

University of Arizona
Agricultural Experiment Station.

SIXTEENTH ANNUAL REPORT.

For the Year Ending June 30, 1905.
(With subsequent items)

Consisting of the Reports of the Departments of

Administration,
Agriculture and Horticulture,
Animal Husbandry,
Botany and
Chemistry.

Tucson, Arizona, December 30, 1905.

UNIVERSITY OF ARIZONA
AGRICULTURAL EXPERIMENT STATION.

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(Regents of the University)

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J. W. LEWIS, Clerk

The Experiment Station office and the botanical and chemical laboratories are located in the University main building at Tucson. The range reserves (cooperative, U. S. D. A.) are suitably situated adjacent to and southeast of Tucson. The departments of agriculture and horticulture and of animal husbandry conduct operations on the Experiment Station farm, 3 miles north-west of Phoenix, Arizona. The date-palm orchards (cooperative, U. S. D. A.) are 3 miles south of Tempe, and 1 mile south-west of Yuma, Arizona, respectively.

Visitors are cordially invited, and correspondence receives careful attention.

Samples of water, fertilizers, etc., which are of agricultural interest, and which are sent with full information, are analyzed free of charge as time permits.

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

Address,

THE EXPERIMENT STATION,

Tucson, Arizona.

LETTER OF TRANSMITTAL.

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

SIR: In accordance with the Congressional act of March 2, 1887, I submit herewith, the Sixteenth Annual Report of the Arizona Agricultural Experiment Station, for the fiscal year ending June 30, 1905.

Very respectfully,

R. H. FORBES,

Director.

CONTENTS.

	PAGE
Administrative	1
Cooperative work	3
Range investigations	3
Date palms	4
The Tempe cooperative date orchard	4
The Yuma cooperative date orchard	7
Publications	7
Finances	8
Department of Agriculture and Horticulture	10
Shading experiments	10
Variety tests	10
Broad beans	10
Guavas	11
Cassava and chufas	11
Corn and millet	11
McNeal pea	11
Berseem	12
Olives	12
Alfalfas for hot, arid regions	13
Durum wheats	14
Spraying	14
Seed selection	15
Department of Animal Husbandry	16
Department of Botany	17
Range improvement	17
Cultural operations on the small range reserve	19
Continuation of work upon the economic cacti	19
The forage garden	20
Viability of native grass seeds	20
Miscellaneous notes	21
Plant diseases	21
The codling-moth in Arizona	22
Department of Chemistry	23
Researches with dates	23
Sediments in irrigating waters	24
Physical effects	24
Toxic effects of copper compounds	26
Miscellaneous	26



1. Site of Yuma Cooperative Date Orchard, before breaking ground. May 1, 1905.
2. First irrigation, after leveling and bordering. May 18, 1905.
3. After planting first consignment of date palm offshoots. Alfalfa sown between rows. May 20, 1905.

SIXTEENTH ANNUAL REPORT.

ADMINISTRATIVE.

By reason of substantial support granted by the Twenty-Second and Twenty-Third Legislative Assemblies, the Arizona Station has been enabled, during the year ending June 30, 1905, and subsequently, to make and plan much needed improvements for the benefit of various lines of experimentation.

The appropriations referred to consist of the proceeds of the bond sale authorized by the Twenty-Second Legislature, amounting with premium, to \$11,564 95; and sundry items in the University appropriation bill, allowed by the Twenty-Third Legislature, amounting to \$2,800 00.

The improvements planned, and in progress, upon the basis of these amounts are, with costs, approximately as follows:

For the Tempe Cooperative Date Orchard, a dwelling, a pumping plant to irrigate the orchard, and a barn, also horses and tools. These have been installed at a cost of about \$5,100.00.

For the establishment of a new cooperative date orchard near Yuma, \$1,300.00.

For publications, \$1,500.00.

For the establishment and support of farmer's institutes, \$2,700.00.

These accessions to Station equipment, and extensions of Station work, have materially added to experimental facilities at command, to the convenience of those engaged in investigation, and to the range of conditions available, especially for cultural operations. The soils now at disposal, for instance, are widely representative both in their own character and in their water supply. The Station Farm affords sandy loam and clay soils irrigated under average conditions for Salt River Valley. The Tempe date orchard is in a strongly salty clay irrigated both by ditch and pumped water. The Yuma date orchard is in a sandy, alluvial,

Colorado flood-plain loam, slightly alkaline and irrigated with water pumped from the river. The small range reserve near Tucson is typical, sandy, semi-arid mesa, irrigated only by natural rainfall.

With such a diversity of conditions to choose from, the work of testing new classes and varieties of plants may be prosecuted to excellent advantage, and it is intended to make increasing use of Station facilities to this end.

The provision made for publications and institute work affords desirable additional means for disseminating the results of investigation both in written form and through the direct efforts of institute speakers.

While this increase in facilities and in prospective usefulness is most welcome to those engaged with the Experiment Station, it is also gratifying to feel warranted, to some extent, in the belief that the legislative support granted is an expression of public approval of the work done, and being done, by the Station. It may not be out of place in this connection, to recall the animating sentiment, expressed in these pages years ago, which has supplied an ethical back bone to the work. That sentiment is: "*Science, not for science's sake only; but, science for humanity's sake.*" The purely scientific man, necessarily most technical in his accomplishments, does not as a rule translate his findings into terms which may be generally understood and used: he should be free, indeed, to conduct his studies without reference to their immediate utility. The economic investigator, however, who is more closely in touch with, and responsible to, those who make use of his results, finds it both a necessity and an advantage to so conduct and present his work that it will come into early fruition in our work shops and upon our farms. Such relations are capable of more than ordinary usefulness in so new a country as Arizona where cultural conditions are unique, and where settlement and development are but just well begun.

