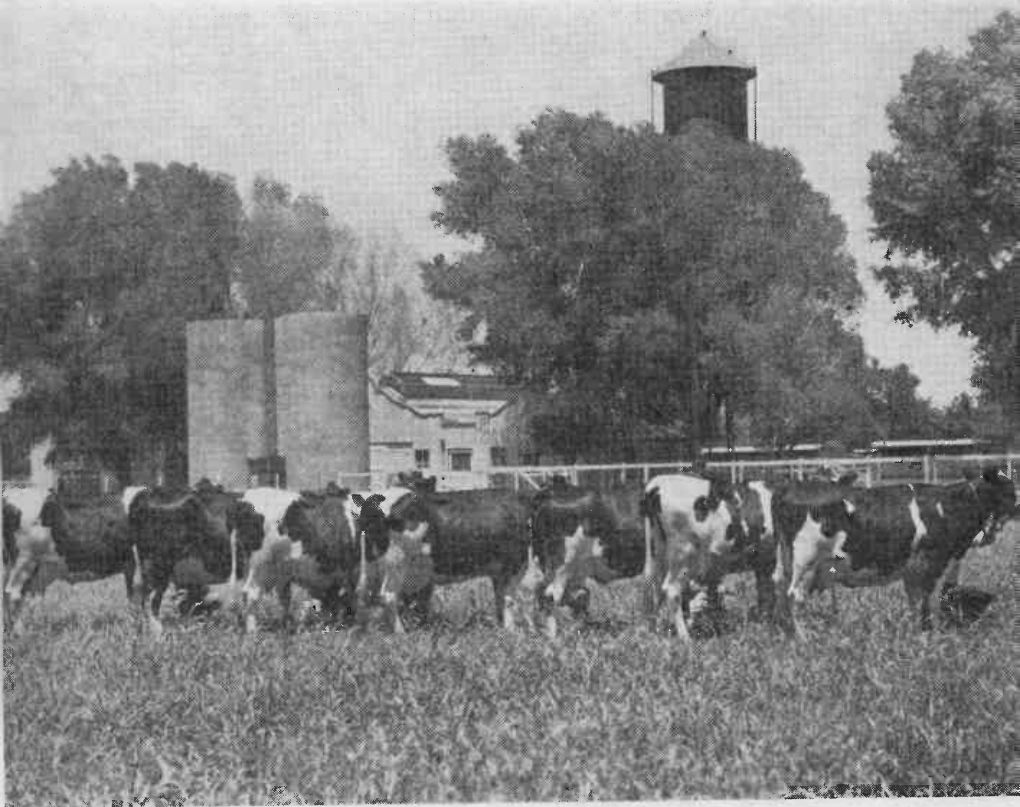


FIFTY-THIRD ANNUAL REPORT  
FOR THE YEAR ENDING  
JUNE 30, 1942



**AGRICULTURAL EXPERIMENT STATION  
UNIVERSITY OF ARIZONA, TUCSON**

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§Resigned October 17, 1941.

January 1, 1943

*President Alfred Atkinson*  
*University of Arizona*

DEAR SIR: ,

I have the pleasure of presenting herewith the Fifty-Third Annual Report of the Arizona Agricultural Experiment Station for the fiscal year ending June 30, 1942. It contains reports of progress on active research projects, brief summaries of other station activities, and the summarized fiscal statement.

Respectfully submitted,

P. S. BURGESS, *Director*

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Note: The cover page pictures daughters of the proven sire, Posch Ormsby Fobes 6th, owned and developed in the University of Arizona herd. Thirteen of these, to date, have averaged 16,610 lbs. milk, 608 lbs. butterfat (mature "B" basis) in the Holstein-Friesian Herd Improvement Registry.

Highest producing daughter is U. of A. Posch Maricopa Belle with 18,069 lbs. milk, 721 lbs. butterfat at 6 years of age, twice a day milking.

# TABLE OF CONTENTS

	PAGE
INTRODUCTION.....	5
RESULTS OF THE YEAR'S RESEARCH.....	8
Agricultural Chemistry and Soils.....	8
Plant Food Availability.....	8
Chemical Analysis of Soils.....	9
Productive Capacity of Arizona Soils.....	10
Soil Moisture Studies.....	10
Salinity of Puddled Soils.....	11
Burroweed Investigations.....	12
Rubber Plant Investigations.....	13
Fluorine Investigations.....	15
Boron.....	16
Lysimeter-Nitrogen Balance.....	16
Vertical Zonation of Great Soil Groups on Mt. Graham, Arizona, as Correlated with Climate, Vegetation, and Profile Characteristics.....	17
The Effect of Field Applications of Organic Matter on the Properties of Arizona Soils.....	18
Feeds and Fertilizers.....	19
Agricultural Economics and Rural Sociology.....	19
Farm Labor in Arizona.....	19
Sharing Farm Machinery.....	20
Parity for Arizona Products.....	20
Supply-Price Relationships.....	21
Farm Leases Under Irrigation.....	21
Diversified Plan for Small Farms.....	21
Land Ownership and Operation in Casa Grande Valley.....	22
Agricultural Engineering.....	22
Ground Water Studies.....	22
Physiography-Ground Water Correlations.....	24
Forecasting the Water Supply.....	25
The Tamarisk Tree and Its Wood.....	25
Miscellaneous.....	28
Agronomy.....	28
Cotton.....	28
Soybeans.....	29
Hybrid Corn.....	30
Flax.....	30
Small Grains.....	31
Perennial Weed Control Under Irrigation.....	31
Green Manure Crops.....	32
Sorghums.....	32
New Crops.....	32
Gila Project Farm (Yuma).....	33
Animal Husbandry.....	33
Cattle Fattening Rations.....	33
Pasture Tests with Calves.....	35
Progeny Test of Hereford Sires.....	37
Animal Pathology.....	38
Infectious Keratitis.....	38
Parasite Control.....	38
Turkey Pullorum Tests.....	39
Botany and Range Ecology.....	39
Range Resources of Arizona.....	39
Climatic and Grazing Influences on Desert Grassland Range.....	39

Destruction of Range Forage by Rodents and Rabbits.....	40
Determination of Correct Scientific Names of Common Plants.....	41
The Rubber Content of Southwestern Plants.....	44
Plant Collection and Identification.....	44
Economic Value of Native Plants.....	44
Sugar Beet Seed Production.....	46
Dairy Husbandry.....	46
Normal Growth of Dairy Cattle in Arizona.....	46
The Stop-Milking Method of Drying Off Cows.....	47
Pasture Investigations.....	47
Alfalfa Hay Analyses.....	48
Bacterial Studies on the Cleaning of the Milking Machine.....	49
Serum Solids Content of Milk.....	50
Entomology and Economic Zoology.....	50
Range Rodent Investigations.....	50
Water Relations of Desert Animals.....	50
The Grasshopper Project.....	50
Scale Insects.....	51
Biology and Control of the Cotton Pest <i>Creontiades femoralis</i> .....	51
Horticulture.....	52
Changes at the Tempe Date Garden.....	52
Date Studies.....	53
Vegetable Crop Studies.....	54
Citrus Studies.....	59
Pecan Studies.....	60
Miscellaneous.....	62
Human Nutrition.....	62
Vitamin C Content of Cantaloupe.....	62
Thiamin (Vitamin B <sub>1</sub> ) Metabolism in Rats.....	63
Nutritional Status of School Children.....	64
Supplemental Feeding of School Children Showing Follicular Conjunctivitis.....	66
Pecans as a Source of Vitamin B <sub>1</sub> and B <sub>2</sub> .....	67
Variations in the Vitamin B <sub>1</sub> (Thiamin) Content of Pinto Beans.....	69
Plant Breeding.....	69
Alfalfa.....	69
Cotton.....	70
Wheat.....	72
Soybeans.....	73
Plant Pathology.....	73
Bacterial Wilt of Alfalfa.....	73
Phymatotrichum (Cotton or Texas) Root Rot.....	74
Angular Leaf Spot of Cotton.....	75
Germination of Treated and Untreated Cotton Seeds Under Severe Conditions.....	76
Citrus Dry Root Rot.....	76
Citrus Brown Rot Gummosis.....	78
Inflorescence Blight of Date Palm.....	78
Guayule Rubber Plant and Diseases.....	78
Giant Cactus Necrosis.....	78
Bacterial Rot of Sanseveria.....	78
Bacterial Canker of Oleander.....	79
Diseases New to Arizona.....	79
Diseases Unusually Prevalent.....	79
Poultry Husbandry.....	79
Breeding Inheritance Studies.....	79

Poultry Feeding.....	81
Pullorum and Range Paralysis Resistance.....	82
Environmental Factors and Their Effect on the Natural Egg Cycle.....	82

#### APPENDIX

Analytical Service.....	83
Arizona Egg Laying Test.....	83
Soil Survey.....	85
Summary of Station Publications.....	86
Technical Bulletins.....	86
General Bulletins.....	86
Other Publications.....	88
Climatological Summary.....	92
Financial Statement.....	93

# FIFTY-THIRD ANNUAL REPORT

P. S. BURGESS, *Director*

R. S. HAWKINS, *Vice-Director*

## INTRODUCTION

Uppermost in the thoughts of all today is the problem of winning this war. Without victory there is no future for us, either as individuals or as a nation. Many have attempted to analyze their relationships and, if possible, find their rightful places in the national defense effort, for in this era of total war each has his part to play. But for farmers and those who serve agriculture this is not difficult. Farmers and manufacturers are concerned with production, and if we are to win this war, food, fiber, mechanized equipment, and munitions are prerequisites. Workers in these fields are essential to victory. Our national productive capacity is enormous but the job ahead surpasses anything in past history. The war will be won on the farm and in the factory. We have sufficient military man power if it can be properly equipped, clothed, fed, and transported.

The agricultural experiment stations of the country were organized for the purpose of utilizing scientific methods in the solution of farm production problems. Science in the service of the farmer and for the well-being of all rural people has been the guiding principle of the state stations since their establishment by the federal government in 1887. The Arizona Experiment Station is the fact-finding agency for agriculture in our state. The individual farm or ranch unit is too small to finance its own research, hence federal and state funds are appropriated for the support of our Experiment Station as a public service institution. This past year the total costs of maintenance amounted to 0.3 of 1 per cent of the gross value of agricultural commodities sold in Arizona. Were we to examine the farm management program on a typical up-to-date Arizona farm we should find that the crops grown, the livestock raised, the farm machinery and fertilizer used, the pest-control methods followed, and many other detailed operations have resulted largely from and been made possible by the research work of our state and federal agricultural experiment stations. To this investigational work goes much of the credit for the present high standards of agriculture in our nation.

When great emergencies such as the present one confront us this Station, in common with all other institutions of like nature, is confronted with many additional duties and responsibilities. During the past few months the war has necessitated a careful re-evaluation of all our work. Faced with acute shortages of farm

labor and equipment, with inadequate supplies of chemical fertilizer and insecticides, with many needed commodities rationed, and with heavy demands for agricultural products, the Station has shaped its program to secure timely information needed by both federal and state agencies and by our farmers. During the spring of 1942 we were asked by the State U.S.D.A. War Board for an analysis of two very important production problems—that of the farm labor supply and the extent of farm machinery utilization. A careful study was made of seasonal farm labor requirements for the coming year and the results submitted to the State War Board. Also, 10 per cent of the irrigated farms in different parts of southern Arizona were studied to determine the amount of machinery, its age, and the percentage of full-time utilization. Estimates were made of the needs for replacement parts and also of minimum requirements for new machinery. The results of this study are now available to federal and local authorities which may be charged with the allotment of new farm machinery and the obtaining of full-time use of machinery now available. These studies are important, for they present the factual information on labor and machinery upon which federal rationing programs later may be established.

