fall of 1917. An individual plant study has been made of (1) heat resistance, as indicated by rapidity of growth and yield of consecutive cuttings as the heat of the summer comes on, and (2) quality, as indicated by size of stems and percentage of leaves. The work was confined mostly to the study of heat resistance. The entire plot was irrigated about

ENTOMOLOGY

In continuation of the experiments with grasshopper baits begun in 1917, forty combinations were tested in 1918, beginning in the month of May. Definite records were made concerning applications of these combinations to 269 acres of alfalfa and cotton lands. In this work assistance was rendered in various ways by Messrs. O. C. Bartlett, D. C George, J. L. E. Lauderdale, George Acuff, M. E. Kimsey, and R. H. Armstrong. The work was directed against the same species as in 1917, the differential grasshopper, *Melanoplus differentialis*. The tests were all made in the Salt River Valley with the exception of one application made by the writer in a ten-acre alfalfa field in the Verde Valley near Camp Verde.

The movement or drifting of the grasshoppers in the fields both toward and away from poisoned areas tends to confuse the results of experiments with poisoned baits and makes it necessary to repeat the tests many times under various conditions before drawing final conclusions. Tentative conclusions from the work done in 1917 are as follows:

1. A combination of half and half wheat bran and pine sawdust is fully equal to wheat bran alone for the bulk of the substance of the bait and is easier to distribute than when all wheat bran is used.

2. All sawdust is decidedly inferior to all bran or to a half and half bran sawdust mixture.

3. For the fruit, oranges are in no degree inferior to lemons and are perhaps slightly better.

4. Canteloupes are in no degree inferior to lemons but on the contrary are apparently slightly superior as well as cheaper.

5. Molasses is not only an unnecessary ingredient of poisoned baits but when used with citrus fruits the effectiveness of the bait is reduced rather than increased.

From the experiments conducted in the summer of 1918 the following tentative conclusions are drawn concerning poisoned baits for the differential grasshopper:

1. Half and half and 60-40 percent wheat bran and sawdust mixtures are fully as good as all bran.

2. Barley middlings is not entirely satisfactory as a substitute for wheat bran although it usually gives fairly good results when used in half and half mixtures with sawdust.

3. Dry horse manure is not a satisfactory substitute for wheat bran altho it is not without merit for use in emergencies.

4. A mixture composed of wheat and corn bran (not over 50 percent of the latter) is as good as straight wheat bran.

5. Canteloupes are fully equal to lemons as ingredients of poisoned baits.

6 Molasses does not add to the value of the bait.

7. London purple as the poisonous ingredient in baits is inferior to Paris green.

Owing to the shortage of wheat bran, barley middlings was extensively used in Arizona in 1918 as a substitute in grasshopper baits. It was necessary to use sawdust with the barley middlings to prevent lumping, the proportion used and advised being from two-fifths to one-half sawdust In the experiments here considered in which combinations of barley middlings were used approximately 120 acres of infested lands were treated The results were not as satisfactory as observed in many other cases where barley middlings and sawdust mixtures were used on large areas in demonstrations and in subsequent work by alfalfa and cotton growers. Fortunately it is probable that hereafter there will rarely if ever be any occasion for the use of barley middlings as a substitute for wheat bran

Horse manure has been recommended by the writer and successfully used in Arizona in grasshopper baits, mixed according to the formula known as "Criddle mixture," but this has not been tested particularly against the differential grasshopper as far as known. Outbreaks of the differential grasshopper occurred in 1918 in localities where neither wheat, bran, barley middlings or sawdust were available. In one instance it was reported that a farmer used dry horse manure in the place of bran with good results Tests made in the Salt River Valley in 1918 with dry horse manure in various combinations did not give very satisfactory results but more work with this material is very desirable and is planned for next season

Corn bran alone appeared inferior to barley middlings and sawdust but the conditions were such in the tests of this that even tentative conclusions could not be drawn. A wheat and corn bran mixture was used with almost perfect results. This mixture was purchased as wheat bran but was apparently nearly one-half corn bran

Of the nine series of experiments in 1918, six gave results relating to the use of molasses In four series in which molasses was omitted in one or more tests this did not appear to reduce the effectiveness of the baits. In one experiment in which the molasses was increased two-thirds over the usually recommended amount no

effect could be detected. In one series in which a medium light grade of molasses was used instead of the usually recommended darker grade the results were almost perfect, tending to show, independent of all other experiments, that a darker grade, particularly "Black Strap," is not necessary.

Baits for use against the differential grasshopper which can be tentatively recommended as a result of two seasons' work reduce the cost of the materials from approximately 50 cents to less than 35 cents. When cull canteloupes are available the cost runs as low as 30 cents per acre This is on the basis of one pound of Paris green to 5 acres of land.

Poisoned baits are the principal means of combatting cutworms. The regular grasshopper baits are generally recommended thruout the United States at present, altho a few years ago the simple combination of bran and Paris green with or without water was considered satisfactory. As far as known to the writer there are no published results of cutworm experiments showing the value of either lemons or molasses in combination with the bran and Paris green. An excellent opportunity for testing the bran, Paris green, and water combination against a common alfalfa pest *(Feltia annexa* Tr.) was afforded in the fall of 1918 with apparently perfect results. No live worms could be found in the treated field three weeks after the application altho they remained in destructive numbers in a nearby field which had not been poisoned. Cutworm poison consisting of half a sack of bran (32½ pounds) and one pound of Paris green costs at the present time at the rate of 36 cents per acre as compared with 50 cents or more per acre for the usual grasshopper bait containing molasses and lemons. It seems reasonable to assume until actual tests prove the contrary that molasses and lemons are unnecessary and of no value in baits for cutworms.

In connection with investigations of grasshoppers and cotton square daubers *(Lygus elisus* var. *hesperus* Knight and *L. pratensis oblineatus* Say) it was discovered that many cotton fields suffer from these pests as a result of the insects being driven out of adjoining alfalfa fields when the alfalfa crop is cut. As a result of observations made on this point an article was prepared and published in leading publications in cotton growing districts of the State recommending a system which helps to protect cotton from injury from this source. Alfalfa cutting and raking in fields adjoining cotton fields should be started on the sides and continued toward the central land or a land near to it on which alfalfa should be left standing temporarily. The grasshoppers and cotton square daubers are thus concentrated near the center of the field. The grass-

hoppers can then be destroyed by means of a comparatively heavy application of poisoned bait or by means of a hopperdozer. The hopperdozer proved successful in capturing large numbers of other destructive insects, particularly cotton square daubers and the three-cornered alfalfa hopper. In one test the daubers were captured at a rate of more than 7000 of the insects per acre. It is estimated that this number of the square daubers liberated in or driven into an Egyptian cotton field would be capable of doing damage amounting to between $5 00 and $15 00 per day. The cost of using the hopperdozer would not exceed 25 cents per acre. Even if the insects are not destroyed by this or other means it is very important in cutting alfalfa that they be driven into the middle of the field or away from the cotton rather than toward it.

The cotton square daubers are active fliers and if disturbed when feeding quickly emerge from the feeding place inside the bracts of the square and dart away, usually alighting on another plant a few feet distant. Two contrivances have been designed by the writer for the protection of cotton fields against these insects. The first is for the purpose of driving the bugs to the outside rows of the field where, when concentrated, they may be captured by means of the second device. Even if the insects are left concentrated on the outside rows there is a decided advantage in this system, since two or three of the insects per plant are sufficient to destroy all the squares as fast as they are developed, and concentrating the insects on outside rows so that there will be several times as many of them per plant can not, therefore, result in any additional injury. When concentrated in excessive numbers, however, there would probably be a tendency for the insects to spread out again over the field unless some other means was used against them An important feature of the work planned for the coming season consists in the development of the devices mentioned to a point where they can be recommended to cotton growers.

Publications by the Consulting Entomologist during the fiscal year included the Annual Report of the State Entomologist in the Ninth Annual Report of the Arizona Commission of Agriculture and Horticulture, pages 15 to 61, December 30, 1917, and a paper entitled "Experiments with Grasshopper Baits, with Incidental Observations on the Habits and Destructiveness of the Differential Grasshopper *(Melanoplus differentialis)*" in Journal of Economic Entomology, Vol. II, No. 2, pp. 175-186, April, 1918.

A. W. MORRILL,
Consulting Entomologist.

ZOOLOGY

Early in the college year 1917-18, the writer was transferred from the College of Arts and Sciences to the College of Agriculture and the Experiment Station, as Zoologist, this line of work having been previously represented in the Station only by Entomology under the Consulting Entomologist.