As has happened before, the Station has suffered delay in its work through unavoidable losses and changes in its staff.

Professor Alfred J. McClatchie, whose fruitful connection ended, with general regret, in September, 1904, has been succeeded

by Mr. Vinton A. Clark, formerly with the Geneva, New York, Station. Mr. W. W. Skinner, associate chemist of the Station, now with the Department of Agriculture, was succeeded by Mr. Henry B. Slade, who, after only eight months of promising research relating to the fruit of the date palm, died suddenly in his laboratory of heart failure, June 5, 1905. The very full records left by Mr. Slade, however, have enabled his successor, Dr. A. E. Vinson, to take up these investigations with but little loss of time. The vacancy in animal husbandry has been filled by the appointment of Mr. F. W. Wilson, from the Kansas Agricultural College; and Professor S. M. Woodward, now with the Department of Agriculture, has been succeeded by Professor G. E. P. Smith, in irrigation investigations.

It may here be stated that at this time the greatest need of the Station is an increase in the number of competent men on the working staff. The office is cumbered with unpublished material, the laboratories are crowded with unfinished work, and cultural investigations, in particular, have reached a stage where they should be divided and more highly specialized. Our next advance lies, not in the increase of facilities, which are fairly adequate, but in securing the means with which to add to the Station personnel.

COOPERATIVE WORK.

Investigations in cooperation with the U. S. Department of Agriculture have been continued upon the subjects of grazing ranges and date palm culture. A study of Colorado River waters in cooperation with the U. S. Geological Survey has been brought to a satisfactory close.

RANGE INVESTIGATIONS.

As indicated by the reports of Professor Thornber and Dr. Griffiths, both of the fenced range enclosures southeast of Tucson, 350 acres and 49.2 square miles in area, respectively, have developed interesting phases of self restoration by reseeding and spread of useful species. As thus far developed, it appears that much of our best range country, though depleted by overgrazing

and dry years, is capable of a satisfactory degree of improvement. The poorer districts, however, represented by the small reserve, make slow and unsatisfactory recovery, and the problem of their economic betterment is one of dubious outcome. Figuratively speaking, a grazing range which has had its back broken—whose herbaceous soil cover has been destroyed and whose surface has been eroded until essential conditions of growth no longer exist—is too badly crippled to get up again. Less deadly damage leaves a working margin, even at this late day, for restorative measures.

Too much cannot be said of the importance of the conservation of Western grazing ranges, estimated at over 300,000,000 acres in extent. The leading asset throughout most of this vast area, it is also to be remembered that our grass-covered plains, by their power to retain rainfall, stand in the same relation to stream-flow and irrigation, as does forest cover on the mountain sides. But while forest protection has become a national watchword, conservation of the grazing ranges is as yet a subject for confused discussion. It is earnestly to be hoped that efforts looking to an equitable and saving administration of grazing ranges, now being made by the U. S. Department of Agriculture which, alone, is situated to deal with this problem in its entirety, will result at an early day in the reclamation, within our own borders, of a neglected empire.

DATE PALMS.

The Tempe Cooperative Date Orchard.

During the year, Territorial appropriations having become available, the orchard has been variously improved until it is now a beautiful, model property. The improvements consist of a neat, brick, four-room cottage; a pumping plant consisting of two twelve inch tubular bored wells, a thirteen horse power gasoline engine, and a five inch centrifugal pump; a barn, with tools to work the place; and ten additional acres of land. Mr. F. H. Simmons is resident and in charge of the orchard.

In order to meet the requirements of a growing enterprise, the original cooperative agreement has been revised and the time

extended ten years, or until June 30, 1919, at which time the property, now leased to the Department of Agriculture, reverts to the Board of Regents for the Experiment Station.

The leading features of this agreement, as perfected after much discussion, are as follows:

1. The United States Department of Agriculture agrees to provide imported offshoots of desirable varieties of date palms. The Arizona Station agrees to provide for their subsequent care.

2. During the life of the agreement, the Department and the Station share equally in the produce, both fruit and offshoots, of the imported palms. Equal privileges of observation are secured. Certain matters relating to publication are equitably arranged.

3. It is provided that all experimental work with imported date palms in Arizona may be cooperative on the same terms as at Tempe.

4. It is provided that the Station may carry on such other experimental work, not cooperative in character, as it desires within the orchard, as long as this work is not detrimental to the palms.

It is believed that this arrangement, which so far as possible, imposes equal responsibilities and secures equal benefits to the cooperators, will prove satisfactory for the extended term of years which it covers.

The following summary, from data taken in July, 1905, indicates the status of the enterprise at the present time:

<i>Importations.</i>			<i>Condition, July 17, 1905.</i>				
<i>Date received.</i>	<i>No. of varieties.</i>	<i>No. of trees.</i>	<i>Varieties living.</i>	<i>Trees living.</i>	<i>Offshoots growing.</i>	<i>Trees in bloom.</i>	<i>Trees dead.</i>
August 1, 1899.....	5	6	.....	.....	.....	.....	6
July 17, 1900.....	24	405	19	271	900	77	134
May 20, 1901.....	5	18	3	6	16	1	12
Oct. 21, 1901.....	6	35	6	19	68	1	16
June 11-12, 1902....	46	212	30	66	few and small	2	146
May 24, 1904.....	39	41	34	36	.....	.....	5
July 12, 1904.....	13	13	13	18	.....	.....	.....
August 8, 1904.....	4	7	4	6	.....	.....	1
Nov. 14, 1904.....	5	52	5	52	.....	.....	.....
May 15, 1905.....	54	126	54	126	.....	.....	.....
May 24, 1905.....	5	21	5	21	.....	.....	.....
June 24, 1905.....	6	13	6	13	.....	.....	.....
Totals.....	212	949	170, net, not counting kinds twice rec'd.	629	984	81	320

Four more shipments numbering 212 trees in about 65 new varieties, were placed in the orchard during the summer, bringing the total of living imported trees up to 629, in about 170 varieties. The offshoots on the first three importations have increased to nearly one thousand in number, about one hundred of them having reached sufficient size for distribution during the season of 1906.