A price study of the Arizona dairy industry has recently been undertaken. Relative prices now received by Arizona dairymen compared with prices throughout the United States for the grades of milk sold will furnish a basis for fair adjustment of maximum or ceiling prices. This study includes a history of dairy prices in this state from 1910 to the present time. An analysis of comparative costs and returns in respect to the upland and long-staple cottons also has been started. These will be tabulated for each year, 1935 to 1942, inclusive. Such a study furnishes a basis for governmental determination of proper relative prices for these commodities.

The war has greatly increased popular interest in all phases of human nutrition, arousing an awareness of need for more knowledge about the nutritive value of foods and about vitamin and mineral requirements, both for our armed forces and for the civilian population. For that reason a great expansion in research on food values is taking place in all the state experiment stations. This Station now is engaged in a study of the vitamin content of a large number of Arizona-grown fruits and vegetables to determine the stability of these factors when subjected to storage, commercial transportation, artificial dehydration, canning, and other methods of food preservation. Several of our more important winter-grown vegetables are receiving special attention from the standpoint of varieties, seasonal production, fertilization, and maturity. Such studies may point the way to the production of higher vitamin products. Co-operative work along this line with the New Mexico Station on the vitamin B content of pinto beans is in progress; also, with the National Cannery Association on



the effects on the vitamin A and vitamin C contents of vegetables, fruits, and meats as affected by commercial canning and storage methods.

One of the most necessary wartime commodities is rubber. This Station is conducting a survey of native desert plants for possible rubber-yielding species. Thus far about forty plants have been analyzed. With the exception of guayule, no plant so far examined has contained rubber in commercial quantities. This work is being continued. We also are co-operating with the Federal Department of Agriculture in growing three plots of guayule, one at Yuma and two on the University Farm at Tucson, with and without fertilization. One of the plots is located on an area known to be seriously infected with Texas root rot and with southern sclerotial rot in order to find out whether guayule is susceptible to these diseases. The results so far indicate that guayule is immune. Other possible diseases of this plant also are being studied. The Station has just entered into a formal agreement with the federal government to determine the suitability of the Russian dandelion for rubber production when grown as a winter annual in Arizona, and seeds have been sown on three of our experimental farms. Russia secures a sizeable part of her rubber supply from this plant.

Some of the older research projects of the Botany Department are being discontinued temporarily to study our native desert plants as possible sources of medicinals, insecticides, oils, and resins. This Department is co-operating with a number of commercial companies interested in this work. Merck and Company is investigating the native cockroach plant and several others as possible commercial sources of insecticide material. Parke-Davis is studying the yuccas and agaves from Arizona as sources of hormones and other medicinals. Northwestern University Medical School is working on the liquid wax of the jojobe bean as a carrier for medicines injected by needle. A number of large paint companies are interested in the resins and waxes readily dissolved from the leaves of the creosote bush as a raw material for the manufacture of lacquers and varnishes. Many requests are received for samples of Arizona plants for these and other purposes.

Culinary and medicinal herbs under study by our Horticulture Department include chicory, savory, parsley, sweet basil, caraway, anise, coriander, fennel, dill, sage, marjoram, and licorice. Supplies of these materials can no longer be imported. Seed production of the following vegetables is also receiving attention: table beets, Swiss chard, broccoli, cauliflower, cabbage, Brussels sprouts, kohlrabi, turnip, radish, collards, kale, rutabaga, onion, carrot, and endive. Our vegetable seed supply before the war came largely from the Balkan States, Italy, and the Low Countries. Three years' work along these lines indicates that Arizona can profitably grow most of these vegetable seeds.

The increased demand for long-staple cotton for war purposes has intensified the interest in the production of extra-staple varieties. The Agronomy and Plant Breeding departments have been working on this problem for some time and have obtained considerable data now being used by cotton growers in determining their planting programs for next year.

Much other war work is described in the pages which follow. We may briefly mention tamarisk as a source of fence posts and lumber, a study of our range resources in terms of possible animal production, quick cleaning and sterilization of milking-machine equipment, new protein supplements for poultry rations necessitated by war-induced shortages, irrigation studies with long-staple cotton, and others.

However, we must not discontinue all fundamental research, for these results give us the tools for solving the more intricate problems of production. Programs of plant and animal breeding require extended periods of continuous work. The same is true for nutritional, entomological, pathological, and chemical researches. It is from these and other long-continued efforts that investigators derive those basic principles without which many baffling farm problems cannot be solved. Much of this research becomes of special importance in times of emergency when stepped-up performance is required. Peacetime research always pays wartime dividends, provided that this research has been based squarely upon the needs of the industry concerned.

In closing this introduction, we wish to impress upon all our farmers and ranchers the enormous amounts of food and fiber essential to victory. Three ways in which you can greatly help are: produce to the limit, keep debts at a minimum, and buy War Bonds.

## RESULTS OF THE YEAR'S RESEARCH

### AGRICULTURAL CHEMISTRY AND SOILS

#### PLANT FOOD AVAILABILITY

One project involving a continuation of studies on plant food availability in alkaline-calcareous soils was completed during the year and published as *Technical Bulletin 94*. The investigation dealt with a comparison of seedling and chemical methods for measuring mineral plant food availability and factors which influence absorption by plants in such soils.

#### **Seedling comparisons for Neubauer method**

There has been some objection to the Neubauer seedling method of measuring plant food availability on the basis that different crops require different amounts of plant food for growth

and have different powers for extracting mineral plant food from the soil. In order to study this question the extracting power of rye, barley, wheat, hegari, corn, tomato, and cowpea seedlings for calcium, potassium, and phosphorus in 14 different soils was determined. This phase of the investigation showed that while different plants do extract different amounts of plant food from the same soils, there is good relative agreement in the amounts extracted over an equal period of seedling growth. That is, the soils showing low rye values will show low values for the other seedlings, even though the amounts are not the same. This holds true for the high and intermediate values. The data showed that the rye Neubauer values are useful in estimating available calcium, potassium, and phosphorus for many crops.

#### **Factors influencing ion absorption**

In irrigated soils, even though availability is high, other factors may be present to increase or decrease the absorption by the plant roots. A study of some of these factors yielded interesting results. Phosphate absorption was least at the highest soil pH values. It decreased with increase in  $\text{CO}_2$  soluble calcium, water-soluble calcium, and the increasing amounts of  $\text{CaCO}_3$  in the soil. Potassium absorption increased with a decrease in pH value, but there was no apparent relation between soluble calcium and potassium absorption. Calcium absorption was least at highest pH values and increased with the amount of soluble calcium in the soil. A comparison of the data obtained from the extraction of the soil with carbonic acid showed a good correlation between the chemical analysis, by this method, and the Neubauer values for all three of these plant food elements. For the potassium studies there was a good correlation between replaceable potassium and the Neubauer values.

#### **Empirical nature of the Neubauer method**

In view of the objection to chemical soil analyses based upon their empirical nature, the empiricism of the Neubauer method was studied. This investigation showed that the values vary with the weight of soil and number of plants used in the cultures. The Neubauer values decrease with increase in weight of soil and number of plants. The values also decrease when the number of plants is kept constant at 100 and the weight of soil varies from 25 to 200 grams. It appears quite evident from this phase of the investigation that the Neubauer seedling test is just as empirical as the chemical soil analysis.

#### **CHEMICAL ANALYSIS OF SOILS**

The laboratory is continually being asked for information on the availability of mineral plant food in Arizona soils. The chemical method now in daily use was described in the last Annual Report. Suffice it to say here that further investigations and

experience with the method continue to show its usefulness for estimating the available plant food in alkaline-calcareous soils.

#### PRODUCTIVE CAPACITY OF ARIZONA SOILS

In order to present information which will assist Arizona farmers in getting maximum production from their soils during the present emergency a general bulletin (Bulletin 182) was published. The information is assembled in three parts. The first part is largely on our own research and offers suggestions for controlling alkali and for maintaining soils in good structural or mechanical condition. Leaching and the use of gypsum, sulfur, and manure are the subjects discussed. The second part presents recommendations for conserving and composting farm manure and other organic farm wastes. This is important because our semiarid soils are extremely deficient in organic matter; also because organic matter is one of our best soil conditioners in addition to being a low-grade fertilizer. The third part discusses soil analysis and the part it can play in formulating a fertilizer program.

#### SOIL MOISTURE STUDIES

Water, of course, is the greatest growth-limiting factor in Arizona agriculture; hence, the soil moisture problem is a major research project. Soils may bind water in an unavailable form just as they may fix fertilizers in an unavailable form. Unavailable moisture is known as bound water. Investigations are under way designed to study the factors and conditions which bind water in Arizona soils. Evidence gained thus far indicates that the chemical and mineralogical composition of the colloidal clay fraction of the soil are the principal factors, and that puddling is the principal condition associated with the variable degrees of water-binding.

X-ray studies have been made on two important soil types—namely, a Pima clay loam which shows a strong tendency to puddle, and a Mohave clay loam showing a lesser tendency. For comparison and identification of minerals, silica, kaolinite, and bentonite (largely montmorillonite) were also included in these studies.

The Pima clay loam colloid gives an X-ray pattern which contains the strong 15-Angstrom line characteristic of montmorillonite and an appreciable amount of hydromuscovite (or muscovite), as shown by the 10-Angstrom line. There were none of the characteristic quartz lines, nor those of calcite, although the clay is slightly calcareous. The presence of considerable montmorillonite indicates extensive chemical weathering of the parent material.

The Mohave clay colloid, on the other hand, gives a strong 10-Angstrom line, indicating the predominance of hydromus-

covite. The 15-Angstrom line of montmorillonite is rather faint though definite, indicating the presence of a small amount of this mineral. In addition, the strong 4.47-Angstrom line of the so-called "X-mineral" of Kelley and co-workers (which has not yet been conclusively identified as a mineral species) is present in the pattern.

The finding that montmorillonite is the dominant mineral in the Pima clay loam colloid confirms the high tendency of this soil to become puddled and to hold water to a high degree in a bound form. The much lesser tendency on the part of the Mohave soil is similarly confirmed. From this evidence it seems justifiable to conclude that water becomes bound by entering the expanding lattice of the montmorillonite, since the dimensions of the lattice depend upon the amount of water present. It is also clear that the manner and extent to which water is bound by a soil is closely linked up with the nature of the minerals of which the colloidal fraction is composed.

These studies will be continued with colloids of other arable soils of the state, since a knowledge of the dominant minerals is also of importance in interpreting the fixation of plant nutrients by soils.

#### SALINITY OF PUDDLED SOILS

Measurements have also been made on the effect of puddling upon the active salinity of soils to determine whether such treatment tends to increase the apparent salt concentration. This effect was studied by measuring the electrical conductivity of the moist soil between fixed electrodes. A soil mixed with a known amount of finely pulverized sodium chloride was made up to a series of different moisture contents, with time allowed for moisture distribution to be equalized. The conductivity was first determined on the unpuddled soil, the sample then puddled and the conductivity redetermined. Theoretically the conductivity was expected to decrease as a result of puddling, due to the replacement of calcium and magnesium by base exchange. Actually it was found that the conductivity increased because of the puddling, thus confirming the fact that some of the water had become bound. It is recognized that part of the conductance may have been due to the soil particles themselves in addition to the ions of the salt in solution, but it may be assumed that such conductance would be the same in both the puddled and unpuddled states of the soil. This experiment emphasizes the importance of care in the cultivation of saline soils, for the soil solution of a puddled soil may contain a greater concentration of salt than it would if the same soil were in an unpuddled or good structural condition. A technical bulletin will soon be published setting forth these bound-waters investigations in some detail.