The first work taken up was an investigation of cutworms in Arizona, and the preparation of a bulletin to be referred to later. Shortly after taking up the cutworm work, attention was directed to the range problems of the State, particularly with reference to the injurious effects of rodents on the native grass lands. This problem soon loomed so large as to make it desirable to drop the cutworm work, and take up an intensive study of certain range rodents, which was done. Cooperation with the Forest Service, the Biological Survey, and the Carnegie Institution has led to the development of important range studies which are being conducted on the Santa Rita Range Reserve, 40 miles south of Tucson. The Forest Service, under the direct recommendation of the Biological Survey, has furnished funds (about $800) for the construction of special fences for experimental plots, the first fences of their kind ever built. The Forest Service has also cooperated in furnishing the conveniences of a headquarters camp on the edge of the Reserve, thru the courtesy of Mr. Hensel, Forest Examiner in charge. The writer has been occupied to a considerable extent with supervision of construction of these fences, as well as actual labor on same, and with rodent studies, especially on kangaroo rats, carried on month by month with the fencing work. It was expected to have these experimental areas fenced by June 30, 1918, but difficulties in securing materials and labor forced an extension of time, and they were not entirely completed until late fall. However, the drought was so severe on the Reserve, and especially on those portions of it where the experiments are located, that the inauguration of certain features of the work will have to await the next summer's rainy season

Severe injury to corn in the Rillito Valley near Tucson, by a stalk borer, was reported to the writer in October, 1917. This borer, according to Dr. Morrill, State Entomologist, was first reported in this State in 1915 from Cochise County. (See Eighth Ann. Rep. Ariz. Com. Agri. and Hort.) Some life-history observations were undertaken in cooperation with the Commission of Agriculture and Horticulture in order to secure adult moths and determine whether

this pest is identical with the larger corn stalk borer of the East. Moths have been secured which appear to be identical, but this latter point is not yet fully settled. Further reports have been received the past season indicating the presence of this borer at Sahuarita, in the Santa Cruz Valley. As a preventive measure where this borer occurs, the corn stubble should be plowed under during the fall or winter, and such stubble as is left on top of the ground should then be raked up and burned.

A beginning has been made on the task of building up a representative collection of the insects of the State, emphasizing especially the economic forms, for demonstration, and for general study purposes in the courses in Entomology in the College of Agriculture. This task will necessarily be continuous for a number of years.

The growing importance of honey during the sugar shortage and the extremely high market value of the product led to a decision to start, in a small way, an apiary for demonstration purposes and for study Four standard 10-frame hives have been secured, and three of these now contain thriving colonies of bees, transferred from old boxes on a neighboring ranch. At the University Farm four hives, left there by some former foreman, have been cleaned up and house as many strong colonies. Thus seven colonies are ready for active operation in the next honey season From the Farm hives some surplus chunk honey was secured the past season, which is being held against possible need in bringing all colonies thru the winter in good condition. There was also taken from these hives 24 pounds of comb honey, which was sold for thirty cents a pound, wholesale

PUBLICATIONS

The preparation of Bulletin No 83, on Poisonous Animals of the Desert, occupied a considerable amount of time in the earlier part of the year. This bulletin is perhaps a bit out of the ordinary in the usual run of Experiment Station bulletins. It deals with not only the poisonous animals of this region, but gives reliable information concerning many popularly feared, but actually harmless forms. The demand for this bulletin has justified its preparation.

CHAS. T. VORHIES,
Zoologist.

CHEMISTRY

The activities of the Chemists, as heretofore, have fallen under three divisions: research, routine analytical work, and instruction The facilities for research in soil alkalinity have been improved much by the construction of a screened garden so that now laboratory investigations may be accompanied by pot cultures and even small plot experiments. Such facilities are indispensable for protection against birds, insects, and rabbits, which because of the scarcity of green food in a semi-arid country preclude experiments on a small quantitative scale in the open. The general laboratory equipment has been improved by completing the equipment of a dark and nearly constant temperature room. The room is located near the center of the agricultural chemistry laboratories in the new Agriculture Building. Besides desks for calorimeter and polariscope the equipment includes a special table for ether extractions. A large refrigerator occupies the space beneath the table usually given to cupboards and is provided with water coils, which supply ice water for condensing purposes For several months in the year tap water cannot be used for condensing ether, a fact that heretofore has worked great inconvenience, requiring special cooling devices or the postponement of fat determinations until the winter months

Routine analytical work has covered a considerable range of material. Many irrigating waters and soils for alkali have been examined for farmers in the State, and much analytical work was required in connection with expert advice furnished other branches of the State and Federal Governments. The Chemist, accompanied by the Agronomist of the Station, examined and reported on a number of parcels of land offered the State for a state prison farm. In the case of all properties offered soil and water tests were made at the laboratory.

During November and December the Chemist was again called upon to serve on a commission, together with the Agronomist and Horticulturist, whose duty it was to investigate the suitability of the mesa at Yuma for citrus and other subtropical fruit culture, when irrigated with the silty waters of the Colorado as proposed by the U. S. Reclamation Service. The analytical and soil experimental work required in investigating this problem has occupied the personnel and facilities of the laboratories for several weeks. Total, acid soluble, and citric acid soluble potassium and phosphorus are being determined on a number of typical soil samples from the

Mesa. Mechanical analyses and tests of water holding capacities are being made, and parallel pot cultures using inoculated legumes are also included in the investigation. In cooperation with the Horticulturist a series of samples of citrus fruit from the old Blaisdell orchard on the Yuma Mesa have been analyzed with a view to showing their early maturing and other qualities. The details of these several lines of investigation will be found in the report of the commission to the Project Manager of the U. S. Reclamation Service at Yuma. This report, which is a joint report from the three departments concerned will be published as a bulletin by the Experiment Station and is here referred to as forming a part of the Chemist's annual report.

RESISTANCE OF CROPS TO ALKALI

A series of soil analyses illustrating the resistance of cotton and other crops to alkali under field conditions have accumulated in the laboratory and are given in Table XIX.

An inspection of Table XIX reveals the extreme difficulty of attempting to establish limits of tolerance for alkali under field conditions. Possible reasons may be offered for some of the discrepancies. First should be mentioned the difficulty of getting soil samples that really represent the conditions under which the plants are growing. The surface crust is always very alkaline and should not enter into the sample in greater relative proportion than it occurs. The roots of the plants may be drawing on other zones than the one sampled, alkali being known to vary abruptly with depth. In cultivated fields the variation in concentration also varies greatly within a few feet. The mechanical composition of the soil undoubtedly has much to do with alkali tolerance. In the case of black alkali dissolved organic matter possibly may be poisonous. One salt also influences the effect of another. Water soluble salts due to calcium sulphate are harmless, but calcium chloride or soluble magnesium salts are harmful forms of white alkali.

The soil 6819 carries excessive amounts of soluble salts, mostly sodium chloride, but it was said good crops were produced the previous year, and the land had again been prepared for planting. The sample analyzed was moist subsurface when collected. Dry surface clods with capillary contact ran much higher in soluble salt. The high tolerance in this case may be explained by the subirrigation which kept the soil constantly wet.

Barley soils 6823 and 6824 show the best growth in the case of

TABLE XIX.—RESISTANCE OF CROPS TO ALKALI UNDER FIELD CONDITIONS

Crop	Description	Soluble salts	Sodium chloride equivalent	Sodium carbonate equivalent	Calcium sulphate equivalent
		%	%	%	%
Cotton 6819	Good crop previous year; sub-irrigated by seepage from canal	1.06	.636	....	.48
Milo 6821	Adjoining above; yielded some milo previous year	.66	.360	..	.07
Cotton 6822	1¼ bales to acre; near above	.44	.016	..	.02
Barley 6823	Just failure at this point	.80	.306	.15	...
Barley 6824	Same field; just profitable	.71	148	.20	...
Barley 6825	Growing but failure; hard soil; poor water relations	.30	.040	.09	...
Barley 6826	Same field; commencing to head at 12 to 15 inches; thin	.26	.004	.10	...
Cotton 6827	Failure previous year; old stalks 1 foot high; land probably bakes	.35	.068	.02	...
Cotton 5828	Part same field; cotton good; soil very hard	.24	.02	.07	...
Cotton 6752	No cotton	2.29	1.408	...	.609
Cotton 6753	Same field; some growth	0.47	.168	...	.109
Cotton 6754	Tall cotton	.37	.152	...	.065
Teparies 5887	Edge of bare spots	.63	.124	...	.152
Teparies 5888	Same; bare spots	1.30	516	...	.416
Teparies 5889	Same; edge of bare spots	.55	.112	...	.174
Teparies 5890	Same; 50 percent injury	.42	.076	...	.109
Teparies 5898	Same healthy	.30	008	...	.022
Asparagus 6161	Plants just alive	1.50	.50	.22	..
Barley 6004	3" to 5" high; same field	1.32	.50	.02	...
Barley 6005	3½" high; same field	.43	008	.034	...
Barley 6006	4" to 7" high; same field	.88	26	.017	...
Barley 6007	4" high; same field	.41	.008	.12	...
Feterita 6203	Barely existing	.50	.012	.15	...
Feterita 6204	Same; scattering light growth	.49	.012	.12	...
Feterita 6205	Same; 35 percent stand	.23	.008	.06	...
Feterita 6206	Same; 50 percent stand	.24	.008	.04	...