The orchard as a whole bloomed and bore shyly during the season of 1905, not more than 100 pounds of matured fruits having been harvested. This is the normal behavior of the tree.

however, which in the average instance bears a good crop about every second year. Compensating for the small yield, no less than twenty varieties, ten of them new, came into bloom, a sufficient number of these maturing fruit to afford a most interesting assortment. An exhibit of about ten kinds, displayed at the Territorial Fair in December, served to set forth the wide variations in quality and value of different typical sorts.

Producing little fruit, the orchard has made noticeable growth during the season. About 15 per cent of living trees planted in 1900 and 1901 are now ten feet high or over, with many stout trunks showing between leaf stalks and the ground.

The Yuma Cooperative Date Orchard.

In extension of the work at Tempe, a new cooperative orchard, on similar lines, has been started one mile southwest of Yuma in the flood plain of the Colorado River. An appropriation of \$1300.00 was granted in March, 1905, by the Twenty-Third Legislative Assembly, and ground was broken May 1st, on a most desirable tract of 7.2 acres generously donated for the purpose by Mr. Oscar F. Townsend, of Yuma. Three consignments from Algeria and Tunis, Egypt and Persia, numbering 152 trees in 58 varieties, were planted during May and June, and have made satisfactory progress since that time.

It is believed that the demonstration of early commercial varieties in this orchard, which represents several millions of acres of Colorado flood plain and delta lands, will have noteworthy influence upon the development of that region.

A small cottage has been built upon this ground, and Mr. E. L. Crane is in charge of the orchard.

PUBLICATIONS.

Because of many changes in the Station Staff during the year publications have been fewer than usual, although it is believed that the standard of excellence has been maintained. Volume IV of Station publications has been completed and indexed.

Issues for the year ending June 30, 1905, are as follows:

Bulletin 49, November 28, 1904. Cost of Pumping for Irrigation.—By S. M. Woodward.

Fifteenth Annual Report, December 31, 1904.—By the Station Staff.

Bulletin 50, May 30, 1905. Steer Feeding Experiments.—By G. H. True, T. F. McConnell and R. H. Forbes.

Bulletin 51, June 30, 1905. Timely Hints for Farmers, collected, edited and illustrated edition for 1903-1905.—By the Station Staff.

Index to Vol. IV of Station publications —By W. O. Hayes.

Timely Hints for Farmers:

No. 53, Oct. 1, 1904. Pickling Olives for Home Use.—By W. W. Skinner.

No. 54, Jan. 30, 1905. Pear Culture.—By A. J. McClatchie.

The appropriation of \$1500.00 for Experiment Station publications, made by the Twenty-Third Legislative Assembly in March, 1905, is adequate for the time being.

A growing mailing list has made it necessary to increase regular editions to 6000 copies.

FINANCES.

With increased receipts due to Territorial appropriations, financial conditions for the year have been satisfactory. The income of the Station for the year ending June 30th, 1905 was:

Receipts from the Treasurer of the United States.....	\$15,000.00
Receipts from the University Territorial Fund	733.91
Farm sales, live stock and milk	788.96
Farm sales, fruit and plants	45.60
Miscellaneous fees, receipts, etc.....	205.85
Experiment Station Bond Fund	3,793.37
Publications, Laws of 1905, Sec. 1, Par. 4	338.20
Date Palms, Laws of 1905, Sec. 1, Par. 3	387.22
	<u>21,293.11</u>
Less overdraft carried from preceeding year \$122.40	
Less balance carried to next year.....	<u>172.85</u>
Net Total	\$20,997.86

The following statement of expenditures shows that \$8,275 16 has been disbursed in connection with the office and scientific laboratories; \$7,350.78 upon the Station Farm; and \$5,371.92 upon the two date orchards

R. H. FORBES,
Director.

EXPENDITURES BY SCHEDULES AND DEPARTMENTS FOR THE YEAR ENDING JUNE 30, 1905.

		Administration.	Agriculture and Horticulture.	Animal Husbandry.	General Farm Expenses.	Botany.	Chemistry.	Entomology and Meteorology.	Date Palm Orchards.	Miscellaneous.	Totals.
\$15,000.00 U. S. appropriation.	Salaries	1341.09	1788.47			999.96	2204.07	75.00	Tempe 23.25		6431.84
	Labor	2.22	1422.36	1159.56		822.35	236.60	7.30	854.43		4504.82
	Publications.....							49.09			49.09
	Postage and stationery	235.18	16.20		42.75	.50	7.70	1.00	47.35		350.08
	Freight and express	46.26	75.95	.35	.25	12.54	127.87	2.50	28.59		294.31
	Heat, light and water					6.75	42.68		1.60		51.03
	Chemical supplies.....	.75	33.47	3.80		1.60	314.89				354.51
	Seeds, plants and sundries.....	.45	129.37	88.43		17.41	.40		9.58		245.64
	Fertilizers				442.20				15.03		457.23
	Feeding stuffs.....		94.33	156.16		1.30					251.79
	Library	20.76									20.76
	Tools, implem'ts and mch'y.....	9.65	190.71	63.75	166.09	31.63	38.20		124.21		624.24
	Furniture and fixtures	194.21	.95		1.75		1.20				198.11
	Scientific apparatus	30.85	51.56	1.04			3.45	6.65	64.25		157.80
Live stock		2.00	29.25							31.25	
Traveling expenses.....	243.02	128.10		48.70	28.30	42.75	16.80	156.52	5.25	669.44	
Contingent	15.00			5.40						20.40	
Building and repairs		34.81	84.53	4.70		13.60		149.42		287.06	
											15,000.00
Sales fund	Publications.....	157.04	402.63	42.96		33.62	52.76	27.45	20.50		736.96
	Contingent.....	1.00					.50	6.70			8.20
											745.16
Territorial fund	Office work	733.91									733.91
											733.91
Laws of '05 No. 59	Publications.....		200.00	138.20							338.20
											338.20
Laws of '05 No. 59	Plant'g, developm't and care of date palm orchard (Yuma)								Yuma 387.22		387.22
											387.22
Bond fund	Buildings, equipment, publications and institutes.				300.00				Tempe 3483.27	Inst. Wk 10.10	3793.37
											3,793.37
	Total cost of departments	3031.39	4570.91	1768.03	1011.84	1955.96	3086.67	185.79	5371.92	15.35	20,997.86