## BURROWEED INVESTIGATIONS

Burroweed (*Haplopappus tenuisectus*) has in recent years been spreading itself at an alarming rate over the grass ranges of the state, particularly in the southern sections, and as a result various investigations on the nature of the plant and its distribution are in progress. It seemed of interest to determine whether or not the distribution of the weed was in some manner related to the nature of the soils in the infested areas, and if so, what particular soil properties influenced its predominance over the range grasses. Accordingly, a co-operative project was set up between the Pima County Agricultural Agent's Office, the U.S. Soil Conservation Service, the U.S. Forest Service, and the Department of Agricultural Chemistry and Soils of the University. Five typical areas were studied: (1) the Altar Valley; (2) the Empire Ranch district; (3) the Santa Rita Range Reserve; (4) the Continental-Sasabe-Twin Buttes district; (5) an area along U.S. Highway 80 from Tucson to Oracle Junction and Oracle, including the Page-Trowbridge Ranch. Characteristic sites were chosen for the sampling of soils and the securing of density counts so as to represent different types of terrain, elevation, slope, degree of erosion, vegetative cover, and soil type. The infestations were divided into three classes:

1. None.
2. Light—that is, up to 1,500 plants per acre.
3. Heavy—that is, from 1,500 to over 5,000 plants per acre.

The soil samples were taken at the several horizons in the profile. Analyses were made of constituents and properties as follows:

## PHYSICAL

1. Per cent sand
2. Per cent particles less than 0.005 mm.
3. Per cent dispersion at 0.05 mm.
4. Per cent pore space
5. Volume weight
6. Volume expansion on wetting
7. Per cent moisture (moisture equivalent)
8. Per cent moisture at saturation
9. Specific gravity

## CHEMICAL

1. Total soluble salts
2. PH value at saturation
3. CO<sub>2</sub>-soluble phosphate
4. Total nitrogen
5. Total organic matter
6. Total carbonates

Altogether fifty-four sites were sampled for soil and counts of plant density taken. In order to put all the sampled sites on a uniform basis for statistical treatment of the data, the several samples of soil taken at different horizons below the surface were grouped together and termed "subsoil."

The data so obtained were subjected to statistical analysis and the T-values calculated for the following comparisons:

1. None with heavy
2. None with light
3. Light with heavy

The comparisons were made with both surface and subsoils.

The T-values indicated significant differences (odds of 1 to 20) only in case of the comparison of None and Heavy infestations, and the specific soil properties in which the T-values were significant were as follows:

Property	T-Value (None vs. Heavy)
Volume weight.....	2.067
Per cent pore space.....	2.435
Per cent moisture at saturation.....	2.533
Per cent organic matter.....	2.075

Not quite significant differences (odds of less than 1 to 20) were observed in only two cases:

Per cent sand.....	1.958
Per cent nitrogen.....	1.735

None of the comparisons for the subsoil samples were within the range of significance, nor did the comparisons of None vs. Light and Light vs. Heavy for either surface or subsoil show significant differences.

The foregoing results indicate rather definitely that the distribution of burroweed is related primarily to those physical properties of the soil which affect the penetration of rainfall. Apparently moisture is the limiting factor, the soils being supplied in general with sufficient plant nutrient elements. In some cases burroweed had crowded out the grasses even though the soil was well supplied with plant food elements. Hence it appears that the distribution of the weed is determined chiefly by the fact that it is better able to resist drought than are the range grasses, for the infestations are greatest on those soils which are least favorable to the penetration of rainfall. A bulletin is being prepared setting forth the findings of this investigation.

#### RUBBER PLANT INVESTIGATIONS

In view of the present rubber shortage and a widespread interest in possible new sources, a study was begun this year in co-operation with the Botany Department covering desert plants of the milkweed and other closely related families not previously included in the extensive reconnaissance of rubber plants by Hall and Long.<sup>1</sup> The plants were air dried, finely pulverized, and successively extracted with acetone and benzene. The first of these solvents removes the resins, oils, waxes, and coloring matters; the latter extracts the rubber and rubberlike plant constituents. The results obtained to date are summarized in the following table:

<sup>1</sup>Carneg. Inst. Wash. Publ. No. 313, 1921.

TABLE 1.

Plant	Moisture, per cent	Acetone extract, per cent	Benzene extract, per cent
<i>Amsonia Kearneyana</i> .....	.....	19.12	1.38
<i>Amsonia longiflora</i> (whole plant, 20-mesh).....	3.77	14.63	0.49
<i>Amsonia longiflora</i> (whole plant, 80-mesh).....	3.90	17.40	0.39
<i>Amsonia longiflora</i> (tops only, 80-mesh).....	.....	19.83	0.51
<i>Apocynum cannabinum</i> .....	.....	15.01	0.45
<i>Artemisia vulgaris</i> var. <i>discolor</i> <i>Asclepiadora decumbens</i> .....	4.31	11.77 9.94	0.90 0.39
<i>Asclepias eriophylla</i> .....	.....	20.28	0.69
<i>Asclepias mexicana</i> .....	.....	14.97	0.84
<i>Atriplex lentiformis</i> var. <i>Griffithsii</i> .....	.....	5.00	0.15
<i>Cichorium intybus</i> .....	.....	10.19	0.16
<i>Chrysothamnus nauseosus</i> (rabbit brush).....	.....	12.77	0.67
<i>Encelia farinosa</i> .....	.....	17.64	0.10
<i>Ephedra trifurca</i> .....	3.99	16.95	None
<i>Eriodictyon californicum</i> .....	.....	33.30	0.05
<i>Euphorbia</i> sp.....	.....	21.95	0.23
<i>Euphorbia</i> sp. (Willowbrook, Calif.).....	5.00	10.20	0.13
<i>Fouquieria splendens</i> (ocotillo) <i>Fouquieria splendens</i> (bark only).....	1.78 .....	18.13 18.16	0.39 0.34
<i>Fouquieria splendens</i> (wood only).....	.....	2.49	None
<i>Franseria deltoidea</i> .....	.....	13.37	0.10
<i>Franseria deltoidea</i> .....	4.49	14.25	0.06
<i>Funastrum cyanchoides</i> .....	3.90	10.65	0.54
<i>Funastrum heterophyllum</i> .....	.....	10.68	0.72
<i>Haplopappus tenuisectus</i> .....	.....	16.84	0.17
<i>Haplopappus tenuisectus</i> (young plants).....	4.11	14.19	0.39
<i>Jatropha angustidens</i> .....	.....	9.54	0.19
<i>Lachnostoma arizonica</i> .....	.....	7.71	0.51
<i>Lactuca scariola</i> .....	.....	5.53	0.19
<i>Larrea tridentata</i> (creosote bush).....	.....	23.32	0.64
<i>Lycium</i> sp.....	0.16	6.28	0.10
<i>Nerium Oleander</i> .....	.....	14.00	0.61
<i>Thevetia nereifolia</i> .....	5.45	13.56	0.90
<i>Parthenium argentatum</i> (guayule).....	.....	14.05	4.50
<i>Euphorbia pulcherrima</i> (poinsettia).....	.....	5.80	0.18
<i>Sonchus oleraceus</i> .....	.....	7.34	0.38
<i>Tragopogon porrifolius</i> .....	.....	10.61	0.15
<i>Urtica holosericea</i> var. <i>californica</i> .....	.....	7.38	0.23
<i>Xanthocephalum</i> <i>gynospermoides</i> .....	4.08	15.24	0.27



The foregoing analyses show that with exception of the guayule plant, which is already under commercial cultivation, very few of the plants analyzed show percentages of rubber which would be a promising commercial source. The highest rubber-bearing plants thus far found are: *Asclepias mexicana*, 0.84 per cent; *Thevetia nereifolia* (Florida oleander), 0.90 per cent; *Artemisia vulgaris* var. *discolor*, 0.90 per cent; and *Amsonia Kearyana*, 1.38 per cent.

While the aim of this investigation is to extend our knowledge of desert plants with reference to their rubber and resin contents, it is evident that because of the rare occurrence of some of these rubber-bearing plants one cannot expect to find an available supply of any magnitude that might be harvested immediately. To be sure, certain range plants have encroached as highly undesirable weeds upon certain areas, as for example, *Haplopappus tenuisectus* (burroweed); but though the immediate supply of this plant is extensive, it is unfortunately too low in its rubber content to justify consideration as a commercial possibility. Burroweed contains only 0.50 per cent of rubber on the basis of the entire plant. As a general rule, plants which run low in rubber have a correspondingly high percentage of resins and waxes which may prove valuable as by-products when the demand for such products becomes sufficiently high. Preliminary greenhouse plantings of some of these plants have shown that they are able to produce rubber under the artificial conditions of cultivation and irrigation. Since some of the plants make rather rapid growth, it is thought that a latex-bearing plant might be found which could be cultivated on a large scale, yielding several cuttings a year. This investigation is being continued, and it is suggested that anyone interested in the rubber problem who has knowledge of promising plants send specimens to the Department of Agricultural Chemistry and Soils for analysis.

#### FLUORINE INVESTIGATIONS

During the past fiscal year tests on the bone filter at the Tucson Preventorium have been continued. Co-operative studies with a commercial filter company further to improve the capacity of the bone for fluorine removal have met with only moderate success.

Samples submitted to the laboratory for fluorine analyses average about one per day. At the request of the Arizona Sewerage and Water Works Association a paper was read at the annual meetings in Douglas, and a session on laboratory methods was conducted on the campus.

An invitational paper was presented at a Fluorine and Dental Health Symposium at the A.A.A.S. meetings in Dallas, December, 1941. This paper together with ten others has been published as a monograph by the Association.

## BORON

This project is designed to determine whether boron, either as a deficiency or an excess, is involved in soil productivity problems in the state.

The suitability of certain analytical methods for the boron determination has been investigated. As a result the turmeric method has been discarded and the quinalizarin method adopted.

Boron analyses on nearly 500 carefully chosen samples of soil, water, and vegetation from various parts of the state have been made. Some irrigation waters which are toxic toward citrus are being used on field crops with no ill effects. Analyses of well waters from different strata show variations in boron content which are useful.

A method of determining boron deficiency based on growing beets in soil diluted with sea sand is under investigation. Boron deficiency which was produced by growing beets in sea sand was corrected by the addition of 5 per cent soil to the sand. If such small additions of soil to sand cultures universally dispel boron deficiency symptoms, it might be concluded that the soil is not deficient in boron.

The relationship between the lime content of the soil and boron availability is under investigation. Sunflowers grown in the greenhouse in the presence of high concentrations of boron apparently absorb less calcium than those grown in lower boron concentrations.