TABLE XIX.—*Continued*

Crop	Description	Soluble salts	Sodium chloride equivalent	Sodium carbonate equivalent	Calcium sulphate equivalent
		%	%	%	%
Feterita 6207	Same; good crop	22	.008	.02	
Feterita 6212	Adpacent land; 25 percent stan(	32	.008	.22	...
Feterita 6213	Same; good crop..... ..	30	.008	.06	.
Feterita 6214	Same; almost killed.	.33	.008	.12	...
Feterita 6215	Same; very good crop.....	.32	008	.03	..
Milo 6210	Adjacent land; barely existing	.59	.036	.13	...
Milo 6211	Same; very good crop.....	.32	.008	.05	...
Alfalfa 5979	At head of land; no alfalfa...	57	152	.19	...
Alfalfa 5980	Same; good alfalfa.....	38	048	.10	...
Alfalfa 6197	Killed.....	.82	.024	.33	...
Alfalfa 6198	Same; just existing.....	.42	.012	.12	...
Alfalfa 6199	Same; affected...	27	.012	.05	...
Alfalfa 6200	Same; good growth.....	29	.012	.04	...

the latter which contained one-third more black alkali; but it is to be noted that the first contains twice as much sodium chloride. The failure in 6825 and 6826 as compared with 6824 was due probably to a hard condition of the soil intensified by the deflocculating effect of the black alkali so that water did not penetrate well when the soil was irrigated—so-called slick land.

In the case of cotton soils 6752, 6753, and 6754 white alkali is the limiting salt but there is no apparent explanation for the marked difference in growth between 6753 and 6754. Teparies are apparently quite sensitive to soluble chlorides. Asparagus, which is ordinarily a salt-loving plant, was affected by black alkali in the presence of the rather excessive amount of white alkali. The series of barley soils 6004, 6005, 6006, and 6007 seem to yield no conclusive evidence. The injury thruout was probably due to a tight soil intensified by the varying amounts of black alkali present which prevented it from taking sufficient water. The feterita and milo series were taken from sandy soils at the University Farm, which are discussed in the section of this report dealing with alkali studies. This soil is particularly favorable for study of black alkali tolerance, since the sodium chloride is uniformly low, the white alkali being

due to sodium sulphate. Here again, however, results are not entirely consistent, probably due to water conditions. In general .10 seems to be the limiting percent of black alkali for these crops, altho in one case a considerable stand was found where .22 percent was present and considerable injury was noted where .06 percent was present in samples believed to represent the soil under field conditions. The alfalfa soils illustrate to a certain extent the influence of texture. Sample 5980 was a rather heavy soil occurring near Wellton, Arizona, while 6197, 6198, 6199, and 6200 were from the sandy soil of the University Farm.

MISCELLANEOUS ANALYSES

One interesting set of samples came from a mining company that had failed in an attempt to raise a war garden and sought a remedy. The soil was impregnated with copper, and the mine water which was used for irrigating carried so much copper that possibly it might have been recovered with profit. Such conditions would inhibit practically all plant growth.

Various materials of agricultural interest other than soils and irrigating waters have been examined by the Chemists. These include foods and feeding stuffs such as barley flour, barley bran, cottonseed meal, and fish meal. Only moisture, ash, and ether extract were determined in the barley flour. Barley flour, being a wartime product, probably will be of transient interest, but since the product is rather uncommon and produced in Arizona the results are recorded in Table XX.

TABLE XX.—COMPOSITION OF ARIZONA BARLEY FLOUR

Date of Mill Run	Moisture	Ash	Ether Extract
	%	%	%
August 12, 1918.....	7 63	1.13	2 18
" 13, "	7 73	1.12	2 19
" 14, "	6 57	1.19	2 08
" 15, "	6.45	1.25	2 21

Fertilizing materials or materials supposed to carry fertilizer values, especially bat guanos, have been sent in from time to time. On one occasion the Chemists visited a bat cave deposit with a prospector and advised against the shipment as unprofitable.

At the time when food stuffs in general were suspected of having been tampered with, a number of samples of corn meal and cocoa were sent in to be examined for powdered glass. Several

grams of the material were dissolved in boiling sulphuric acid till almost colorless, the acid diluted and decanted from any residue remaining undissolved. All the corn meals left small residues of easily identified minerals, such as quartz and garnet, but no glass. One sack of meal contained several large fragments of glass which could not have been eaten and evidently were intended to create prejudice rather than to do injury. No fine glass was found in any of the samples, but the millers in all cases were cautioned to clean their corn so that no adhering soil would be carried into the meal, causing grit that might be mistaken for glass. One sample of cocoa was found to contain a few very minute fragments of glass-like material which may have been chipped off the porcelain lining of some machinery used in its preparation. One sample of bran that was reported to have killed a calf was found to contain cyanide

THE TEMPE DRAINAGE DITCH

In continuation of the work reported in the Twenty-seventh and Twenty-eighth Annual Reports occasional analyses of the discharge of the Tempe drainage ditch have been made. The results for the year 1918 are detailed in Table XXI which should be studied in connection with previous results given in the Twenty-eighth Annual Report on page 475.

TABLE XXI.—MONTHLY VARIATION IN COMPOSITION OF WATER FROM THE TEMPE DRAINAGE DITCH, PARTS PER 100,000—BY C. N. CATLIN

Date	Total Solids	Chlorides as NaCl.	Hardness (permanent) $CaSO_4$	Hardness (temporary) $Ca(HCO_3)_2$	Alkalinity Na_2CO_3	Qualitative		
						SO_4	CaO	MgO
1918								
Jan. 10	212 6	133 0	1.1	127 5		Str	Mod.	Sl.
Feb. 10	322 0	219 0	11.5	130 0		Str	Mod-S	Mod.
Mar 10	303 0	211 0	18.5	127 2		Str.	Mod-S	Mod.
Apr. 10	226 4	154 0		112.6	1 7	M S.	M.	M.S.
May 11	351.2	248.0	11 9	128.4		M.S.	M..	M.
June 5	296 6	207.0	6 5	118.3		M S.	M.	M.
July 8	301	206.0	1.1	113.8		S.	M.	M.
Aug. 1	249.8	181.0		69.5	2.5	M.S.	M.	M.
Sept.				No Sample				
Oct. 10	205 8	137.0		93.5	5.9	M S.	M.	M.
Nov 3	245 0	170.0		87.4	5.9	M.S.	M.	M.
Dec. 12	216 6	138.0	2.2	127.5		M S.	M.	M.

ALKALI STUDIES

The research work of the department conducted under the Adams Fund has been limited to alkali problems. During the past year the Chemists have studied the influence of various chemicals in different amounts on the rate of percolation and on the composition

of the percolate. This involves much analytical work. Attempts were made to parallel the laboratory studies by pot cultures which at first proved unsatisfactory due to the difficulty of preventing leaching when the pots were irrigated and the consequent change of concentration of alkali in the soils. Successful pot culture studies in this climate require that the pots be sunk in soil to prevent too high temperature and excessive drying. Benches have now been constructed in the screened garden in which the pots are sunk in sand at the level of the surrounding soil and any percolating water due to heavy irrigating is caught in receptacles and returned to the pots. The pots are paraffined to prevent losses by transfusion.

The percolation experiments with gypsum have been especially interesting. When a percolation test is made comparing untreated University Farm soil with samples to which the theoretical amount and half that amount of gypsum have been added, it is found that the second half of the gypsum applied has two or three times the effect of the first half in promoting percolation. Large plot experiments are now being conducted which are planned to test this result in a practical way. Several lands at the University Farm have been divided into numerous small plots each of which has been analyzed to a depth of three feet and the necessary amount of gypsum calculated separately for each plot of 1500 to 2000 square feet. These lands had been treated previously by applying gypsum uniformly over the surface, but without reclaiming them successfully. After the proper amount of gypsum has been applied, the lands will be leached by confining the water on the more alkaline areas. Without gypsum, percolation is very slow, altho the soil is a very fine sand. In the laboratory water applied an inch deep to the wet soil in 10-inch flower pots and covered to prevent evaporation has stood for two or three weeks without entirely disappearing. It appears from the investigations in the laboratory that light or insufficient applications of gypsum would be unprofitable. On some areas it is necessary to apply 30 or even 40 tons of gypsum to the acre. Under some conditions this would be prohibited, and never could be considered for large areas. Gypsum beds, however, are available near the University Farm and hauling is done by the farm teams when other work is light. Small areas of black alkali in otherwise good lands, as is the condition at the University Farm, would often warrant the expenditure of several hundred dollars for reclamation. How permanent the effect will be remains to be shown. The groundwaters

are slightly black alkaline and occasionally rise to within seven or eight feet of the surface. The effect of gypsum on the rate of percolation with this soil in 10-inch pots is given in Table XXII

TABLE XXII.—PERCOLATION THRU UNIVERSITY FARM SOIL AFTER GYPSUM TREATMENT

Amount used	Percolate in 24 hours[1] after standing 5 days	Percolate in 24 hours[2] after standing 7 days
	C.C.	C.C.
None	400	288
Half enough to neutralize Na_2CO_3	880	696
Just enough to neutralize Na_2CO_3	2560	2112
Twice amount to neutralize Na_2CO_3	3680[3]	4320

1. Calculated from a 6-hour test by adding 1000C C. of water to each pot. 2. Insufficient head to keep up percolation for 5 hours. 3. Calculated from a 5-hour test by adding 1000 C.C. of water to each pot. Note: The 10-inch pots used in these tests each contained 10 kilos of soil. The soil used gave the following analysis: Total water soluble salts dried at 110° C. .70 percent, chlorides as sodium chloride .012 percent, black alkali as sodium carbonate .254 percent.

An analysis of the percolates showed a saving in humus and all plant foods with the exception of potassium. The saving in nitrogen values at customary fertilizer prices would go far toward paying for the gypsum treatment, even if it were possible to reach the black alkali from the soil without the previous application of gypsum.