DEPARTMENT OF AGRICULTURE AND HORTICULTURE.

SHADING EXPERIMENTS.

In the hot desert climatic conditions of the Southwest, is found a natural starting point for local agricultural investigation. Irrigation and alkali are, of course, of first importance; but these subjects are common to all of the states in the arid region and their management is also well established in local agricultural practice. In the intense heat and light of this Saharan region, along with excessive aridity, we have obstacles to plant growth not found elsewhere in the United States even approximately in the same degree, nor in the same banefulness of effect. For these conditions shading is a specific, at least with most crops. During the past summer a variety of crops were shaded with excellent results; for many plants which were checked in their growth or injured or even killed in the open, were brought through the summer by various kinds of shading safe and sound.

Our intense midsummer heat raises the surface soil to so high a temperature as to interfere with root growth and action, and in the case of some shallow-rooted plants, as even to kill the roots. Mulching with straw is in this case a specific and has been applied with excellent results.

Another method of protecting the roots of fruit trees from the excessive heat of the surface soil is by deep setting of the trees. This device was first suggested to the writer by Mr. Thomas Hall, a fruit grower near Phoenix. So far as tested, it has given the predicted results.

VARIETY TESTS.

Several crops new to the region have been tested, with varying results.

Broad Beans. Forty-three varieties of English broad beans and horse beans from England, Algeria and Lower California are

under test. The horse beans came from Algeria and are rather too tender for our lowest temperatures. The broad beans from England and the avas from Lower California stand our frosts fairly well; but the season between frost time in February and the heat and intense aridity in May is so short that they have not yet matured a full crop.

Guavas. Cattley guavas have been grown both in the open and under shade. They stand the intensest heat of our summers without protection and have come through the present winter in the open thus far, the thermometer having fallen to 19°, with only slight injury.

Cassava and Chufas. Cassava has been tried. This plant is leafy and makes little growth before mid-summer, that is, during our driest weather. But with the advent of more humidity in July, growth proceeded rapidly and a moderate crop was obtained. Chufas did nicely, showing no ill effects due to climate.

Corn and Millet. Comparative trials were made of varieties of field corn for this climate. The particular obstacles in the way of growing corn here are, imperfect fertilization, commonly attributed to excessive heat, ravages of the corn ear-worm, and smut. These trials brought out a wide range of variation in different varieties in respect to resistance to these unfavorable conditions. They indicate that flints from the great western corn belt are best adapted to this region, followed by some of the dents. The small early varieties from the northern part of the corn belt are entirely unsuited to southern Arizona.

A number of kinds of millet were grown. These will be reported on later.

McNeal Pea. Seed of this variety was sent us in October, 1904, by Mr. John Dehoff, then of Florahome, Florida, for testing. Its particular recommendation is, that it grows at a lower temperature and withstands frost better than do the common varieties of garden peas. This is a point of importance in southern Arizona, where peas must be grown in winter and are subject to frosts. One hundred feet of row was planted October 15, 1904. A row of American Wonder served for comparison. The McNeal is a medium-season dwarf variety, a strong grower and very pro-

lific. Neither it nor American Wonder showed injury from any frost which occurred here last winter except on the nights of February 13 and 14, when the thermometer fell to 24° and 27° respectively. At this time both varieties were in full bloom. The McNeal had set its first pods while the American Wonder had a few peas large enough to pick. All of these and all flowers in both varieties were killed by the frost. But the McNeal showed no other injury, while the American Wonder was visibly set back in its growth.

Berseem. One plat each of berseems S. P. I. D. Nos. 9874, 9875 and 9876, was brought through the winter successfully. The plats were in a depressed area protected by tall trees on two sides. These plats were planted November 25, and made two heavy crops of hay the following spring. No. 9875 made a rank growth and attained to a height of five feet; but it was more favorably situated than the others and had more water. Apparently another crop could have been made except for shortage of water in May and June. A few plants which had water from a watering tank lived until July, when they died from heat.

Other plats of the same varieties, sowed October 31, in an open field without protection, were uninjured by any frosts which occurred here last winter until February 13 and 14, when the crop was killed. On those nights the thermometer fell to 24° and 27° respectively. The crop was about 4 inches high.

Horses ate green berseem with avidity.

OLIVES.

A beginning has been made in studying varieties of olives for Arizona. The olive, as the date palm, we consider to be a fruit well adapted by nature to our very dry and very hot climate. A partial examination has been made of the varieties known to be fruiting in Arizona at the present time, these being about twenty in number. This examination has already brought out a wide range of variation in the olive with reference to quality and other properties. Oils made from different varieties of olives have widely different physical, chemical and organoleptic properties. This preliminary examination has already suggested certain defi-

nite selections of varieties for oil, differing according to the particular purpose to be served. From this study have also arisen suggestions for the intelligent and systematic blending of oils.