## LYSIMETER-NITROGEN BALANCE

This long-time nitrogen-balance experiment was started in 1930. As one phase of the experiment, two tanks are planted only to wheat and hegari. One of these contains Gila clay loam (river bottom soil) and the other Mohave clay loam (upland soil). During the period 1931-40 the nitrogen removed from the Gila soil by cropping was 1,625 pounds per acre. The original nitrogen content of this soil was 0.085 per cent. The crops removed 1,133 pounds per acre of nitrogen from the Mohave soil during the same period. The original nitrogen content of this soil was 0.05 per cent. Only 70 per cent as much nitrogen was removed from the Mohave soil as from the Gila soil under these conditions of cropping. The amount of nitrogen removed from other tanks in the experiment, which have been in a 5-year rotation for a similar period, has greatly exceeded the hegari and wheat double-cropping system. The regular rotation consists of 3 years of alfalfa, cotton and wheat, and hegari and wheat. In the latter rotation, the actual amounts of nitrogen removed were: Gila clay loam, 2,414 pounds per acre; and Mohave clay loam, 2,335 pounds per acre. In the alfalfa rotation the Mohave soil gave up 96 per cent as much nitrogen as the Gila soil, while in the wheat-hegari system of cropping the Mohave soil gave up only 70 per cent as

much nitrogen as the Gila soil. This points out the greater original fertility of the Gila soil and the ability of alfalfa to enrich the soil with nitrogen.

VERTICAL ZONATION OF GREAT SOIL GROUPS ON MT. GRAHAM,  
ARIZONA, AS CORRELATED WITH CLIMATE, VEGETATION,  
AND PROFILE CHARACTERISTICS

The investigations involved in carrying out this project were essentially completed during the past year, and the results have been prepared for publication. The study was initiated because of the recognized need for fundamental information about the range soils of Arizona if the range is to be kept in good condition for grazing purposes or restorative measures taken where deterioration exists. Soils from Mt. Graham and vicinity which represent a cross section of the range lands of the state were chosen for this purpose and have been under investigation for the past several years.

Specifically, the present study consisted of a description of certain representatives of the great soil groups of the United States which were found to be present in vertical zones on Mt. Graham. Vegetation and climatic changes on the mountain were noted, and these were correlated with the different type soils examined. Finally, profile samples were taken and submitted to physical, chemical, and microbiological analyses.

Gray-brown podzolic soils were found associated with the conifer forests, whether of Douglas fir or ponderosa pine, at elevations above 6,400 feet. In adjacent mountain meadows, prairielike soils prevailed. At lower elevations in the oak-woodland zone (elevation, 4,800 to 6,000 ft.) were found shantung or noncalcic brown soils. In the desert-grassland area (elevation, 3,000 to 5,000 ft.), reddish brown soils prevailed. These soils were characterized by the presence of a claypan in subsurface horizons. Red desert soils were found on the desert at elevations below 3,600 feet.

Rainfall and temperature averages were obtained for the different vegetation zones on Mt. Graham, from which efficiency indices after Thornthwaite were calculated. On the basis of these climatic types, the soils on Mt. Graham were appropriately classified.

Physical, chemical, and microbiological characteristics of the profile samples yielded a wealth of data, certain interesting results of which are as follows: In general, with increasing elevations, the soils showed lower volume weights, larger pore spaces, increased moisture equivalents and water-holding capacities, and greater expansion on wetting. Higher organic matter content in the soils from mountainous areas was the contributing factor in these changes. Some of the reddish brown and red desert soils, however, contained a high percentage of clay in subsurface

horizons, and in these instances the results were equivalent to those found for soils from higher elevations.

Soils from the desert and desert grassland were alkaline in reaction, and the alkalinity increased with depth in the profile. Soils from the higher elevations on Mt. Graham were distinctly acid in reaction, and the acidity increased with depth in the profile. A surprising feature of these results was the high accumulation of soluble phosphorus in the zone of maximum root density in the very acid forest soils. Subsurface horizons contained very little phosphorus.

Some of the desert soils contained less than  $\frac{1}{2}$  per cent organic matter. The organic matter contents increased with elevation of the soil samples. In some surface soils from the forested areas, the organic matter contents were as high as 40 per cent.

The alkaline soils from desert and desert-grassland areas contained a surprisingly high proportion of beneficial bacteria. A greater number of nitrifying bacteria, aerobic cellulose-destroying bacteria, and nonsymbiotic, aerobic nitrogen-fixing bacteria were found in these soils than in the others tested. Gray-brown podzolic soils from forested sections contained neither nitrates nor nitrifying bacteria.

Total numbers of bacteria, actinomyces, and molds were highest in the more moist, higher organic matter containing soils from the higher elevations on the mountain.

It is evident that the characteristics of the different type soils from Mt. Graham and vicinity varied through wide limits. It was noted in a general way, however, that certain combinations of characters were associated with a given type of plant cover. Such information will undoubtedly be of value in range management, erosion control, revegetation, and other types of work.

#### THE EFFECT OF FIELD APPLICATIONS OF ORGANIC MATTER ON THE PROPERTIES OF ARIZONA SOILS

The range soils of Arizona are known to be low in organic carbon, especially under conditions where the perennial grass cover has deteriorated and the bare soils have been largely exposed. This fact, together with the knowledge that organic matter has various beneficial effects upon the properties of soils, in many cases making them better media for the growth of plants, constitutes the basis for the work accomplished on this project during the past year.

Alfalfa, filaree, and native grass straw were applied, both as a mulch and incorporated with two Arizona soils under actual range conditions. Pima silty clay loam from the City Farm near Tucson and Continental sandy clay loam from the Page-Trowbridge area near Oracle were used. Rainfall simulator plots were established on each soil type and determinations made periodically for infiltration rate, stability toward erosion, per cent

moisture, the extent of water-stable aggregation, pH, percentage of organic matter, and nitrate-nitrogen. In addition to these studies, changes occurring in the Pima soil under irrigated conditions also were determined.

It was observed that surface mulching of organic materials on the Pima and Continental soils under natural rainfall conditions strikingly increased infiltration, decreased runoff, and practically eliminated erosion; the grass mulch was most effective in this regard. The incorporation of organic materials with these soils either had no significant effect on rates of infiltration or decreased them slightly. An interesting observation on the Continental sandy loam was that the increased infiltration of water into the mulched soil favored the establishment of twice as many perennial grasses as were established on the undisturbed and untreated soil.

Carbon dioxide evolution measurements made on the irrigated Pima soils and used as an index of decomposition rate showed that a greater amount of carbon dioxide was produced in the case of the alfalfa treated soils than in the case of native grass straw. Alkalinity was decreased, however, with all treatments.

Incorporation of the organic materials with the Pima soil under irrigated conditions caused an appreciable increase in aggregation and infiltration of water into these soils, native grass straw proving more effective in this respect than alfalfa.

On the basis of these results it was concluded that serious consideration should be given to the partial incorporation of organic matter in Arizona soils, leaving an appreciable amount on the surface in the form of a mulch. This practice would undoubtedly result in greater water penetration, decreased evaporation, and the development of an erosion-controlling plant cover.

#### FEEDS AND FERTILIZERS

The regulation of feeds and fertilizers for the state is assigned by law to the Department of Agricultural Chemistry and Soils. During the calendar year 1941 the samples analyzed were 460 mixed feeds, 49 samples of cottonseed meal, 13 mineral feeds, and 63 fertilizers. Total sales were 48,388 tons of mixed feeds, 19,115 tons of cottonseed meal, and 9,787 tons of fertilizer. The tonnage of feeds sold in the state is based on the sale of tonnage-fee stamps and tags. The fertilizer tonnage is based on shipment reports.

#### AGRICULTURAL ECONOMICS AND RURAL SOCIOLOGY

##### FARM LABOR IN ARIZONA

Seasonal requirements of farm labor for Arizona irrigated farms were found to reach maximum numbers in November. Low numbers of workers are required in March and August. The

needs for year-round and seasonal labor in the year 1942 were estimated to be 26,000 workers in April and 56,000 in November. The principal sources for Arizona labor were found to be resident laborers in small towns and on farms, laborers on Indian reservations, extra hands living in larger towns and cities, and migrant labor in cotton-picking season from Texas and other states. For the first time, the year 1942 tapped another source of Arizona labor which may prove to be very useful during the years of labor shortages—that is, the labor drawn from among older school children. It seems quite certain that a more thorough-going organization of the community for the recruiting of labor will be necessary before the state will realize the full benefit of all the resident labor supply. The findings of the labor study were prepared for publishing late in 1942 as *Arizona Experiment Station Bulletin No. 186*, entitled "Wanted, Man Power for Arizona Farms."

#### SHARING FARM MACHINERY

The hope of securing increased agricultural production with little new machinery available hinges on getting greater use of existing farm machinery. The determination of the present supply and condition of machinery on farms and the possibilities of expanding its use was the purpose of a detailed study covering 10 per cent of the farm land in the larger irrigated valleys of Arizona.

Farmers generally entered the 1942 season with large supplies of relatively new machinery on hand. New machinery sales in the state in 1941 were larger than normal. Even so, because of the extensive year-round use made of machinery in this state, the study showed that many of the older machines would be worn beyond the point where they could be economically repaired by the end of 1943. Greater use must be made during wartime of custom contracting, machine renting, and other methods of machine sharing. Information on the cost and advantages of custom machinery work for heavy tillage and harvesting operations, which was published in *Arizona Experiment Station Bulletin No. 174*, September, 1941, entitled "Efficiency in the Use of Farm Machinery in Arizona," was brought up to date and amplified in the later study.

#### PARITY FOR ARIZONA PRODUCTS

In respect to a number of important products, Arizona parity price is substantially larger than United States parity. For eggs, the Arizona parity price is about 33 per cent above U.S. parity; and in the case of this commodity, parity prices vary in different parts of Arizona. Parity price for barley in Arizona is about 25 per cent above U.S. parity; wheat, 17 per cent above; grain sorghums, 10 per cent above; and fat in churn cream, 8 per cent

above the U.S. parity price for butterfat. In respect to commodities like short-staple cotton and lambs, the parity price for Arizona is not far different from the U.S. parity price, while in respect to alfalfa hay of similar quality Arizona prices are normally substantially lower than U.S. prices.

American-Egyptian cotton parity income in terms of upland cotton income from 1935 to 1939 was determined. For SxP No. 2 cotton a price two and one half times the price of middling upland cotton would give a parity income to the SxP grower under cost-of-production conditions such as prevailed in 1942 and with normal yield.

Discounts established against irrigated cotton by the Commodity Credit Corporation loan program cost the Arizona cotton growers approximately \$230,000 in the crop year 1941-42. Partly as a result of this finding, the Commodity Credit Corporation modified its loan program for the season 1942-43, making little differentiation in loan price between rain-grown and irrigated cotton in the grades and staple lengths ordinarily produced in Arizona.

#### SUPPLY-PRICE RELATIONSHIPS

A record of the production, supplies, and prices of farm products in Arizona for the year 1941, together with an analysis of the returns from these products, was shown in "Arizona Agriculture 1942: Supplies, Prices, and Income."<sup>2</sup>

#### FARM LEASES UNDER IRRIGATION

A flexible lease form was made for use in the improvement of rental agreements in the irrigated areas of Arizona. Points and features now in use in Arizona and in other states and regions were incorporated in a working instrument for the use of Arizona farm owners and ranchers, the aim being to combine the best and most workable parts of other leases into a form suitable for irrigated agriculture. Findings of the lease study and a copy of the recommended lease form are incorporated in "Arizona Farm Leases."<sup>3</sup>

#### DIVERSIFIED PLAN FOR SMALL FARMS

The development of programs of diversification to make the most efficient use of the available supply of labor, land, and capital on small farms was the purpose of a study started in January, 1941. Twenty-two farm financial records for small farms were summarized and reports returned to the operators. The study has not progressed sufficiently far to make recommendations on the desirability of diversification.