DATE PROCESSING AND MARKETING

During the summer the appliances for ripening and processing dates at the Tempe Date Orchard were inspected and put in order for handling the fall crop. Several visits were made to the orchard during the harvest to supervise the packing house operations and give instructions in handling the different varieties under varying weather conditions. A suitable packing house for the Yuma Orchard has been designed but not yet constructed. Before the arrival of the Horticulturist the Chemist temporarily supervised cultural operations at the date orchards.

In the opinion of the writer after thirteen years of close study, the date industry in Arizona, properly managed, can be recommended to the investing public. Fresh dates of the soft varieties which can be grown of such excellent quality in Arizona and marketed as safely as any other crop are becoming known thruout the country, and orders and inquiries from every part of the United States are coming in quantities—a marked contrast to the condition ten years ago when the foreman of the orchard with difficulty disposed of a few hundreds pounds at a nominal price by

house to house peddling in nearby towns. During the past year over $6000 without soliciting have been received for the product of palms that could have been placed on about four acres. After paying liberal wages and other operating expenses, exclusive of the foreman's salary, a net profit of 40 or 50 per cent on the gross sales will be realized. Had the usual business policy of selling for all the market would bear been followed, the gross sales probably would have reached $10,000. The policy followed, however, has been to maintain a uniform, fair price, estimated safely to cover expenses, and limit sales to the individual. A part of the crop has been marketed in the east to introduce the product and create a market for future growers. The immediate vicinity would have consumed the crop many times over at even higher prices, had limitations not been placed on sales to the individual. The Experiment Station has proven at least some of the varieties that are successful in Arizona; climatic difficulties have been overcome to the extent that losses due to this cause are almost negligible; and a market has been made that will take the output of a large acreage at profitable prices. Fresh soft dates, such as Hayany, Rhars, Tadala, and similar varieties, promise to become a staple food as soon as they can be supplied in quantity, and may be carried for months in dry cold storage without serious deterioration in quality. Culls and stock that have been damaged for the fresh date trade by weather conditions can be processed quickly for ordinary commercial dried dates. The close of the war should mark the importation of large numbers of Hayany offshoots from Egypt, and the establishment of the date industry in Arizona on a firm basis.

EDUCATIONAL AND EXTENSION WORK

Altho the department is not identified with the Extension Service, a large amount of correspondence regarding soils and irrigating waters is necessarily carried on with the farmers of the State. These demands, as previously mentioned, often require much analytical work. In February and March a four weeks' short course for farmers was given, during which the Chemist conducted a class in soils for two periods each week. A correspondence course in soil physics is being given. In the College of Agriculture the Chemist has conducted classes in soil physics and soil fertility. A laboratory course in agricultural chemical analysis is also offered, but due to temporary disarrangements has not been given. Two new courses in household chemistry for young women in Home

Economics are being given. The first semester's course, after a brief introduction to organic chemistry, largely nomenclature, deals with the chemistry of foods. The laboratory exercises are designed to familiarize the student with the compounds occurring in foods rather than as a drill in analytical methods. The second semester deals with textiles and laundering, including the removal of stains

The department is well equipped for work with advanced or graduate students. Some of the problems under investigation in the Experiment Station may be entered into by the students or independent investigations may be made. Work in this line should be encouraged by offering suitable fellowships which would be to the mutual benefit of the student, the department, and the Experiment Station.

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

ENTOMOLOGY

In continuation of the experiments with grasshopper baits begun in 1917, forty combinations were tested in 1918, beginning in the month of May. Definite records were made concerning applications of these combinations to 269 acres of alfalfa and cotton lands. In this work assistance was rendered in various ways by Messrs. O. C. Bartlett, D. C George, J. L. E. Lauderdale, George Acuff, M. E. Kimsey, and R. H. Armstrong. The work was directed against the same species as in 1917, the differential grasshopper, *Melanoplus differentialis*. The tests were all made in the Salt River Valley with the exception of one application made by the writer in a ten-acre alfalfa field in the Verde Valley near Camp Verde.

The movement or drifting of the grasshoppers in the fields both toward and away from poisoned areas tends to confuse the results of experiments with poisoned baits and makes it necessary to repeat the tests many times under various conditions before drawing final conclusions. Tentative conclusions from the work done in 1917 are as follows:

1. A combination of half and half wheat bran and pine sawdust is fully equal to wheat bran alone for the bulk of the substance of the bait and is easier to distribute than when all wheat bran is used.

2. All sawdust is decidedly inferior to all bran or to a half and half bran-sawdust mixture.

3. For the fruit, oranges are in no degree inferior to lemons and are perhaps slightly better.

4. Canteloupes are in no degree inferior to lemons but on the contrary are apparently slightly superior as well as cheaper.

5. Molasses is not only an unnecessary ingredient of poisoned baits but when used with citrus fruits the effectiveness of the bait is reduced rather than increased.

From the experiments conducted in the summer of 1918 the following tentative conclusions are drawn concerning poisoned baits for the differential grasshopper:

1. Half and half and 60-40 percent wheat bran and sawdust mixtures are fully as good as all bran.

2. Barley middlings is not entirely satisfactory as a substitute for wheat bran although it usually gives fairly good results when used in half and half mixtures with sawdust.

3. Dry horse manure is not a satisfactory substitute for wheat bran altho it is not without merit for use in emergencies.

4. A mixture composed of wheat and corn bran (not over 50 percent of the latter) is as good as straight wheat bran.

5. Canteloupes are fully equal to lemons as ingredients of poisoned baits.

6 Molasses does not add to the value of the bait.

7. London purple as the poisonous ingredient in baits is inferior to Paris green.

Owing to the shortage of wheat bran, barley middlings was extensively used in Arizona in 1918 as a substitute in grasshopper baits. It was necessary to use sawdust with the barley middlings to prevent lumping, the proportion used and advised being from two-fifths to one-half sawdust. In the experiments here considered in which combinations of barley middlings were used approximately 120 acres of infested lands were treated. The results were not as satisfactory as observed in many other cases where barley middlings and sawdust mixtures were used on large areas in demonstrations and in subsequent work by alfalfa and cotton growers. Fortunately it is probable that hereafter there will rarely if ever be any occasion for the use of barley middlings as a substitute for wheat bran.

Horse manure has been recommended by the writer and successfully used in Arizona in grasshopper baits, mixed according to the formula known as "Criddle mixture," but this has not been tested particularly against the differential grasshopper as far as known. Outbreaks of the differential grasshopper occurred in 1918 in localities where neither wheat, bran, barley middlings or sawdust were available. In one instance it was reported that a farmer used dry horse manure in the place of bran with good results. Tests made in the Salt River Valley in 1918 with dry horse manure in various combinations did not give very satisfactory results but more work with this material is very desirable and is planned for next season.

Corn bran alone appeared inferior to barley middlings and sawdust but the conditions were such in the tests of this that even tentative conclusions could not be drawn. A wheat and corn bran mixture was used with almost perfect results. This mixture was purchased as wheat bran but was apparently nearly one-half corn bran.

Of the nine series of experiments in 1918, six gave results relating to the use of molasses. In four series in which molasses was omitted in one or more tests this did not appear to reduce the effectiveness of the baits. In one experiment in which the molasses was increased two-thirds over the usually recommended amount no

effect could be detected. In one series in which a medium light grade of molasses was used instead of the usually recommended darker grade the results were almost perfect, tending to show, independent of all other experiments, that a darker grade, particularly "Black Strap," is not necessary.

Baits for use against the differential grasshopper which can be tentatively recommended as a result of two seasons' work reduce the cost of the materials from approximately 50 cents to less than 35 cents. When cull canteloupes are available the cost runs as low as 30 cents per acre. This is on the basis of one pound of Paris green to 5 acres of land.

Poisoned baits are the principal means of combatting cutworms. The regular grasshopper baits are generally recommended thruout the United States at present, altho a few years ago the simple combination of bran and Paris green with or without water was considered satisfactory. As far as known to the writer there are no published results of cutworm experiments showing the value of either lemons or molasses in combination with the bran and Paris green. An excellent opportunity for testing the bran, Paris green, and water combination against a common alfalfa pest *(Feltia annexa* Tr.) was afforded in the fall of 1918 with apparently perfect results. No live worms could be found in the treated field three weeks after the application altho they remained in destructive numbers in a nearby field which had not been poisoned. Cutworm poison consisting of half a sack of bran (32½ pounds) and one pound of Paris green costs at the present time at the rate of 36 cents per acre as compared with 50 cents or more per acre for the usual grasshopper bait containing molasses and lemons. It seems reasonable to assume until actual tests prove the contrary that molasses and lemons are unnecessary and of no value in baits for cutworms.