Competition in the olive oil business is sharp and Arizona olive growers must select varieties with intelligence if the Arizona olive business is to be greatly extended. But nature favors the olive grower in Arizona. In a hot desert climate such as we have the olive is richer in oil than it is in a more humid climate and at the same time the oil is more delicate in flavor. Cheapness of land is not the only reason why Algeria has made the olive oil business unprofitable in southern France in recent years. Besides, here in Arizona not an insect or fungus pest has yet appeared upon the olive.

ALFALFAS FOR HOT, ARID REGIONS.

Next after irrigation itself, alfalfa lies at the basis of Arizona agriculture and as such deserves attention. A comparison is being made of alfalfas from various countries, principally dry regions in different parts of the world. These comparisons have brought out very considerable varietal differences.

In 1904 the Station received from the United States Department of Agriculture for trial three varieties of alfalfa seed, which, from their origin, might be expected to be particularly well adapted to the hot and arid Southwest. They were as follows: S. P. I. D. Nos. 7500 from Oued Rirh Oases, Northern Sahara; 8806 from Basrah, Arabia; and 8823 from Bagdad, Arabia.

These varieties have been grown at this Station only one season but they have already established a claim to particular attention. A detailed report will be deferred until after another season's observation and experience; but suffice it to say for the present, that they are all earlier than our local strain of alfalfa, that they make a greater leaf growth and a notably more succulent stalk; and most important of all, they grow with vigor through the hottest of our weather, when local alfalfa is checked by the heat. But they grow somewhat less in cool weather and are more easily affected by frost, though not to the killing point.

On account of the promising nature of the work with Sahara strains of alfalfa, it is being extended to include other varieties also furnished by the United States Department of Agriculture.

DURUM WHEATS.

One-tenth acre each of three varieties of durum wheat, also called Macaroni wheat, was sowed November 19, 1904, with a check plat of local Sonora wheat. All did well but the durum wheats distinguished themselves by their fine performance. The durum wheats, at least the varieties tried here, are taller than the Sonora, yet they show no tendency to lodge, thanks to their stiff straw. It is well known that they are peculiarly drought resistant, a high recommendation in Arizona; and they maintained their established reputation for resistance to rust this last winter, when, during a protracted period of almost unprecedented wet weather, Sonora and other varieties of common wheats rusted very badly. The plats were cut about May 1, giving yields at the following rates per acre:

VARIETY	YIELD LB.
Gharnovha (Durum).....	1480
Mamavnani ".....	1550
Kubanka ".....	1940
Sonora.....	1030

It appears, so far as yield is concerned, that the durum wheats compare favorably with Sonora wheat; and making all allowance for unequal injury by rust, it is still the general experience and testimony of those who have tried durum wheat, that it makes a very good yield, as well as that it has various other qualities generally ascribed to it.

Amidst this general acknowledgment of merit it must be admitted, however, that our local millers have not as yet been successful in milling it. Except for this, the durum wheats show promise of filling a much felt want in Salt River Valley agriculture—that of a hard, productive wheat that can be profitably grown in our climate.

SPRAYING.

A little work has been done in spraying. Arizonians congratulate themselves upon their freedom from those insect and

fungus pests which so beset the farmer and the fruit grower in most other sections. But it will not do to be over-confident that Nature will always fight our battles for us. The date palm scale, accidentally introduced only a few years ago on imported date palms, has maintained itself for years at the Station Farm. It has cost much effort and money to eradicate it before it should spread to other places. A *Lecanium* scale, introduced presumably on oleanders, multiplied enormously during the spring months and has cost much to eradicate. Happily, this outbreak was confined to one door yard.

SEED SELECTION.

A little work has been done in seed selection, especially according to specific gravity. In a climate so rigorous as ours, varying from the frosts of February to the parching heat of June, the endurance of the plant is put to a severe test. For instance, pea plants from light seed die from our heat in May a number of days earlier than plants from heavy seeds of the same lot. Small alfalfa plants from light or weak seed succumb to untoward conditions much sooner than do strong vigorous ones. Seed selection work has an especial application in connection with the industry of alfalfa seed growing in this valley.

V. A. CLARK,
Agriculturist and Horticulturist.

DEPARTMENT OF ANIMAL HUSBANDRY.

The work for the year in animal husbandry consisted in the completion of unfinished experiments in steer feeding; in continuing routine observations, and in the improvement of alfalfa fields, fences and feeding facilities belonging to this department.

The steer feeding experiments having been completed, a thorough study was made of the results obtained by Messrs. Gordon H. True and T. F. McConnell, during the five years covered by their experiments. This study is presented in Bulletin 50, which answers certain important questions relating to feeding practice under southwestern conditions. It was clearly established in the course of six feeding trials that a straight alfalfa ration produces practically the same gains as the theoretically balanced ration, made up of a combination of alfalfa and carbohydrate feeds. Alfalfa, though containing an excess of protein, under favorable conditions yields the largest amount of the most valuable forage obtainable in the Southwest. Sorghum, corn and other forages of that class, can sometimes be produced to advantage in situations where alfalfa can not be satisfactorily grown. In such cases these carbohydrate feeds can be fed profitably in combination with alfalfa, but do not produce as good results fed alone.

The quality of meat produced may be improved by the addition of barley to the ration, but southwestern markets will not make returns for the barley fed.

In a general way it is concluded from these experiments that advancement in feeding practice in the Southwest is chiefly to be brought about by more thorough development and more careful utilization of alfalfa. Development of this crop will be brought about by improvement in cultural methods and by the introduction and breeding of better varieties for various cultural conditions encountered. Better utilization will be secured by selecting more profitable feeders, by the use of economical methods of handling forages and by proper consideration of market conditions.