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<sup>2</sup>*Ariz. Exp. Sta. Bull.* 178, January, 1942.

<sup>3</sup>*Ariz. Exp. Sta. Bull.* 179, February, 1942.

## LAND OWNERSHIP AND OPERATION IN CASA GRANDE VALLEY

The nature and size of ownership and operating units in the Casa Grande valley were reported upon in brief form in "Agricultural Land Ownership and Operating Tenures in Casa Grande Valley."<sup>4</sup> In addition to material included in the bulletin, a set of maps was prepared showing several types of relationships in respect to the status of state grant and institutional land, the size of Agricultural Conservation and Parity payments on state grant and institutional land, Triple A base allotments of short-staple cotton, etc.

## AGRICULTURAL ENGINEERING

## GROUND WATER STUDIES

**Upper Santa Cruz Valley**

Just previous to the summer flood season of 1942, water levels reached their lowest point in history throughout the entire area. Almost negligible recharge to ground water aquifers was provided by the extremely small runoff of the Santa Cruz River during the winter of 1941-42. With the exception of the large flood of July 8, with its source in Mexico, flood flows during the summer of 1942 were of small size, of short duration, and few in number. Only in that portion of the valley above the junction of Nogales Wash with the Santa Cruz River was summer recharge equal to draft upon the ground waters. Below this point water levels at the end of the irrigation season, in October, 1942, were as low or even lower than at the beginning of the summer rainy season.

**The Cortaro-Marana district**

In the Cortaro area of this district the pumping draft during the 1941 irrigation season was about 20,800 acre-feet, the greatest since 1930. Notwithstanding the delayed effects of recharge from flood flows of the winter 1940-41, an average residual lowering of about 5.7 feet was found January 28, 1942. Only in the Canada del Oro region was there no apparent lowering of the water table as a result of the 1941 season's pumping draft.

The planned draft of 29,600 acre-feet in 1942, with the actual withdrawal of nearly 26,000 acre-feet by the middle of September, resulted in the lowest water levels in the area since the beginning of pump development. An average lowering of almost 13 feet in the static water level occurred during the 1942 pumping season, which is the same as the lowering which took place during the 1928 pumping season when 29,900 acre-feet of water were pumped from the area.

The continuous water-level recorder on Well 16-C2 showed a maximum depth to water of about 102 feet as compared with that

<sup>4</sup>Ariz. Exp. Sta. Bull. 175, November, 1941.



of 99.5 feet in 1929, which was the lowest point which the water level had previously reached. The record covers the period from 1919 to the present date.

The pumping draft in the Marana area was reduced from over 9,000 acre-feet in 1940 to about 6,400 in 1941. As a result, no significant change in water level took place between March, 1941, and the beginning of the pumping season in 1942. Recharge in the area during this period apparently balanced the pumping draft.

#### **The Eloy district**

This study is the continuation of investigations reported in *Technical Bulletin 87*.

The area under irrigation in the Eloy district as of October 1, 1941, was 41,800 acres—an increase in 1 year of 8,400 acres. Of this area, 23,450 acres were in long-staple cotton and 10,920 in Upland cotton. Grain, alfalfa, flax, and truck crops made up the remainder.

For the year 1941-42 the volume of ground unwatered was 845,000 acre-feet. The quantity of water pumped, as determined by indirect methods, was 129,600 acre-feet. The equation for the year (see *Tech. Bull. 87*) was  $845,000 S + N = 129,600$ , in which  $S$  is the specific yield of the ground unwatered and  $N$  is the "new" water. Adopting a value of  $S$  based on determinations of the previous years, the quantity of water taken from storage was approximately 100,000 acre-feet and the volume of new water approximately 30,000 acre-feet.

The volume of new water is considerably larger than was found for previous years, because of increased downward percolation. The increase can be ascribed principally to percolation downward from ditches and irrigated fields. A little may have been recharge from the bed of the Greene Canal Arroyo during the high floods of the winter of 1940-41, but the scanty evidence of a few wells close to the channel indicates little or no recharge from that source.

The heavy winter rains reduced the use of water at planting time. There was no power shortage such as had been experienced the previous year; therefore the pumping rate was heavy during the summer.

The average lowering of the water table at the 88 wells measured was 5.3 feet from March 1, 1941, to March 1, 1942. In eleven sections of land the lowering exceeded 10 feet.

For 5 years the bringing of new land under cultivation has been deplored, because it increases the pumping lift at all wells and shortens the life of the district. Good land-use planning would dedicate the Eloy district to a controlled acreage of truck crops, sugar beet seed, flax and other high-value crops, with perhaps a limited area in long-staple cotton during wartime.

### Little Chino Valley

Water levels and artesian pressures in April, 1942, in Little Chino Valley showed an average lowering of 3.3 feet in the central portion of the artesian area, a lowering of less than a foot in the upper end of the area, and of 0.5 foot in the Granite Creek area, as compared with the corresponding time in 1941. Extreme drouth conditions during the 1941-42 winter, together with a warm spring, resulted in the use of irrigation water much earlier in the season than usual. Water-level measurements in April, 1942, therefore reflected in part, at least, the effects of this draft upon the artesian basin.

This general lowering of the pressure surface and water levels early in the season did indicate that the drawdown effect due to seasonal draft upon the artesian basin was much greater than had been previously realized. Measurements were therefore made in the latter part of the irrigation season — August 25-27, 1942 — and it was found that a further general lowering of approximately 6.5 feet had occurred. It is probable that a general lowering in pressure or a drawdown effect of 10 feet or more obtained throughout the artesian area during the period of heaviest irrigation draft.

Although the acreage irrigated from ground water supplies of the artesian basin has not changed materially during the past 3 years, it is believed that the draft upon the ground water supplies in 1942 is almost twice that of 1941. Supplementary water amounting to over 1,100 acre-feet was pumped from the artesian basin and used on the lands of the Chino Valley Irrigation District. Drouth conditions and a longer irrigation season have resulted in the higher water requirements for the crops ordinarily grown in the valley. In addition there was an increase in the acreage in vegetables on which large quantities of water were used.

Surface-water wells adjacent to heavily irrigated fields have in some instances shown a gradual rise in water level with seasonal fluctuation corresponding to the use of water for irrigation. Other wells somewhat isolated from irrigated areas have shown no material change in water level over a 5-year period.

### PHYSIOGRAPHY—GROUND WATER CORRELATIONS

The physiography of the San Pedro Valley is under study with a view to the eventual mapping of the physiographic features. Progress has been made in the determination of these features along the trough of the valley from its head south of the border to its mouth at Winkleman, and also in the vicinity of Clark Wash where favorable exposures have resulted from deep erosion.

## FORECASTING THE WATER SUPPLY

The study of sublimation losses from snow cover were continued at Alpine in March, 1942. A favorable period during which dry winds prevailed offered an opportunity for observations which had been lacking on previous trips to Alpine. High rates of loss during the period of dry wind were shown. A paper discussing the investigations during the past two winters was read at the meeting of the Southwest Section of the American Association for the Advancement of Science on April 30, 1942.

## THE TAMARISK TREE AND ITS WOOD

**Preservative treatment of tamarisk fence posts**

Previous investigations of creosote treatment of tamarisk fence posts were described in 1941.<sup>5</sup> Other preservatives than creosote are available, and their use might be necessitated if creosote should be put on the priority list. Some are less expensive than creosote. The relative values can be determined only by trial in the ground.

Investigations were started in June, 1942, to compare the life of tamarisk posts treated with four different preservatives: coal-tar creosote, wood-tar creosote, permatox A, and zinc chloride. Permatox A is a 5 per cent solution of pentachlorophenol, which is toxic to microorganisms, including fungi. The permatox is shipped as a concentrate and is diluted with some light fuel oil before using.

The tamarisk posts were cut late in June. Half of each lot was treated at once by standing the posts in drums partly filled with the liquid, without heat except that of the sun. The remaining posts were stored in an open-sided shed, butts down, until September 25, when they were given treatments as nearly as possible like those of the posts treated green. The schedule of treatments is shown in Table 2.

It can be noted that the quantity of permatox absorbed was comparable to that of creosote, differences being attributable to differences in the size of posts. Knots and crooks also influence the absorption. The green posts took much more of the preservative oils than did the dry ones.

One post of each lot was sawed into short pieces for examination. All these posts except one showed that they had been well treated up to 30 inches above the butt end, except for the outer annular ring—that is, the recent growth of “spring” wood, which appears not to have developed long capillary vessels.

The zinc chloride was applied by the tire-tube method recommended by the Forest Service of the United States Department of Agriculture. This requires that the posts be treated while

<sup>5</sup>Ariz. Agr. Exp. Sta. Tech. Bull. 92.

TABLE 2.—TREATMENT OF TAMARISK POSTS WITH VARIOUS PRESERVATIVES.

Preservative	No. of posts in lot	Condition of posts	Depth of submer-sion (inches)	Time treated (hours)	Average quantity absorbed (gallons)	Per cent of thorough treatment at various heights in feet above butt end				
						2	2.5	3.75	5	6
Wood-tar creosote.....	17	Green	18.5	12	.15	40*	30	20	10	5
Wood-tar creosote.....	17	Dry	15	12	.052	100	90	50	30	20
Coal-tar creosote.....	17	Green	21.5	13.5	.12	65†	65	35	25	10
Coal-tar creosote.....	17	Dry	25	12	.097	100	100	85	70	40
Permatox A.....	17	Green	24	13.5	.17	100	100	50	40	20
Permatox A.....	17	Dry	17	12	.085 (lbs.)	100	100	30	15‡	8
Zinc chloride.....	5	Green	.....	20-40	1.33	.....	.....	.....	.....	.....

\*This post was selected for examination because of a large knot and crook in the post at 1.5 feet from the butt end.

†Small knot at 1.5 feet from butt end.

‡Base of large limb at 4.5 feet from butt end.

thoroughly green, and only round, unsplit posts with the bark on them can be so treated.

Half of each lot will be set on the University Farm where frequent irrigations and general soil conditions will be those of the irrigated valleys. The other half will be set on the Page-Trowbridge farm, 30 miles north of Tucson, where conditions simulate those of the average cattleman's fence line. Inspections will be made at intervals, and the life of each post will be determined.

#### **Plantings of tamarisk trees for saw logs**

Plantings of tamarisk groves were made March 13 to 17 on the Yuma Valley farm to determine whether tall vertical trunks can be grown from which 15-foot saw logs free from knots can be secured.

There are tens of thousands of tamarisk trees in Arizona growing as shade trees or windbreaks but without pruning or other attention. As an ornamental they are best with thick foliage from the ground upward. Rarely is a trunk found that would be acceptable for milling.

The beautiful grain and color of tamarisk wood was discovered in 1935. In 1939 the Forest Products Laboratory of the U.S. Forest Service reported very favorably on the physical properties of tamarisk wood.<sup>6</sup> It now remains to determine how successfully good commercial tamarisk lumber can be grown.

Two areas were selected on the Yuma farm — one on the south side, in sandy soil; the other on the north side, in clay loam. There are nine plots of 3 to 6 rows each for differential treatments. The number of cuttings set was 2,951, of which 960 were from the University campus, the others from a windbreak near the Yuma Valley farm. The rows are 8 feet apart, to fit the width of the cultivator. Three spacings in the row are being tried; they are 2.5, 5, and 8 feet. Thinning will be done progressively as some trunks exhibit greater symmetry and straightness and more rapid growth.

The survival in June was 92.6 per cent. Most of the loss was because of the drying of the cuttings brought from Tucson before they were set.