In connection with investigations of grasshoppers and cotton square daubers *(Lygus elisus* var. *hesperus* Knight and *L. pratensis oblineatus* Say) it was discovered that many cotton fields suffer from these pests as a result of the insects being driven out of adjoining alfalfa fields when the alfalfa crop is cut. As a result of observations made on this point an article was prepared and published in leading publications in cotton growing districts of the State recommending a system which helps to protect cotton from injury from this source. Alfalfa cutting and raking in fields adjoining cotton fields should be started on the sides and continued toward the central land or a land near to it on which alfalfa should be left standing temporarily. The grasshoppers and cotton square daubers are thus concentrated near the center of the field. The grass-

hoppers can then be destroyed by means of a comparatively heavy application of poisoned bait or by means of a hopperdozer. The hopperdozer proved successful in capturing large numbers of other destructive insects, particularly cotton square daubers and the three-cornered alfalfa hopper. In one test the daubers were captured at a rate of more than 7000 of the insects per acre It is estimated that this number of the square daubers liberated in or driven into an Egyptian cotton field would be capable of doing damage amounting to between $5 00 and $15 00 per day. The cost of using the hopperdozer would not exceed 25 cents per acre. Even if the insects are not destroyed by this or other means it is very important in cutting alfalfa that they be driven into the middle of the field or away from the cotton rather than toward it.

The cotton square daubers are active fliers and if disturbed when feeding quickly emerge from the feeding place inside the bracts of the square and dart away, usually alighting on another plant a few feet distant Two contrivances have been designed by the writer for the protection of cotton fields against these insects. The first is for the purpose of driving the bugs to the outside rows of the field where, when concentrated, they may be captured by means of the second device. Even if the insects are left concentrated on the outside rows there is a decided advantage in this system, since two or three of the insects per plant are sufficient to destroy all the squares as fast as they are developed, and concentrating the insects on outside rows so that there will be several times as many of them per plant can not, therefore, result in any additional injury. When concentrated in excessive numbers, however, there would probably be a tendency for the insects to spread out again over the field unless some other means was used against them. An important feature of the work planned for the coming season consists in the development of the devices mentioned to a point where they can be recommended to cotton growers.

Publications by the Consulting Entomologist during the fiscal year included the Annual Report of the State Entomologist in the Ninth Annual Report of the Arizona Commission of Agriculture and Horticulture, pages 15 to 61, December 30, 1917, and a paper entitled "Experiments with Grasshopper Baits, with Incidental Observations on the Habits and Destructiveness of the Differential Grasshopper *(Melanoplus differentialis)*" in Journal of Economic Entomology, Vol. II, No. 2, pp. 175-186, April, 1918.

A. W. MORRILL,
Consulting Entomologist.

ZOOLOGY

Early in the college year 1917-18, the writer was transferred from the College of Arts and Sciences to the College of Agriculture and the Experiment Station, as Zoologist, this line of work having been previously represented in the Station only by Entomology under the Consulting Entomologist.

The first work taken up was an investigation of cutworms in Arizona, and the preparation of a bulletin to be referred to later. Shortly after taking up the cutworm work, attention was directed to the range problems of the State, particularly with reference to the injurious effects of rodents on the native grass lands. This problem soon loomed so large as to make it desirable to drop the cutworm work, and take up an intensive study of certain range rodents, which was done. Cooperation with the Forest Service, the Biological Survey, and the Carnegie Institution has led to the development of important range studies which are being conducted on the Santa Rita Range Reserve, 40 miles south of Tucson. The Forest Service, under the direct recommendation of the Biological Survey, has furnished funds (about $800) for the construction of special fences for experimental plots, the first fences of their kind ever built. The Forest Service has also cooperated in furnishing the conveniences of a headquarters camp on the edge of the Reserve, thru the courtesy of Mr. Hensel, Forest Examiner in charge. The writer has been occupied to a considerable extent with supervision of construction of these fences, as well as actual labor on same, and with rodent studies, especially on kangaroo rats, carried on month by month with the fencing work. It was expected to have these experimental areas fenced by June 30, 1918, but difficulties in securing materials and labor forced an extension of time, and they were not entirely completed until late fall. However, the drought was so severe on the Reserve, and especially on those portions of it where the experiments are located, that the inauguration of certain features of the work will have to await the next summer's rainy season

Severe injury to corn in the Rillito Valley near Tucson, by a stalk borer, was reported to the writer in October, 1917. This borer, according to Dr. Morrill, State Entomologist, was first reported in this State in 1915 from Cochise County. (See Eighth Ann. Rep. Ariz. Com. Agri. and Hort.) Some life-history observations were undertaken in cooperation with the Commission of Agriculture and Horticulture in order to secure adult moths and determine whether

this pest is identical with the larger corn stalk borer of the East. Moths have been secured which appear to be identical, but this latter point is not yet fully settled. Further reports have been received the past season indicating the presence of this borer at Sahuarita, in the Santa Cruz Valley. As a preventive measure where this borer occurs, the corn stubble should be plowed under during the fall or winter, and such stubble as is left on top of the ground should then be raked up and burned.

A beginning has been made on the task of building up a representative collection of the insects of the State, emphasizing especially the economic forms, for demonstration, and for general study purposes in the courses in Entomology in the College of Agriculture. This task will necessarily be continuous for a number of years.

The growing importance of honey during the sugar shortage and the extremely high market value of the product led to a decision to start, in a small way, an apiary for demonstration purposes and for study. Four standard 10-frame hives have been secured, and three of these now contain thriving colonies of bees, transferred from old boxes on a neighboring ranch. At the University Farm four hives, left there by some former foreman, have been cleaned up and house as many strong colonies Thus seven colonies are ready for active operation in the next honey season. From the Farm hives some surplus chunk honey was secured the past season, which is being held against possible need in bringing all colonies thru the winter in good condition There was also taken from these hives 24 pounds of comb honey, which was sold for thirty cents a pound, wholesale

PUBLICATIONS

The preparation of Bulletin No 83, on Poisonous Animals of the Desert, occupied a considerable amount of time in the earlier part of the year This bulletin is perhaps a bit out of the ordinary in the usual run of Experiment Station bulletins. It deals with not only the poisonous animals of this region, but gives reliable information concerning many popularly feared, but actually harmless forms. The demand for this bulletin has justified its preparation.

CHAS. T. VORHIES,
Zoologist.

CHEMISTRY

The activities of the Chemists, as heretofore, have fallen under three divisions: research, routine analytical work, and instruction The facilities for research in soil alkalinity have been improved much by the construction of a screened garden so that now laboratory investigations may be accompanied by pot cultures and even small plot experiments. Such facilities are indispensable for protection against birds, insects, and rabbits, which because of the scarcity of green food in a semi-arid country preclude experiments on a small quantitative scale in the open. The general laboratory equipment has been improved by completing the equipment of a dark and nearly constant temperature room. The room is located near the center of the agricultural chemistry laboratories in the new Agriculture Building. Besides desks for calorimeter and polariscope the equipment includes a special table for ether extractions A large refrigerator occupies the space beneath the table usually given to cupboards and is provided with water coils, which supply ice water for condensing purposes. For several months in the year tap water cannot be used for condensing ether, a fact that heretofore has worked great inconvenience, requiring special cooling devices or the postponement of fat determinations until the winter months.

Routine analytical work has covered a considerable range of material Many irrigating waters and soils for alkali have been examined for farmers in the State, and much analytical work was required in connection with expert advice furnished other branches of the State and Federal Governments. The Chemist, accompanied by the Agronomist of the Station, examined and reported on a number of parcels of land offered the State for a state prison farm In the case of all properties offered soil and water tests were made at the laboratory.

During November and December the Chemist was again called upon to serve on a commission, together with the Agronomist and Horticulturist, whose duty it was to investigate the suitability of the mesa at Yuma for citrus and other subtropical fruit culture, when irrigated with the silty waters of the Colorado as proposed by the U. S. Reclamation Service. The analytical and soil experimental work required in investigating this problem has occupied the personnel and facilities of the laboratories for several weeks. Total, acid soluble, and citric acid soluble potassium and phosphorus are being determined on a number of typical soil samples from the

Mesa. Mechanical analyses and tests of water holding capacities are being made, and parallel pot cultures using inoculated legumes are also included in the investigation. In cooperation with the Horticulturist a series of samples of citrus fruit from the old Blaisdell orchard on the Yuma Mesa have been analyzed with a view to showing their early maturing and other qualities. The details of these several lines of investigation will be found in the report of the commission to the Project Manager of the U. S. Reclamation Service at Yuma. This report, which is a joint report from the three departments concerned will be published as a bulletin by the Experiment Station and is here referred to as forming a part of the Chemist's annual report.

RESISTANCE OF CROPS TO ALKALI

A series of soil analyses illustrating the resistance of cotton and other crops to alkali under field conditions have accumulated in the laboratory and are given in Table XIX.

An inspection of Table XIX reveals the extreme difficulty of attempting to establish limits of tolerance for alkali under field conditions. Possible reasons may be offered for some of the discrepancies. First should be mentioned the difficulty of getting soil samples that really represent the conditions under which the plants are growing. The surface crust is always very alkaline and should not enter into the sample in greater relative proportion than it occurs. The roots of the plants may be drawing on other zones than the one sampled, alkali being known to vary abruptly with depth. In cultivated fields the variation in concentration also varies greatly within a few feet. The mechanical composition of the soil undoubtedly has much to do with alkali tolerance. In the case of black alkali dissolved organic matter possibly may be poisonous. One salt also influences the effect of another. Water soluble salts due to calcium sulphate are harmless, but calcium chloride or soluble magnesium salts are harmful forms of white alkali.