R. H. FORBES,

For the Department.

DEPARTMENT OF BOTANY.

RANGE IMPROVEMENT.

The rainfall on the small range reserve for the year ending June 30, 1905, was 19.57 inches, which was precisely equal to the precipitation for the same area during the two preceding years, and more than three times its rainfall for the remarkably dry year ending June 30, 1902. Of this rainfall 9.46 inches, or 48.3 per cent, fell during the period of minimum plant growth, *i. e.* between November 1, 1904, and March 15, 1905, leaving 10.11 inches, or 51.7 per cent, for the period of maximum plant growth, which constitutes the remaining seven and one-half months of the year.

A seasonable rainfall of three inches will maintain in good condition during the winter months the average southwestern range. The recent winter rainfall being more than double that amount was far in excess of the needs, and resulted in considerable gullying in sandy alluvial soils, notably in the valleys of the San Pedro and the Santa Cruz.

Plant growth on the small range reserve has materially increased during the year just ending. The summer growth was quite up to the average, and, so far as we could judge, equally abundant on the protected and unprotected mesa areas. The mesa grama, *Bouteloua rothrockii*, was quite abundant within the fenced enclosure, though confining itself, as heretofore, to the lower portions. Scattered volunteer bunches of the native blue stem, *Andropogon torreyanus*, were occasionally seen on the lower parts of the enclosed tract, a feature not heretofore noted. The Mexican poppy, *Tribulus grandiflorus*, grew in sufficient numbers over the mesas to give to them a decided color with its deep orange flowers. The annual spring growth was more abundant than it has been since the range study was begun. The two commoner species of Indian wheat occupied, to the exclusion of the other annual species, one-half of the fenced enclosure, and they were nearly as abundant on the open range for

several miles in extent. The average height of the Indian wheat was ten inches, which was double that of two years ago grown under less favorable conditions. The abundant, late spring rains caused the fallen seeds of these species to form into hard, crust-like masses one to several feet in extent. The other species which were of sufficient importance to be controlling, at least in patches, were the two annual borages, *Pectocarya linearis*, and *P. penicillata*; the California poppy, *Eschscholtzia mexicana*; pepper-grass, *Lepidium lasiocarpum*; the common bladder-pod, *Lesquerella gordonii*; and the annual milk vetch, *Astragalus nuttallianus*. On gravelly clay soils in the vicinity of mountains, *Lotus humistratus* formed an almost continuous layer, miles in extent, while in the vicinity of Oracle, alfalfa, *Erodium cicutarium*, was the dominant species and the forage plant par excellence. As a result of the limited number of stock on the range in the vicinity of Wilmot, the spring growth appeared as abundant on the open mesas as within the protected enclosure. This condition is in marked contrast with that which obtains in the case of the large range reserve, especially on those areas lying above an altitude of 3500 feet, where the rather abundant spring and summer growth is kept closely grazed on the open range by a larger number of stock, while that within the fence remains untouched from year to year. This difference is becoming more pronounced as the protection offered by the fence is continued. Some estimates of the relative amount of spring forage on the mesas were made last April when the growth was at its maximum. Small plats nine by fifteen feet were measured off, the plants being pulled by the roots, dried with the sun and weighed. The average yield for five of these plats was at the rate of 2812 pounds to the acre. The writer estimates that one-half the above amount, 1400 pounds to the acre, would be a fair average for the ranges about Wilmot. The ease with which a prairie fire was able to burn for two days in this vicinity over an area approximating twelve square miles, would seem to justify this estimate. It will be of interest to note that this is the first time in a considerable number of years that the amount and continuity of plant covering over the lower mesas was sufficient to support a fire.

An enumeration of the native species growing within the small range reserve, a tract embracing three hundred and fifty acres, gave a total of one hundred and sixty-eight, of which two species are ordinarily trees, twenty-one are shrubs, ten are half shrubs, thirty-seven are perennial herbs, one is a biennial herb, sixty-three are spring-blooming annuals, and thirty-four are summer-blooming annuals.

CULTURAL OPERATIONS ON THE SMALL RANGE RESERVE.

Last January the surface of about two acres was ridged at right angles at intervals of twenty feet. The ridges are such as can ordinarily be made with a plow by throwing together two furrows. The small squares thus formed receive only the actual rainfall, and hence are especially desirable for experimental purposes. During March and April two hundred small plants of each of several species of native and Australian saltbushes and a grass were set out in this area. These seedlings were grown in the greenhouse, and, with the exception of the grass plants, were not as well hardened as they should have been when planted, so that notwithstanding the favorable season they were mostly dead two months after the close of the rainy period. The following are the species that were planted: Australian salt bush, *Atriplex semibaccata*; old man salt bush, *A. halimoides*; *A. leptocarpa*, *A. polycarpa*, *A. Nuttallii*, *A. canescens*, *A. lentiformis*, *Eurotia lanata*, and *Oryzopsis miliacea*. Small plats of a number of grasses were sown on June 30, 1905, on the area occasionally flooded by dam No. 7, known as Woodward's contour dam. As usual the ground was cultivated and harrowed before sowing. Seeds of the following species were sown: *Muhlenbergia porteri*, *Hilaria mutica*, *Panicum texanum*, *Chaetochloa composita*, *Andropogon contortus*, *Paspalum dilatatum*, *Triodia mutica*, *Aristida fasciculata*, *Sporobolus cryptandrus flexuosus*, *Pappophorum aperitum*, *Chloropsis mendozina*, *Andropogon torreyanus*, *Eragrostis lugens*, *Stipa neo-mexicana*, *Oryzopsis miliacea*.

CONTINUATION OF WORK UPON THE ECONOMIC CACTI.