The number of shoots on a cutting averaged six. On June 17 and 18 the shoots, except the best one in each case, were trimmed out on every second row beginning with the first row on each plot. The same treatment was given to the even-numbered rows on September 8 to 10. At that time the average height of the young trees in the odd-numbered rows was 71 inches, while in the even-numbered rows it was 74 inches, indicating that there is an advantage in waiting until September to do the thinning.

The average height attained by the Tucson cuttings was 2 inches less than that of the Yuma cuttings. The averages for the 2.5-, 5-, and 8-foot plantings, respectively, were 73, 73, and 71 inches, with the young trees on the closer plantings somewhat

<sup>6</sup>Tech. Bull. 92, June 15, 1941, pp. 250-53.

more erect. The average height on the heavy soil of the north plots was 8 inches greater than that on the south plots, which have a sandy soil.

The growth on June 18 had reached an average height of 30 inches. The increase between that time and September 9 was 43 inches. All the plots are being irrigated during the first year.

A soil sample in an alkaline area where a thrifty tamarisk wood lot is growing showed 18,545 parts per million of soluble salts, indicating that the tolerance for alkali is practically unlimited.

#### MISCELLANEOUS

##### **The guayule shrub under irrigation**

A paper entitled "The Production of Guayule Rubber under Irrigation" was prepared and read at the annual convention of the American Society of Agricultural Engineers on June 29, 1942. This paper outlines the domestication of the wild guayule shrub and the successive efforts to bring it into commercial production—particularly the effort at Continental (25 mi. south of Tucson), during the years 1916-22, which effort was thwarted by the low competitive prices of rubber from the plantations of Malaysia. The irrigation engineer of this Station was responsible for the selection of the location at Continental, for the layout of the ranch, and for its irrigation water supply.

##### **Water supplies for air fields**

Frequent assistance has been given to military agencies regarding ground water supplies at proposed air bases and landing fields.

#### AGRONOMY

##### COTTON

##### **Irrigation**

Plants kept growing rapidly from emergence to the period of heavy flowering by means of plentiful water supplies outyield those retarded in growth during this period, as indicated in Figure 1. The weight of lint from the early irrigated treatments A and C was decidedly greater than that from the delayed treatments B and D. Also treatment C, which used less water after August 1 than did any of the other treatments, produced the highest yield of lint. These data are based upon 7 years of tests, each irrigation treatment including three replications every year.

##### **Variety tests**

One of the Deltapine strains again topped all other varieties of upland cotton in money value per acre. Last year (1940) Deltapine 14 was the leading variety in this respect. This year

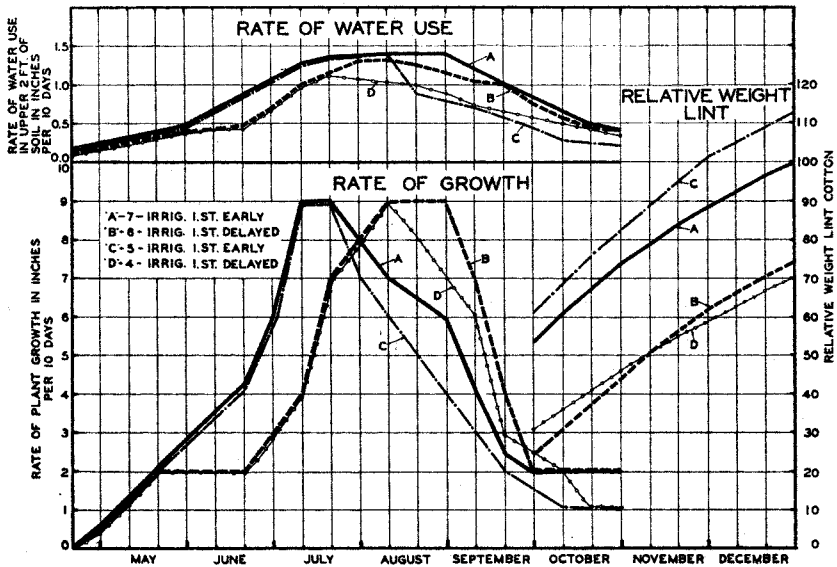


Figure 1.—Effects of four irrigation schedules on (1) the rate of water use, (2) the rate of plant growth, and (3) the relative weight of lint harvested per acre. The data given are annual averages of three replications for each year for the 7-year period of 1935 to 1941. The plots were all well supplied with water prior to planting.

The number of irrigations applied during the growing season were as follows: Treatment A, 7, 1st early; Treatment B, 6, 1st delayed; Treatment C, 5, 1st early; Treatment D, 4, 1st delayed.

(1941) Deltapine 12 was the leading variety, with Stoneville 2B a close second and Deltapine 14 third of the commercial varieties in money value per acre. Ewing's Long Staple is not in commercial production. Stoneville 2B has a materially larger boll and possesses greater fiber strength than the Deltapine strains. Coker-Wilds strains 11 and 12 both led Acala Santan and New Mexico Acala No. 1517 in money value. Money value was based upon Memphis prices for the various staple lengths, as indicated in Table 3, and does not take into account such factors as size of boll, fiber strength, motiness, and freedom from neps.

#### SOYBEANS

Emphasis was placed upon continued selection and testing of soybean strains resistant to shattering. Several relatively non-shattering strains have been obtained, and plots for seed increase were planted at Mesa in the spring of 1942. Sufficient seed of these nonshattering strains was not available for yield tests in 1941.

## HYBRID CORN

Yields were obtained from four different locations in 1941. Our local open pollinated Mexican June produced a greater yield than any of the hybrids when grown at the lower elevations. The acre yield of Mexican June corn at Mesa (elev. 1,200 ft.) averaged 95 bushels, while the yields of the sixteen hybrids which were included ranged from 50 to 85 bushels. The hybrids showed up much better in a test on the farm of Frank Averill near McNeal (about 4,000 ft. elev.). The yield from the twelve hybrids that were included ranged from 34.5 to 57.5 bushels per acre. Mexican June was in ninth place with a yield of 41.5 bushels per acre. Several other observational tests from which no yields were obtained further indicate that hybrids now available may have a definite place at the higher elevations in Arizona.

TABLE 3.—DATA ON COTTON VARIETY TEST, MESA FARM, 1941 (AVERAGE OF THREE REPLICATIONS).

Variety	Pounds lint per acre	Per cent lint	Number bolls per pound seed cotton	Length lint	Strength index	Value lint basis Memphis Jan. 2, 1942, and seed at \$42 per ton
Delta & Pineland 12	662	37.4	90	1 1/16	670	\$156.40
Stoneville 2B.....	622	32.6	74	1 3/32	786	154.27
Ewing's Long Staple	437	29.9	83	1 5/16	824	144.76
Delta & Pineland 14	592	37.9	82	1 1/16	668	139.44
Bobshaw 12.....	435	30.8	82	1 3/16	814	127.60
Delfos 444.....	478	28.7	94	1 1/8	756	127.04
Coker Wilds 11.....	374	30.7	80	1 7/16	936	123.26
Bobshaw 1.....	496	33.2	82	1 1/16	802	120.71
Coker 4-1.....	450	32.9	84	1 1/8	742	115.40
Delfos 3506.....	411	31.9	84	1 5/32	740	114.43
Hartsville.....	348	27.3	68	1 7/32	823	109.48
Delfos 531-C.....	376	30.0	91	1 5/32	787	106.24
Coker Wilds 12.....	320	30.4	75	1 1/2	853	105.64
Acala N. Mex. 1517..	361	34.2	66	1 3/16	743	103.45
Acala, Santan.....	399	35.4	66	1 1/8	681	100.50
Tidewater 31.....	305	29.8	66	1 7/32	833	93.95
Tidewater, Seabrook's.....	237	29.4	76	1 3/8	761	78.79
Durango.....	226	29.4	79	1 3/16	897	67.04

## FLAX

The date of planting, fertilizer response, and the comparison of drill vs. bed methods of planting experiments with flax were continued at the Salt River Valley Experiment Station at Mesa. This concluded the third year of tests. About the same seed yields were obtained from plantings made between October 15 and November 15. However, it is suggested that seedlings be made about November 15 because such plants flower later in spring and hence are less subject to damage by late spring frosts than are earlier seedlings. The 3-year average yields from the bed plantings were from 30 to 55 per cent lower than yields from comparable drill plantings. The main advantage of bed plantings is that the land can be cultivated for weed control. It is suggested that the bed method of planting be used on very weedy



land where it is urgent to plant flax. However, moderate infestations of weed seeds can be germinated by one or two preplanting irrigations and killed by disking prior to planting with the drill. The highest increases in yield were obtained with fertilizers high in nitrogen, like ammonium sulphate and ammo. phos. 16:20.

#### SMALL GRAINS

Four years of yield data have been obtained in the Buckeye district with wheat, barley, and oat varieties. The stem rust- and bunt-resistant Baart 38 and the California Red variety of oats produced the highest yields in that area. There was but little difference between the average yields of the Arivat, Vaughn, and Scarab varieties of barley.

A number of years ago Scarab, a leafy barley, was crossed with Vaughn. The object of this cross was to produce a barley with the Vaughn type of growth, but more leafy. The Scarab is almost as resistant to lodging as Vaughn. The first yields were obtained this year. The prospects seem good for finding a selection, (a) with a grain yield as high as Arivat, (b) as resistant to lodging as Arivat, and (c) with a higher pasture yield than Vaughn.

#### PERENNIAL WEED CONTROL UNDER IRRIGATION

##### Bindweed

Bindweed plots in a cotton field near Tucson, hoed each 2 weeks in 1940 and 1941, had 1.25 clumps per 40-foot-square plot in June, 1942. Plots hoed each 3 weeks had 1.00 clumps per plot in June, 1942. A similar series of plots was started on another field in 1941. The intervals between hoeings were 3 and 4 weeks, and an additional treatment was included in which the plots were hoed when lateral shoots began to develop from the lower buds on the bindweed shoots. The clumps per plot after 1 year's treatment were 5.5, 6.8, and 1.9, respectively. The intervals between hoeings for the last-named treatment averaged 3 weeks until July 15 and 4 weeks after that date.

##### White horse nettle

Four series of plots were started with alfalfa, cotton, hegari, and winter grain in rotation with different methods of cultivation in a field infested with white horse nettle near Phoenix. The average percentage of plants remaining in all the plots for each crop after 1 year were: 101.3, 9.3, 6.1, and 2.7, in the order named above.

##### Nut grass

A few nut grass shoots appeared the last of June, 1942, on plots near Tucson treated by successively deeper turnings in

1940 and planted to Atlas sorghum in 1941. Estimates of stand and yield of silage were obtained for nut grass patches and weed-free areas in a hegari field in 1941. The hegari stand was reduced by 30 per cent and the yield was reduced by 19 per cent in the nut grass-infested areas as compared with nut grass-free areas. The reduction in stand occurred between 6 and 14 days after planting. Soil moisture samples taken at the same time showed a lower moisture in the nut grass-infested patches than in the nut grass-free area.

### GREEN MANURE CROPS

Tests to determine the effect of winter-growing green manure crops on hegari and summer-growing green manures on Arivat barley have been continued. Guar, which has given the best results as measured by the yields of the subsequent barley crop, is attracting considerable attention as a possible source of seed-derived mucilage for use in the paper industry. Average acre yields of barley grain in 1941 from quadruplicated plots following the different green manures were as follows:

	Pounds
Guar.....	4,051
Sesbania.....	3,215
Cowpeas.....	3,070
Check (fallow).....	2,958
Tepary beans.....	2,952
<i>Crotalaria juncea</i> .....	2,943

### SORGHUMS

Work with sorghums consisted of a continuation of selection testing of hegari, Manko, Atlas, and Fargo. The four most promising hegari selections were massed, and these now furnish the basis for the foundation hegari stocks under the Arizona Crop Improvement Program.