The soil 6819 carries excessive amounts of soluble salts, mostly sodium chloride, but it was said good crops were produced the previous year, and the land had again been prepared for planting. The sample analyzed was moist subsurface when collected. Dry surface clods with capillary contact ran much higher in soluble salt. The high tolerance in this case may be explained by the subirrigation which kept the soil constantly wet.

Barley soils 6823 and 6824 show the best growth in the case of

TABLE XIX.—RESISTANCE OF CROPS TO ALKALI UNDER FIELD CONDITIONS

Crop	Description	Soluble salts	Sodium chloride equivalent	Sodium carbonate equivalent	Calcium sulphate equivalent
		%	%	%	%
Cotton 6819	Good crop previous year; sub-irrigated by seepage from canal	1 06	.636	....	.48
Milo 6821	Adjoining above; yielded some milo previous year	.66	.360	...	.07
Cotton 6822	1¼ bales to acre; near above	.44	.016	...	02
Barley 6823	Just failure at this point	.80	.306	.15	...
Barley 6824	Same field; just profitable	.71	.148	.20	...
Barley 6825	Growing but failure; hard soil; poor water relations	.30	.040	.09	...
Barley 6826	Same field; commencing to head at 12 to 15 inches; thin	.26	.004	.10	...
Cotton 6827	Failure previous y e a r; old stalks 1 foot high; land probably bakes	.35	.068	.02	...
Cotton 5828	Part same field; cotton good; soil very hard	.24	.02	.07	...
Cotton 6752	No cotton	2 29	1.408	...	.609
Cotton 6753	Same field; some growth	0 47	.168	...	.109
Cotton 6754	Tall cotton	37	.152	...	.065
Teparies 5887	Edge of bare spots	.63	.124	...	.152
Teparies 5888	Same; bare spots	1.30	516	...	.416
Teparies 5889	Same; edge of bare spots	55	.112	...	.174
Teparies 5890	Same; 50 percent injury	.42	.076	...	.109
Teparies 5898	Same healthy	.30	008	...	.022
Asparagus 6161	Plants just alive	1 50	.50	.22	..
Barley 6004	3" to 5" high; same field	1.32	.50	.02	...
Barley 6005	3½" high; same field	.43	.008	.034	...
Barley 6006	4" to 7" high; same field	88	.26	.017	...
Barley 6007	4" high; same field	.41	.008	.12	...
Feterita 6203	Barely existing	.50	012	.15	...
Feterita 6204	Same; scattering light growth	.49	012	.12	...
Feterita 6205	Same; 35 percent stand	.23	.008	.06	...
Feterita 6206	Same; 50 percent stand	.24	.008	.04	...

TABLE XIX.—*Continued*

Crop	Description	Soluble salts	Sodium chloride equivalent	Sodium carbonate equivalent	Calcium sulphate equivalent
		%	%	%	%
Feterita 6207	Same; good crop	.22	.008	.02	...
Feterita 6212	Adpacent land; 25 percent stanc	.32	.008	.22	...
Feterita 6213	Same; good crop.....	.30	.008	.06	...
Feterita 6214	Same; almost killed.....	.33	.008	.12	...
Feterita 6215	Same; very good crop.....	.32	.008	.03	...
Milo 6210	Adjacent land; barely existing	.59	.036	.13	...
Milo 6211	Same; very good crop.....	.32	.008	.05	...
Alfalfa 5979	At head of land; no alfalfa...	.57	.152	.19	...
Alfalfa 5980	Same; good alfalfa.....	.38	.048	.10	...
Alfalfa 6197	Killed.....	.82	.024	.33	...
Alfalfa 6198	Same; just existing.....	.42	.012	.12	...
Alfalfa 6199	Same; affected	.27	.012	.05	...
Alfalfa 6200	Same; good growth.....	.29	.012	.04	...

the latter which contained one-third more black alkali; but it is to be noted that the first contains twice as much sodium chloride. The failure in 6825 and 6826 as compared with 6824 was due probably to a hard condition of the soil intensified by the deflocculating effect of the black alkali so that water did not penetrate well when the soil was irrigated—so-called slick land.

In the case of cotton soils 6752, 6753, and 6754 white alkali is the limiting salt but there is no apparent explanation for the marked difference in growth between 6753 and 6754. Teparies are apparently quite sensitive to soluble chlorides. Asparagus, which is ordinarily a salt-loving plant, was affected by black alkali in the presence of the rather excessive amount of white alkali. The series of barley soils 6004, 6005, 6006, and 6007 seem to yield no conclusive evidence. The injury thruout was probably due to a tight soil intensified by the varying amounts of black alkali present which prevented it from taking sufficient water. The feterita and milo series were taken from sandy soils at the University Farm, which are discussed in the section of this report dealing with alkali studies. This soil is particularly favorable for study of black alkali tolerance, since the sodium chloride is uniformly low, the white alkali being

due to sodium sulphate. Here again, however, results are not entirely consistent, probably due to water conditions. In general .10 seems to be the limiting percent of black alkali for these crops, altho in one case a considerable stand was found where .22 percent was present and considerable injury was noted where .06 percent was present in samples believed to represent the soil under field conditions. The alfalfa soils illustrate to a certain extent the influence of texture. Sample 5980 was a rather heavy soil occurring near Wellton, Arizona, while 6197, 6198, 6199, and 6200 were from the sandy soil of the University Farm.

MISCELLANEOUS ANALYSES

One interesting set of samples came from a mining company that had failed in an attempt to raise a war garden and sought a remedy. The soil was impregnated with copper, and the mine water which was used for irrigating carried so much copper that possibly it might have been recovered with profit. Such conditions would inhibit practically all plant growth.

Various materials of agricultural interest other than soils and irrigating waters have been examined by the Chemists. These include foods and feeding stuffs such as barley flour, barley bran, cottonseed meal, and fish meal. Only moisture, ash, and ether extract were determined in the barley flour. Barley flour, being a wartime product, probably will be of transient interest, but since the product is rather uncommon and produced in Arizona the results are recorded in Table XX.

TABLE XX.—COMPOSITION OF ARIZONA BARLEY FLOUR

Date of Mill Run	Moisture	Ash	Ether Extract
	%	%	%
August 12, 1918.....	7.63	1.13	2.18
" 13, "	7.73	1.12	2.19
" 14, "	6.57	1.19	2.08
" 15, "	6.45	1.25	2.21

Fertilizing materials or materials supposed to carry fertilizer values, especially bat guanos, have been sent in from time to time. On one occasion the Chemists visited a bat cave deposit with a prospector and advised against the shipment as unprofitable.

At the time when food stuffs in general were suspected of having been tampered with, a number of samples of corn meal and cocoa were sent in to be examined for powdered glass. Several

grams of the material were dissolved in boiling sulphuric acid till almost colorless, the acid diluted and decanted from any residue remaining undissolved. All the corn meals left small residues of easily identified minerals, such as quartz and garnet, but no glass. One sack of meal contained several large fragments of glass which could not have been eaten and evidently were intended to create prejudice rather than to do injury. No fine glass was found in any of the samples, but the millers in all cases were cautioned to clean their corn so that no adhering soil would be carried into the meal, causing grit that might be mistaken for glass. One sample of cocoa was found to contain a few very minute fragments of glass-like material which may have been chipped off the porcelain lining of some machinery used in its preparation. One sample of bran that was reported to have killed a calf was found to contain cyanide.

THE TEMPE DRAINAGE DITCH

In continuation of the work reported in the Twenty-seventh and Twenty-eighth Annual Reports occasional analyses of the discharge of the Tempe drainage ditch have been made. The results for the year 1918 are detailed in Table XXI which should be studied in connection with previous results given in the Twenty-eighth Annual Report on page 475.

TABLE XXI.—MONTHLY VARIATION IN COMPOSITION OF WATER FROM THE TEMPE DRAINAGE DITCH, PARTS PER 100,000—BY C. N. CATLIN

Date	Total Solids	Chlorides as NaCl.	Hardness (permanent) $CaSO_4$	Hardness (temporary) $Ca(HCO_3)_2$	Alkalinity Na_2CO_3	Qualitative		
						SO_4	CaO	MgO
1918								
Jan. 10	212.6	133.0	1.1	127.5		Str.	Mod.	Sl.
Feb. 10	322.0	219.0	11.5	130 0		Str.	Mod-S	Mod.
Mar. 10	303.0	211.0	18.5	127.2		Str.	Mod-S	Mod.
Apr. 10	226.4	154.0		112.6	1.7	M.S.	M.	M.S.
May 11	351 2	248.0	11.9	128.4		M.S.	M.	M.
June 5	296.6	207.0	6.5	118.3		M.S.	M.	M.
July 8	301	206.0	1.1	113.8		S.	M.	M.
Aug. 1	249.8	181.0		69.5	2.5	M.S.	M.	M.
Sept.				No Sample				
Oct. 10	205.8	137.0		93.5	5 9	M.S.	M.	M.
Nov. 3	245.0	170.0		87.4	5.9	M.S.	M.	M.
Dec. 12	216.6	138.0	2.2	127.5		M.S.	M.	M.