In accordance with work begun in April, 1904, looking toward an economic study of the Cactaceae with the idea of pro-

viding a reliable forage supply for range stock during periods of prolonged drought, small plantings of cuttings of six of the more promising species of *Opuntia* have been made at regular intervals during the past year on the small range reserve. By this means the species of cacti best adapted for planting on an economic scale can be determined, together with such other necessary data as the most favorable time for planting, and the best cultural methods. Thus far the varied experiments indicate that the cuttings of the prickly pear type root quicker, and hence are able to make a more rapid growth, than those of the cylindrical lobed forms, or chollas. More than this, a larger percentage of the prickly pear cuttings grow.

THE FORAGE GARDEN.

This line of work has been continued on a much larger scale than heretofore, over two hundred and fifty numbers, representing one-half that number of species and varieties, having been sown and observed during the past year. By means of seed exchanges, a hundred varieties of seeds were obtained for trial from South Africa, Australia and other foreign countries. This study has been extended to include the cereals and other winter-growing grasses and legumes, to which plants the farmer must look for the winter forage supply, which may be grown as a cover crop. The forage garden work has been brought to a point where a large number of the species experimented with may be discarded as practically worthless for the greater portion of Arizona. On the other hand, a limited number of the native and introduced grasses have made a fairly good showing, even with rather adverse soil conditions, and hence merit further study.

VIABILITY OF THE NATIVE GRASS SEEDS.

The importance of knowing the relative percentage of germination of seeds to be sown on the ranges has become very apparent as the work has progressed. It happens frequently that few or no mature plants grow from a number of lots of seeds sown on the ranges, even during a favorable season. Unless the relative viability of the seeds under consideration is known, one is not warranted in drawing any conclusions concerning the fail-

ure. The following results obtained by using the ordinary "plate" germinator, or by testing in fine moist sand, give the percentage of seeds of a number of our important grasses that germinated within a reasonable time: Tangle-top blue stem, *Andropogon contortus*, 48 per cent; silver-top blue stem, *Andropogon torreyanus*, 22 per cent; sand dropseed, *Sporobolus cryptandrus* var., 88 per cent; sacaton, *Sporobolus wrightii*, 84 per cent; erect dropseed, *Sporobolus strictus*, 78 per cent; cotton grass, *Panicum saccharatum*, 61 per cent; black grama, *Muhlenbergia porteri*, 17 per cent; white grama, *Bouteloua oligostachya*, 11 per cent; hairy grama, *Bouteloua hirsuta*, 33 per cent; mesa grama, *Bouteloua rothrockii*, 3 per cent; galleta, *Hilaria mutica*, 3 per cent; branching foxtail, *Chaetochloa composita*, 7 per cent; water grass, *Chloris elegans*, 48 per cent; bulbous switch grass, *Panicum bulbosum*, 52 per cent; spruce-top grama, *Bouteloua bromoides*, 3 per cent; *Leptochloa dubia*, 33 per cent; *Chloropsis mendozina*, 78 per cent; spike grass, *Pappophorum apertum*, 60 per cent; *Eragrostis lugens*, 83 per cent.

MISCELLANEOUS NOTES.

PLANT DISEASES.

The favorable conditions for plant growth which obtained during the greater portion of the year, also made possible the rapid spread of several species of destructive fungi. The alfalfa leaf-spot, *Pseudopeziza medicaginis*, was quite injurious to the alfalfa crop during April and May, being reported from practically all the agricultural sections of Arizona. This disease, which first appears on the lower leaves and gradually spreads to the upper ones, may be recognized by the leaves becoming spotted, turning yellow, and finally dropping off. Where the alfalfa leaf-spot becomes very destructive, the crop should be cut regardless of its stage of growth. This will usually permit the surface of the ground to dry out sufficiently, so that the further growth of the fungus will be checked. The common grain rust, *Puccinia graminis*, was quite injurious in low, wet lands where the crop is usually heavy. This is the first time the writer has noted any considerable injury here from this disease, the normally arid

climate rendering its growth and spread impossible. Bunt, or stinking smut of wheat, was of very general occurrence and frequently quite injurious. There is no reason why the farmer should tolerate the annual losses of two to twenty per cent caused by this disease. Timely Hint No. 20, which deals satisfactorily with this subject, was issued by the Station some time since.

THE CODLING-MOTH IN ARIZONA.

Among insect pests for the past year the codling-moth merits especial mention, since this is its first appearance in Arizona. The writer observed it in the Upper Gila valley in the orchards between Thatcher and Pima. In one of the older orchards near Central, where the insect first appeared two years ago, thirty or forty per cent of the apples examined were worm-eaten. In other orchards in the immediate vicinity the percentage of worm-eaten apples ranged from three to ten. The appearance of the codling-moth in Arizona comes as no surprise, for sooner or later it has found its way to every apple-growing community of any importance in our country. The most diligent care might have averted for years its presence in our midst, just as proper management of the orchard, now, will hold it in check, though never entirely eradicate it. Here as elsewhere, its coming will mark an epoch in the management of orchards, since those who continue to grow apples for commercial purposes will be compelled to spray. The neglected, broken-down, worm-infested orchard will prove not only unprofitable to the owner, but a menace to the community.

J. J. THORNER,

Botanist.

DEPARTMENT OF CHEMISTRY.

For this year two lines of research have occupied the attention of those connected with this department, namely; a study of the composition and ripening processes of date fruits; and an investigation of the effects of irrigation sediments and mining detritus upon lands receiving them.

RESEARCHES WITH DATES.

Mr. Henry B. Slade, whose efforts were interrupted by his untimely death in June, was engaged in a study of the composition and chemical life history of the fruit of the date palm. His work resulted (1) in the adoption of a fairly satisfactory method of procedure for the analysis of the complex mixtures of sugars contained in dates, and (2) in a classification of dates on the basis of their chemical composition. He observed that a predominance of one or another specific sugar in a particular variety was usually associated with certain prominent physical characters, of importance in an estimate of the desirability of the variety for commercial purposes.