### NEW CROPS

A castor-bean variety test was conducted at Tucson, and a row spacing test with one variety of castor beans was carried on at the Salt River Valley Experiment Farm. Yields of clean seed varied from 1,450 to 2,400 pounds per acre. Yields on rows spaced 3 feet apart, with the plants 4 feet apart in the rows, gave best results with a production slightly over 2,000 pounds per acre.

A test planting of *Datura fastuoso* was made at Tucson in cooperation with a New York drug firm to determine possibilities of plant and seed production.

A date-of-planting and variety test with rape at the Mesa farm produced the following results:

TABLE 4

Variety	Date of planting	Pounds cleaned seed per acre	Per cent oil	Pounds oil per acre
Argentine	Oct. 15	1,534	29.9	459
Rumanian	Oct. 15	1,074	35.0	376
Large Dutch	Oct. 15	869	31.7	275
Small Dutch	Oct. 15	1,329	34.6	460
Dwarf Essex	Oct. 1	127	.....	.....
Dwarf Essex	Oct. 15	449	34.7	156
Dwarf Essex	Nov. 1	205	.....	.....

Considerable difficulty was experienced with aphids, a number of dustings being required for control purposes. At present prices, this crop cannot compete with other winter-growing crops at this location.

#### GILA PROJECT FARM (YUMA)

The principal work on this farm was confined to the production of alfalfa hay and seed, a study of the residual effect of phosphate fertilizers, and the comparison of liquid and treble superphosphate fertilizers.

An average yield of 530 pounds of combine-run alfalfa seed was obtained on 23 acres. An acre yield of 650 pounds of combine-run seed was obtained on a small planting of the wilt-resistant alfalfa, Composite 136, from a planting made in 2-foot rows the previous October.

A planting of 1½ acres of guayule was made on the farm by the Bureau of Plant Industry to determine the possibilities of this crop under Yuma Mesa conditions.

#### ANIMAL HUSBANDRY

##### CATTLE FATTENING RATIONS

The cattle fattening project carried on this year was the second of a series instituted primarily to study the value of molasses in Arizona cattle fattening rations. Additional information pertaining to the comparative feeding value of hegari silage and Manko silage and the use of grapefruit cannery refuse silage was obtained in this test. The cattle used were native high-grade Hereford yearling heifers.

##### Molasses

An average daily ration of 7.6 pounds of rolled barley, .63 pound of cottonseed meal, and 15 pounds of alfalfa hay produced slightly greater and more economical gains than a similar ration in which 2.09 pounds of molasses were substituted for 1.33 pounds of rolled barley. Still less favorable results were obtained by

replacing 1.95 pounds of barley with 3.03 pounds of molasses. In this latter comparison the results are contrary to those obtained in the 1940-41 test where the replacement of 2 pounds of barley with 3 pounds of molasses gave slightly better, though less economical, gains. The inconsistency of these two tests can be attributed to the method of feeding the molasses. In the current feeding trial this feed was hand fed by diluting with water and then sprinkling over the feed in the trough. Last year the molasses was mixed with the hay at the time it was ground. This may account for the relatively greater consumption of alfalfa hay in the molasses rations.

Substituting 3 pounds of molasses for 1.75 pounds of barley in a ration including silage did not prove beneficial. An average daily ration of 25.6 pounds of hegari silage, 6.7 pounds of alfalfa hay, 1.5 pounds of cottonseed meal, and 6.75 pounds of barley was productive of a gain of 2.55 pounds per head daily at a feed cost of \$9.56 cwt. gain. The ration including molasses and composed of 25 pounds of hegari silage, 6.8 pounds of alfalfa hay, 5 pounds of barley, 3 pounds of molasses, and 1.5 pounds of cottonseed meal gave a gain of 2.32 pounds per day at a feed cost of \$10.40 cwt. gain.

More favorable results were obtained with molasses in a Manko silage ration by replacing 3 pounds of barley with the same amount of molasses. While the lot receiving molasses made a slightly smaller daily gain of 2.28 pounds per head daily as compared with 2.38 pounds, their feed cost was \$0.80 per cwt. gain less than the check lot fed a comparable ration exclusive of molasses.

#### **Hegari silage vs. Manko silage**

These two feeds were compared when fed with a basal ration of alfalfa hay, rolled barley, and cottonseed meal. The hegari-silage-fed cattle made a significantly greater and more economical gain than the cattle fed Manko silage. This result conforms to those obtained in the 1940-41 test of this same comparison. The heifers ate 2 pounds more of hegari silage while consuming identical amounts of the other feeds, and gained 2.55 pounds per head daily at a feed cost of \$9.56. The Manko-fed cattle gained at the rate of 2.38 pounds per head daily at a feed cost of \$10.40 cwt. gain. On the basis of these results Manko silage was worth only 68 per cent as much as hegari silage fed in this feed combination.

Contrary results favoring Manko silage were obtained using the same feeds but with a limited allowance of concentrates. The heifers fed Manko silage made a more rapid and more economical gain sufficient to give this silage a value of 20 per cent more than hegari silage when fed in this particular way. This test will need to be repeated before the relative values of these silage feeds can be determined.

**Grapefruit cannery refuse silage**

Ensiled grapefruit cannery refuse silage was fed with alfalfa hay, barley, and cottonseed meal to compare its value as a feed with hegari silage. The heifers consumed 17.8 pounds of grapefruit silage daily, or 70 per cent of the daily consumption of hegari silage, but ate 6 pounds more of alfalfa hay to compensate for this difference. The citrus silage was eaten with greater relish in this test than in the two preceding trials, due to an improvement in the quality of the ensiled feed. The cattle fed this new feed made a very creditable gain of 2.36 pounds per head daily at a feed cost of \$10.35 cwt. gain as compared with a gain of 2.55 pounds and a feed cost of \$9.56 made by the cattle receiving hegari silage. These results show that while the ensiled grapefruit cannery refuse can be fed to cattle, there is little to warrant its use as a replacement for hegari silage unless it can be made available at a price less than 30 per cent the value of hegari silage. A considerable shrinkage occurs in the ensiling process, and some loss will be encountered because of waste and spoilage.

**The value of hegari silage**

A ration of hegari silage, alfalfa hay, rolled barley or hegari grain, and cottonseed meal is extensively used as a cattle fattening ration in Arizona. In several preceding tests hegari silage has had a value of from one-third to one-half alfalfa hay when fed with grain and cottonseed meal. The results of this test give hegari silage a value of \$4.82 per ton, or 34 per cent that of alfalfa hay priced at \$14.00 per ton.

**PASTURE TESTS WITH CALVES**

In order to supplement and extend the usefulness of certain data previously obtained on pasturing in the Salt River Valley, a pasturing study was made during the 1941-42 period on the farm of Mr. T. M. Carlton, Casa Grande. Mr. K. K. Henness, County Agricultural Agent, secured the helpful co-operation of Mr. Carlton in having a part of his farm made available for this work.

The study area consisted of about 150 acres with a forage composition for the most part of old stands of alfalfa into which barley had been sown, and it was fenced into eight pasture units. One hundred twenty-four top-grade Hereford weaner calves, 85 heifers, and 39 steers averaging 375 pounds per head were used in the test. The test period started October 24 and continued for a period of 183 days.

A paired plot technique was adopted for determining forage yields, composition, and the degree of utilization.

**Pasture yields**

In this study, eleven pasture crops produced an average of 1,672 pounds of oven-dry forage (6,264 lbs. green wt.) per acre,

which is equivalent to 1,760 pounds of hay. On pasture unit 5, composed entirely of barley, an average of 1,664 pounds of oven-dry forage (8,446 lbs. green wt.) was produced per acre during its first grazing and 1,521 pounds of oven-dry forage (5,652 lbs. green wt.) was obtained during its second grazing period.

During the 1940-41 winter pasture season, studies made by this department in the Salt River Valley revealed an average yield of 8,595 pounds of green alfalfa-barley forage for twenty-four pasture periods; and from eleven pasturings on alfalfa exclusively, the average green forage production was 6,135 pounds.

#### **Forage utilization**

For the twelve pasturing trials at Casa Grande, the average per cent forage utilization was 73.6. This estimate was determined by the dry weight difference method. An average of 78.8 per cent forage utilization was the estimate determined by the ocular estimate method. The degree to which a pasture was utilized by the end of each pasturing period varied from about 55 to about 95 per cent.

The average dry weight of forage utilized per calf per day for eight of the pasturings was 11.4 pounds, which falls within the standard requirements given by Morrison for 500-pound calves being wintered so as to gain from .75 to 1.00 pound per head daily.

During the latter part of the pasture period there was a reduction in the daily forage ingested per calf and a decrease in the nutritive value of the remaining forage.

Although both alfalfa and barley were about equally grazed by the end of each period, an apparent preference was shown for barley during early stages of the grazing period.

#### **Carrying capacity**

The average carrying capacity of eleven of alfalfa and barley pasture crops in this study was 117 calf days per acre. In determining the carrying capacity of this land, it should be realized that it was used part of the time for the production of harvested crops and that certain of the agronomic and pasture-management practices were not conducive to maximum use of the land for pasturing. The average interval between pasturing use was 85.5 days. The time intervals reported in the Salt River Valley study between the first and second pasturing were: for two alfalfa pastures, 58 days; and for six alfalfa-barley pastures, 45 days. Factors that may greatly affect the length of the pasturing intervals are the rate and time of water application, the temperature, the age of the stand, and the intensity of forage utilization.

Considering carrying capacity on the basis of the values obtained in this study, and assuming that it were possible to adjust the agronomics in such a way that each of the pastures during the 6-month grazing period could have been grazed 3 times, a carrying capacity of 363 calf days per acre could have been at-

attained; or on the same basis, the 150 acres of pasture land could theoretically have carried 301 calves for the 6-month grazing period.

From twenty-four pasture records in the Salt River Valley during 1940 and 1941 on alfalfa-barley pasture, an average carrying capacity of 74.1 steer days per acre per pasture period was reported.

A gross weight of 21,330 pounds of beef was produced for the 150 acres of farm land during the 183-day test, amounting to about 142 pounds of beef per acre. However, considering production on the basis of individual pasture periods involving 219 acres, the more applicable value of 97.4 pounds of beef per acre was obtained. By using this figure and knowing the number of times a pasture unit may be grazed, an estimate of the productiveness of the land in terms of beef may be reckoned.

### Gains

The 124 calves made an average daily gain of 0.99 pound a day for the 183-day test period. The average daily gain made by all heifers was 0.95 pound, and, for the steers 1.07 pounds. The data indicate that the difference in rate of gain of steer and heifer calves was insignificant. There was a tendency for calves of lighter weight (239 to 300 lbs.) to make larger daily gains than were made by heavier calves.

### PROGENY TEST OF HEREFORD SIRES

This is the first of a series of studies to determine whether differences exist in the efficiency of beef production from lots of calves sired by different bulls, and to determine the justification and feasibility of a "record of performance" for Hereford sires.