ALKALI STUDIES

The research work of the department conducted under the Adams Fund has been limited to alkali problems. During the past year the Chemists have studied the influence of various chemicals in different amounts on the rate of percolation and on the composition

of the percolate. This involves much analytical work. Attempts were made to parallel the laboratory studies by pot cultures which at first proved unsatisfactory due to the difficulty of preventing leaching when the pots were irrigated and the consequent change of concentration of alkali in the soils. Successful pot culture studies in this climate require that the pots be sunk in soil to prevent too high temperature and excessive drying. Benches have now been constructed in the screened garden in which the pots are sunk in sand at the level of the surrounding soil and any percolating water due to heavy irrigating is caught in receptacles and returned to the pots. The pots are paraffined to prevent losses by transfusion.

The percolation experiments with gypsum have been especially interesting. When a percolation test is made comparing untreated University Farm soil with samples to which the theoretical amount and half that amount of gypsum have been added, it is found that the second half of the gypsum applied has two or three times the effect of the first half in promoting percolation. Large plot experiments are now being conducted which are planned to test this result in a practical way. Several lands at the University Farm have been divided into numerous small plots each of which has been analyzed to a depth of three feet and the necessary amount of gypsum calculated separately for each plot of 1500 to 2000 square feet. These lands had been treated previously by applying gypsum uniformly over the surface, but without reclaiming them successfully. After the proper amount of gypsum has been applied, the lands will be leached by confining the water on the more alkaline areas. Without gypsum, percolation is very slow, altho the soil is a very fine sand. In the laboratory water applied an inch deep to the wet soil in 10-inch flower pots and covered to prevent evaporation has stood for two or three weeks without entirely disappearing. It appears from the investigations in the laboratory that light or insufficient applications of gypsum would be unprofitable. On some areas it is necessary to apply 30 or even 40 tons of gypsum to the acre. Under some conditions this would be prohibited, and never could be considered for large areas. Gypsum beds, however, are available near the University Farm and hauling is done by the farm teams when other work is light. Small areas of black alkali in otherwise good lands, as is the condition at the University Farm, would often warrant the expenditure of several hundred dollars for reclamation. How permanent the effect will be remains to be shown. The groundwaters

are slightly black alkaline and occasionally rise to within seven or eight feet of the surface. The effect of gypsum on the rate of percolation with this soil in 10-inch pots is given in Table XXII

TABLE XXII—PERCOLATION THRU UNIVERSITY FARM SOIL AFTER GYPSUM TREATMENT

Amount used	Percolate in 24 hours[1] after standing 5 days	Percolate in 24 hours[2] after standing 7 days
	C C	C C.
None	400	288
Half enough to neutralize Na_2CO_3	880	696
Just enough to neutralize Na_2CO_3	2560	2112
Twice amount to neutralize Na_2CO_3	3680[3]	4320

1 Calculated from a 6-hour test by adding 1000C C of water to each pot 2. Insufficient head to keep up percolation for 5 hours 3 Calculated from a 5-hour test by adding 1000 C C of water to each pot Note The 10-inch pots used in these tests each contained 10 kilos of soil. The soil used gave the following analysis Total water soluble salts dried at 110° C 70 percent, chlorides as sodium chloride 012 percent, black alkali as sodium carbonate 254 percent

An analysis of the percolates showed a saving in humus and all plant foods with the exception of potassium The saving in nitrogen values at customary fertilizer prices would go far toward paying for the gypsum treatment, even if it were possible to reach the black alkali from the soil without the previous application of gypsum.

DATE PROCESSING AND MARKETING

During the summer the appliances for ripening and processing dates at the Tempe Date Orchard were inspected and put in order for handling the fall crop Several visits were made to the orchard during the harvest to supervise the packing house operations and give instructions in handling the different varieties under varying weather conditions. A suitable packing house for the Yuma Orchard has been designed but not yet constructed. Before the arrival of the Horticulturist the Chemist temporarily supervised cultural operations at the date orchards.

In the opinion of the writer after thirteen years of close study, the date industry in Arizona, properly managed, can be recommended to the investing public. Fresh dates of the soft varieties which can be grown of such excellent quality in Arizona and marketed as safely as any other crop are becoming known thruout the country, and orders and inquiries from every part of the United States are coming in quantities—a marked contrast to the condition ten years ago when the foreman of the orchard with difficulty disposed of a few hundreds pounds at a nominal price by

house to house peddling in nearby towns. During the past year over $6000 without soliciting have been received for the product of palms that could have been placed on about four acres After paying liberal wages and other operating expenses, exclusive of the foreman's salary, a net profit of 40 or 50 per cent on the gross sales will be realized. Had the usual business policy of selling for all the market would bear been followed, the gross sales probably would have reached $10,000 The policy followed, however, has been to maintain a uniform, fair price, estimated safely to cover expenses, and limit sales to the individual. A part of the crop has been marketed in the east to introduce the product and create a market for future growers. The immediate vicinity would have consumed the crop many times over at even higher prices, had limitations not been placed on sales to the individual The Experiment Station has proven at least some of the varieties that are successful in Arizona; climatic difficulties have been overcome to the extent that losses due to this cause are almost negligible; and a market has been made that will take the output of a large acreage at profitable prices. Fresh soft dates, such as Hayany, Rhars, Tadala, and similar varieties, promise to become a staple food as soon as they can be supplied in quantity, and may be carried for months in dry cold storage without serious deterioration in quality Culls and stock that have been damaged for the fresh date trade by weather conditions can be processed quickly for ordinary commercial dried dates. The close of the war should mark the importation of large numbers of Hayany offshoots from Egypt, and the establishment of the date industry in Arizona on a firm basis.

EDUCATIONAL AND EXTENSION WORK

Altho the department is not identified with the Extension Service, a large amount of correspondence regarding soils and irrigating waters is necessarily carried on with the farmers of the State. These demands, as previously mentioned, often require much analytical work. In February and March a four weeks' short course for farmers was given, during which the Chemist conducted a class in soils for two periods each week. A correspondence course in soil physics is being given In the College of Agriculture the Chemist has conducted classes in soil physics and soil fertility. A laboratory course in agricultural chemical analysis is also offered, but due to temporary disarrangements has not been given. Two new courses in household chemistry for young women in Home

Economics are being given The first semester's course, after a brief introduction to organic chemistry, largely nomenclature, deals with the chemistry of foods The laboratory exercises are designed to familiarize the student with the compounds occurring in foods rather than as a drill in analytical methods The second semester deals with textiles and laundering, including the removal of stains

The department is well equipped for work with advanced or graduate students Some of the problems under investigation in the Experiment Station may be entered into by the students or independent investigations may be made Work in this line should be encouraged by offering suitable fellowships which would be to the mutual benefit of the student, the department, and the Experiment Station

A E VINSON,
Chemist
C. N. CALLIN,
Assistant Chemist,

IRRIGATION INVESTIGATIONS

Owing to the absence of the assistant engineer, Capt A L Enger, and the difficulty in obtaining technical assistance, the work of this department has been much restricted during the past year Certain features of Experiment Station work inseparable from the office were performed as in previous years, while other features, and especially research, suffered disproportionately.

STATUS OF IRRIGATION WATER SUPPLIES

The year has been one of light rainfall and the necessity for irrigation has increased The stream flows have been meagre and many areas have suffered for water The advantage of water storage has been exemplified in the Salt River Valley where plentiful water has been available for an increased acreage, because of the supply in Lake Roosevelt, stored during the flood years of 1915 and 1916 The lack of similar storage on the Gila River has been felt keenly The hundreds of thousands of acre-feet of water that were wasted to the sea in 1915 and 1916 could have been used with great advantage in 1917 and 1918 if a storage reservoir had been available. Surely no other project in Arizona offers such inducement for governmental action as the building of the San Carlos dam and irrigation project On the Colorado River, too, the time has arrived when storage is necessary, for the natural flow during the period of low discharge is entirely appropriated, and it will be necessary soon for Arizona to join with other states in storage projects on the Colorado, else even the right to flood waters of the river will be lost The Parker Valley, especially, should be provided with a water supply at the earliest possible time The need for action in the development of storage projects has become more urgent by the call for new lands on which returning soldiers can make homes Arizona is one of the states in which there is abundant opportunity to prepare new lands under projects that are known to be economically feasible

AN IRRIGATION CODE

Arizona, the most arid state, the one most in need of the modern system of establishing and administering rights to water, is the only irrigated state which has not adopted the system The chaotic condition of water rights in the Gila River watershed is retarding the development of agriculture in southern Arizona and the lack of

a state water commission is jeopardizing the interests of this State in the waters of the Colorado River In Yuma County the water rights have never been adjudicated and in the other counties, with the exception of Maricopa, the adjudications have been only partial, are admittedly ineffective, and in many instances are counter to well-established irrigation law Moreover, there are scores of small sources of supply, where a few farmers struggle for the water and not infrequently a murder is the inevitable result

Water rights should be as well protected by the State as are land rights, and the irrigation supplies which belong, and always will belong to the State, should be administered by the State This department has exerted its efforts to stimulate a demand on the part of the agriculturists for the modern code It is hoped that the coming legislature will attack this problem and enact a code based on the principles of the Wyoming and Oregon codes but with such modifications as are needed to meet the needs of this State

In the absence of any workable method of adjudication of the water rights of the Gila watershed, the conflicting interests of Pinal County have endeavored to settle their priorities by mutual agreement, but so far without success This department is assisting in the negotiations

CAISSON WELLS

The type of well, originated by this Station in 1907, has proved to be well adapted to the groundwater conditions of such valleys as the Santa Cruz, and these wells are being adopted increasingly The station is called upon frequently to plan and start the construction of wells,—sometimes in emergencies where the groundwater must be developed quickly in order to save a crop The high cost of steel casing during the past year has increased the preference for concrete caisson wells

PUMP IRRIGATION

The acreage of land irrigated from wells has been increased greatly during the past two years The location of the best groundwater supplies is being ascertained and the high prices of agricultural products have warranted even a high cost for irrigation Problems of pumping machinery are being given more attention No new types of machinery have demonstrated any advantages over older types, but more care is being observed in designing pumping plants to fit the conditions of lift and discharge

Fig. 5.—Longitudinal crack in 20-inch pipe line. The open section has been broken out with hammer. Photo by W. C. Axelton.