Of more interest, however, were his observations on the rationale of the ripening process. Passing, often in the course of a few days, from the hard, green, astringent stage, through intermediate conditions to a state of ripeness in which as much as 65 per cent of sugars is present, this fruit constitutes an attractive subject for research. Economically, the determination of the agencies bringing about these profound changes, and the conditions under which they operate, is of high importance. The amount of heat, for instance, required to ripen the fruit varies greatly with different varieties. A more than superficial knowledge of this fact will make possible a more intelligent and rational distribution of different varieties of date palms to localities receiving varying quantities and intensities of heat in the course of the season. These studies also touch upon the question of the practicability of artificially ripening varieties in regions not warm

enough to carry the process to completion:

The results of these studies, which were fully recorded and digested by Mr. Slade just before his death, have been handed over to Dr. Vinson, who is now engaged with the subject.

Progress has been made in the study of the culture of the date palm under southwestern conditions and a publication on the subject is in preparation.

SEDIMENTS IN IRRIGATING WATERS.

Responding to the urgent demand for information upon the effects of mine tailings upon farming lands below, the writer has been engaged for nearly two years upon the general subject of irrigation sediments and their effects upon agriculture. These studies, begun in May, 1904, are now practically complete and the results are shortly to be published in two bulletins treating upon the physical and chemical effects of both natural and artificial sediments upon vegetation.

PHYSICAL EFFECTS.

The physical effects of sediments upon soils are clearly marked, being in one form or another, a matter of common knowledge among good observers throughout the region. As is well known, and as has been shown in detail in Bulletin 44 of this Station, arid region streams carry abnormal quantities of sediments, especially in time of flood. Chemically these sediments are usually beneficial in character, containing, oftentimes, notable amounts of nitrogen and organic matter, in which valuable constituents our desert soils are deficient. When these fertilizing substances, therefore, are incorporated with the soil, where they may be made use of by crops, their beneficial effects are soon apparent in increased yields. But where cultivation is neglected or infeasible the river silts accumulate upon the soil surface, at which plane not only do they fail to exert a proper fertilizing effect but they also act as a more or less impervious blanket. More particularly in the case of alfalfa fields, the soil of which can only be harrowed superficially from year to year, these sediments accumulate, chiefly at the upper edges of the fields where the water first comes upon them. This blanket of fine, plastic mud

finally operates to prevent the penetration of water and air to underlying root systems, thereby limiting the aerial growth of the plants. Such accumulations have been observed in alfalfa fields in various parts of the Territory, having a depth, frequently, of as much as four inches, and causing a marked depreciation of yield.

In order to estimate the amount of this depreciation, alfalfa fields having the most uniform possible soils, were selected near Yuma, Phoenix, Mesa and Solomonsville. Each field, when the crop was ready to cut, was divided into successive plats from its head to its foot and the hay from each plat weighed separately. In all cases where muddy water had been used for irrigating, the yield at the upper edges of the fields was less than lower down, where smaller quantities of sediments had accumulated. Numerous borings revealed the fact, also, that, after irrigation, the soil at less than a foot beneath the heavier accumulations was, in certain cases, almost dust dry.

Extreme sedimentation and dryness of the subsoil, with consequent depreciation in yield of alfalfa, was observed in certain parts of the upper end of the cultivated valley extending from above Solomonsville to below Fort Thomas, Arizona,—conditions due to the unusual quantity, constancy and imperviousness of sediments, carried from the Gila watershed upon these lands.

Conversely, in one alfalfa field near Mesa, Arizona, where clear, pumped water had been used almost exclusively, the largest yield was observed at the head of the field, next the ditch, where by virtue of the location, without opposing factors, a more copious watering should be secured.

Observations have also been made upon various methods of controlling objectionable quantities of sediments in waters to be used for irrigation. The effectiveness of settling basins, both large and small; the distribution of sediments in streams from which a pumped water supply is taken; and cultural operations designed to obviate the bad effects of sedimentation, have been studied with encouraging results.

This part of the investigation, which is now complete, will be published within a few weeks of the date of this report and, it is

hoped, will be helpful in throwing light upon a class of facts involving agricultural interests in this region to an appreciable and, in some cases, serious degree, and upon which, so far as the writer has been able to discover, little or no definite information has heretofore been available.

TOXIC EFFECTS OF COPPER COMPOUNDS.

In connection with the tailings turned into the irrigating water supply from certain mining districts the question arises as to the effects upon vegetation of the small amounts of copper compounds contained in these waste materials. Several lines of chemical and physiological experimentation relative to this question have been carried out, including observations on the occurrence of copper in a representative district, a study of the transformations by which copper compounds may reach the roots of plants, experiments on the toxicity of copper compounds under ideal conditions, experiments on the toxicity of copper compounds under field conditions, and field work during two summers in the district presumed to be affected. The writer is at present prepared to state conclusions only so far as to say that, although under ideal experimental conditions the presence in toxic amounts of copper compounds in solution, and the poisonous action of these compounds upon plants, may easily be demonstrated, it is not possible to state that, under the conditions involving the presence of copper salts reasonably possible in the field, appreciable damage is done to crop plants by these salts.

This branch of the investigation is nearing completion and the results will shortly be available in bulletin form.

MISCELLANEOUS.

As usual, a considerable number of soils, waters, alkali samples and sugar beets have been submitted and examined as regular work has allowed.

No charges are made for analytical work, the results of which are of general interest and may be published. Compensation is required for private work, the receipts being turned over to the Station.

R. H. FORBES,
Chemist.