A few years ago pump irrigators had available an engine fuel oil of suitable quality, but of low cost. This oil has been called by various names, including tops and gas oil. Gas oils with a flash point of about 100° F. and with a gravity of about 44° B. were to be bought at five to six cents a gallon Recently, while the price has been going up the quality has been going down. The tops now being furnished by many refineries is of about 37° gravity and is very troublesome in engines of the ordinary type and size. Meanwhile engine distillate has depreciated in quality until it is no better for irrigation pumping than was the gas oil of five years ago, altho the price is three times as great. The increase in cost is due in part to the fact that the engine distillate is classified as a finished product and therefore takes the same freight rate as gasoline. The Fuel Administration offers no relief. A few of the smaller oil companies continue to furnish a satisfactory tops at a reasonable price. Pump irrigators should demand an unrefined distillate of 40° to 44° gravity and with flash point under 120° F. This oil takes a low freight rate, and moreover the cost of refining will be saved Unless some relief is obtained in this matter, pump irrigation will be more restricted and less profitable than has been thought hitherto.

CEMENT PIPE FOR IRRIGATION PIPE LINES

CEMENT PIPE FAILURES

Several important studies of cement irrigation pipe have been made during the past year.

The study of failures of cement pipe was necessitated by failure

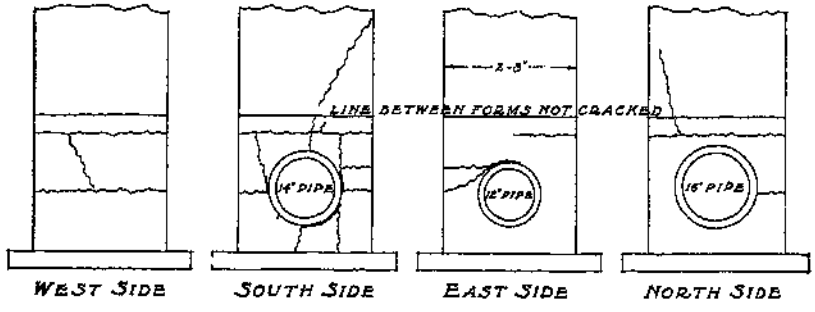


Fig. 6—A cracked gate pit at Continental, caused by expansion of pipe line.

of a long line of 20-inch pipe at Continental, Arizona. Sections of this line, from 20 to 1000 feet at a time, failed by longitudinal cracks. An example of a break is shown in Fig. 5. The photograph was

taken after a cross-section of the pipe had been broken out by the pipe layer. Patching of these breaks was not possible and the long sections were removed from the trench and replaced.

The cause of the breaks was not apparent and inquiry among cement pipe men did not throw any light upon the problem

Additional trouble was being had with the gate pits which occur at intervals of about a thousand feet along the line, and this trouble was not confined to the line of 20-inch pipe. In Fig. 6 is shown a broken gate pit. Examination showed that the gate pits were being destroyed by the thrust of the pipe lines caused by longitudinal expansion. Most of the pipe had been allowed to become very dry in the stack yard, as is recommended by pipe men. This caused a considerable shrinkage When water was admitted to the completed pipe line, the pipe walls absorbed it slowly and expanded, crushing the gate pits. In experimenting with expansion joints, it was found that these joints must be placed closer than 200 feet in order to absorb expansion.

Some laboratory tests were made to determine the nature and rate of expansion, and its relation to the absorption of water. It was found that the absorption of water under no head was rapid on the outside of the pipe specimens but extremely slow on the inside, the difference being due to the glaze left on the inside in the process of manufacture. Under considerable head the absorption on the inside would be more rapid. The expansion lagged somewhat behind the absorption.

The first longitudinal break occurred on a curve and it was thought therefore that the cause might be longitudinal shear Mathematical analysis of the problem demonstrated that while this might be true for pipe lines laid on sharp curves, the deviations from a straight line made by a careless pipe layer could not account for the cracks.

Two 16-inch pipe which had been broken in the internal pressure testing machine and had subsequently become dry, were further tested in the laboratory by being placed horizontally and immersed to cover the lower one-fourth and lower one-half, respectively. The pipes were placed so that the open cracks were at the top. Absorption from the outside caused the cracks first to close and then to reopen in part. In a similar test on a 14-inch unbroken pipe, the lower side was found to expand almost normally while no expansion occurred on the top, and a slight crack opened on the inside at the top at one end.

While making percolation and internal pressure tests of pipe,

it was found that certain specimens failed at very low pressures. The pipe walls when broken showed that the water had penetrated from one-fourth to one-third of the thickness. Apparently the expansion of the inner portion of the wall produced tension in the unwetted portion and caused the pipe to burst. This action, which may be called differential expansion, doubtless is the main cause of the failures of pipe lines by longitudinal cracks.

The intensity of differential expansion must vary with many factors, including the thickness of the pipe walls, the richness of mixtures, the mortar consistency, and the climate. It is believed also that the magnesia content in the cement affects the amount of expansion.

Several methods of overcoming the danger have been proposed, but it is believed that the only thoroly safe method is to prevent the drying of the pipe between the curing and laying. The curing should be continued up to the time of laying.

METHODS OF TESTING CEMENT PIPE

The technique of cement pipe testing has not been well standardized and different methods are in use by those engaged in pipe testing. It is quite impossible, therefore, to make comparisons between pipes made and tested in different places. Factors of safety in design must depend on the methods employed in testing. A paper on this subject, discussing certain alternative methods and pointing out the importance of standardizing the condition of the test specimens as well as the methods of testing, has been contributed to the technical press.*

REINFORCEMENT FOR CEMENT PIPE

Several trials of reinforcing cement pipe were made during the year, but in all cases the reinforced pipe was found to be weaker than plain pipe. Electro-welded wire rings, hog wire, and Triangle Mesh were tried. Reports from other sources show similar disappointing results. This matter needs further extensive investigation. If a means of making the reinforcement effective can be found, the field of usefulness of cement pipe will be widened greatly.

The publication of the bulletin on cement pipe noted in the last annual report has been delayed, but the bulletin is now in press and will be issued shortly as No. 86 of the Station series.

TRACTOR POWER ON FARMS

This department has watched the development of traction en-

*Concrete, Vol. 13, No. 5, p. 156.

gines with a view to their usefulness on Arizona farms. Tractors have been bought quite freely in Arizona and every type on the market has been represented among those in use. During the past year, particularly, many new tractors have been brought into the State, partly on account of the widespread change from alfalfa farming to cotton, which requires much more plowing.

Many of the tractors first used in Arizona did not prove successful. Some were too heavy and too expensive for the purposes to which they were put, some suffered from operators who could neither care for nor repair them, and some were ill-suited to the soil conditions. In many cases the usual number of mules or horses were retained on the farm, and repair bills have been very heavy.

The writer has tended to favor the round-wheel type of tractor; four wheels; slow speed engines; number of cylinders proportional to the power, one or two cylinders for small tractors; long stroke; and a transverse main shaft. As a rule, the more closely a tractor engine resembles automobile engines, the less useful it will prove to be. High speed engines cannot burn low grade distillates. The rating of many tractors is not very liberal, and usually they should be loaded with one less plow than they are advertised to pull. The rating by manufacturers is very variable; of two tractors much used in Arizona, one rated at 20 horsepower and one at 25, the 20-horsepower tractor has the more power. Wide tires with cleats are required for farm work. The utmost protection is needed against the dust and fine sand which usually flies during the plowing seasons. Gears should be housed and run in oil wherever possible. Forced feed lubrication for cylinders and bearings is very desirable. The standard speed adopted by tractor engineers is two and one-third miles per hour; higher speeds are not to be recommended. The creeping tread tractor is justifiable on California unirrigated grain lands where the spring planting is done while the ground is still soft from the winter rains, and on difficult tasks such as dragging the giant V's that clean the Yuma lateral canals.

The criteria for estimating the relative success of a tractor on any farm are: The type of farming, and number of days per year when the tractor is used; the mechanical ability of the owner or operator; and the fitness of the type and size of tractor to the soil and nature of the work to be done. There are many farms where tractors can be employed profitably; there are many others where a tractor would be a proverbial white elephant.

The employment of tractors in custom work should be increased. This implies that each tractor is operated by an expert

tractioneer and in most cases that he is the owner of the machine Failures that have occurred in this line have been due usually to the fact that the owners underestimated certain items of costs, such as repairs and depreciation and fixed their prices too low. Tractor garages should be established in agricultural centers, where tractors can be engaged for farm work.

G. E. P. SMITH,
Irrigation Engineer.