In May of 1940 seventy-five young grade Hereford cows, bred and raised on the Larimore Ranch at Sonoita, Arizona, were divided into three lots of twenty-five head each. The division was made on the basis of individual type so that all lots had the same score. Three bulls of different blood lines were secured and one placed in each pasture. Calves were weighed at birth and at succeeding 30-day intervals. Upon weaning, the steer calves were trucked to the University farm and individually fed to a satisfactory market finish. This first lot of test calves was started on feed in November and December of 1941 and was marketed the following June.

Each steer was scored at the beginning of the feeding period, a standard beef-cattle-scoring form being used for this purpose. Certain additional body measurements were also taken. At the close of the test the feeding efficiency of each steer was calculated on the basis of the total digestible nutrients (T.D.N.) required for each pound of gain in weight. Correlation coefficients between feeding efficiency and 15 score-card points and 8 body

measurements ranged from  $-0.30$  to  $+0.33$ . None of the coefficients were statistically significant for the 23 calves used in the tests.

The F value of 5.18 given in Table 5 shows a significant difference between the feeding efficiency of the calves sired by the three bulls. The average T.D.N. requirement per pound of gain for the calves from bull No. 1 was 5.38, bull No. 2, 5.16, and bull No. 3, 5.96, showing significantly less efficiency for the calves from bull No. 3 than from either of the other two.

TABLE 5.—ANALYSIS OF VARIANCE OF EFFICIENCY OF FEED UTILIZATION BY TWENTY-THREE STEERS Sired BY THREE DIFFERENT BULLS.

Source of variation	Degrees of freedom	Sums of squares	Mean square	F
Total .....	22	7.21	.....	.....
Between bulls.....	2	2.46	1.23*	5.18
Within bulls' group....	..0	4.75	0.2375	.....

\*Significant at the .05 level.

## ANIMAL PATHOLOGY

### INFECTIOUS KERATITIS

The continued studies on infectious keratitis (pinkeye) in cattle failed to isolate any infectious organism as the cause. Cultural studies and direct smears were continued. Stained sections of diseased tissue failed to demonstrate organisms.

Symbiotic action of two or more of the isolated organisms were studied with negative results.

The possibility of a tick-borne disease caused by *richettsia* of a low virulence was studied. Many infected cattle are infested with the spinose ear tick (*A. Megnini*). It was impossible to demonstrate any *richettsia* in stained sections of diseased eyes or smears or to reproduce the disease by injection of ground ticks.

Allergy tests are now in progress, but no definite information is available at this time.

### PARASITE CONTROL

It was found that the single treatment of derris root powder (5% rotenone) and soapy water applied to range cattle during the fall roundup did not reduce the damage of the warble fly. It is necessary to follow up on repeated treatments materially to reduce the fly population. However, this practice is not applicable under range conditions.

No new outbreaks of stomach worms (*Ostertagia-Ostertagia*) were reported in cattle this year. The dry season was probably the factor involved.



## TURKEY PULLORUM TESTS

Two thousand two hundred tube agglutination tests for pullorum were made on turkey serums. The new turkey antigen (Bunyea's stained turkey antigen) was checked against the tube tests with complete agreement.

There has been an increase in material coming to the laboratory for diagnostic studies. These laboratory diagnoses and field trips investigating diseases have been an important function of the Department. This is necessary because of a lack of available veterinary service and the desire to raise a maximum of animal foods.

## BOTANY AND RANGE ECOLOGY

## RANGE RESOURCES OF ARIZONA

A project is under way to synthesize all available information on the range resources for the state of Arizona. Co-operation has been secured with the various state and federal agencies dealing with range lands in the preparation of range-type maps for each county and in the tabulation of data concerning range livestock carrying capacity. Table 6 presents an analysis of private, state, and federal lands for which range-type maps have been prepared showing vegetative cover and carrying capacity in number of livestock units. All Indian reservations, with the exception of the Kaibab Indian Reservation, and all national forests in the state have been surveyed for forage cover and carrying capacity. Of the remaining private and public lands in the state, range-type and carrying-capacity information is available through surveys made by the Agricultural Adjustment Administration, Grazing Service, and Soil Conservation Service. Approximately 68 per cent of the total area of the state has been surveyed in this manner; the remaining 32 per cent, including a large proportion of the desert lands, has little value as range resources.

The livestock carrying-capacity data available to date on surveyed private, state, and federal lands are presented in Table 7. These data represent the proper carrying capacity for approximately 63 per cent of the total state land acreage.

It is planned to present the information available in detailed county reports which will include a description of the important range types and forage plants, the present and potential carrying capacity of each type, and general recommendations concerning range management practices applicable in each area.

## CLIMATIC AND GRAZING INFLUENCES ON DESERT-GRASSLAND RANGE

Interest in this project centered about the effect of the extremely dry spring and early summer seasons of 1942 on range

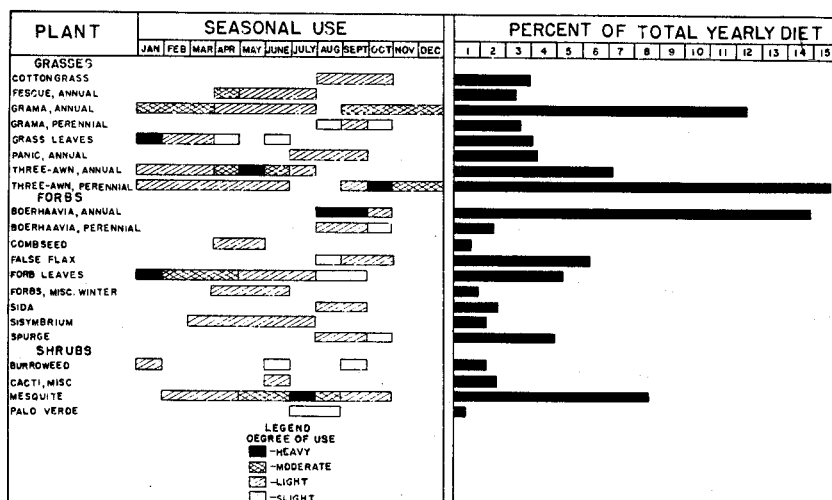


Figure 2.—Seasonal and yearly food preferences of Merriam Kangaroo Rat based on cheek-pouch contents.

forage production. Quantitative data were available from a series of quadrats established in 1931 at Desert-Grassland Station on areas subject to controlled grazing by livestock and on areas completely protected from grazing. Preliminary analysis shows a marked reduction in the numbers of annual grasses and annual and perennial herbaceous plants in response to the prolonged drouth condition. Perennial grasses tended to maintain approximately the same tuft area but showed definite decreases in the volume of forage produced.

#### DESTRUCTION OF RANGE FORAGE BY RODENTS AND RABBITS

Studies are in progress to determine the food habits of several common range rodents in relation to the forage preferences of domestic livestock on southwestern range lands. In addition to obtaining the economic status of each species, complementary data are being collected concerning the animals and their reciprocal relations with the environment.

#### Kangaroo rats

A preliminary outline of the food habits of Merriam's kangaroo rat based on an examination of plant remains recovered from 300 animals is presented in Figure 2. Preferences were established by noting the frequency of occurrence of plant materials in the external cheek pouches of captured animals. The occurrence of any amount of a plant species in a pouch is considered as one frequency. Aggregate frequencies for a plant are expressed as a percentage of the total number of frequencies.

In the yearly diet, 87 per cent of the food is seeds and 9 per cent is composed of leaves, stems, and flowers. The other 4 per cent is unidentifiable material. Perennial grass seeds make up 21 per cent of the food, but over half this amount consists of seeds of three-awns, grasses of secondary importance for cattle. In terms of weight, maximum yearly destruction of range grass seed amounts to about .5 pound of valuable seed, 1.5 pounds of mediocre seed, and 2.0 pounds of annual grass seed. Forb and shrub seeds which make up 48 per cent of the diet are of little economic consequence, because they are seeds of plants which are rarely relished by livestock. Whether the damage caused by average populations of these rodents (5 to 10 animals per acre) can be considered a serious economic loss is yet to be determined.

#### Jack rabbits

Evaluation of the damage done to range vegetation by Jack rabbits has been hampered by lack of a reliable method for determining rabbit numbers and for estimating forage removal. During the past year, analysis of data obtained in a 3-year study with pen-fed Arizona and antelope jack rabbits<sup>7</sup> showed that pellet counts provided a basis for estimating relative rabbit numbers, while pellet weights can be used for direct determination of forage removal. These results will be used in future studies of the relation of rabbits to the maintenance of Arizona range lands.

Results from the jack rabbit experiments dealing with food consumption and relative palatability of various range plants are being prepared for publication as a Station bulletin.

#### DETERMINATION OF CORRECT SCIENTIFIC NAMES OF COMMON PLANTS

A project to clear up the confused scientific names of southwestern plants and the status of each of many genera and species was started in 1939. During the latter part of 1941 and 1942 this work was continued with preparation of a University of Arizona Biological Science Bulletin on the trees and major shrubs of the southwestern deserts. The first half of this project was brought to completion and the second half nearly so during 1942. This work includes all the trees and all the larger shrubs as well as a few of the more important small shrubs and bushes. It is designed for use by both layman and scientist, and it includes both concise popular characterizations and technical descriptions. There are about 60 plates, including colored and black-and-white photographs, line drawings, and distributional maps.

A series of publications on the badly confused genus *Ranunculus* was completed for the types occurring in North America

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<sup>7</sup>Joseph F. Arnold and Hudson G. Reynolds. "Fecal characteristics of Arizona and antelope jack rabbits in relation to the 'pellet census' method." Accepted for publication in *Journal of Wildlife Management*.

TABLE 6.—ACREAGES SURVEYED FOR LIVESTOCK CARRYING CAPACITY BY GOVERNMENTAL AGENCIES.

County	Indian reservations	National forests	Agr. Adjust. Admin.	Soil Cons. Service	Grazing Service	% of total area
Apache	4,514,577	486,671	1,419,000	.....	.....	90
Cochise	.....	504,583	570,000	1,721,212	.....	70
Coconino	4,437,760	3,374,984	1,158,000	209,000	579,000	82
Gila	1,142,640	1,676,154	16,000	.....	.....	93
Graham	994,674	397,275	151,000	1,268,000	.....	95
Greenlee	.....	748,929	.....	426,356	.....	100
Maricopa	189,024	691,801	433,500	.....	.....	22
Mohave	422,326	28,059	127,175*	.....	5,870,000	76
Navajo	4,241,754	471,499	1,219,000	.....	.....	93
Pima	2,470,982	384,998	627,300	.....	.....	59
Pinal	574,948	223,379	1,014,275	.....	.....	53
Santa Cruz	.....	425,365	274,960	69,608	.....	99
Yavapai	.....	1,999,823	1,470,000	232,510	.....	67
Yuma	240,218	.....	4,000	.....	.....	4
Total	19,228,903	11,413,470	8,484,210	3,926,686	6,449,000	68

\*Acreage not included in Grazing Service data.

TABLE 7.—ACREAGES AND LIVESTOCK CARRYING CAPACITY (IN ANIMAL UNIT MONTHS) FOR PRIVATE, STATE, AND FEDERAL LAND SURVEYED BY GOVERNMENTAL AGENCIES.

Land tenure or supervising agency	Total area surveyed, including cultivated and inaccessible land (acres)	Carrying capacity of accessible range land (animal unit months)
<b>Indian Reservations</b>		
Fort Apache.....	1,633,787	268,810
Gila Bend.....	10,235	636
Hualapai .....	991,680	91,263
Navajo .....	11,448,190	104,716
Papago .....	2,775,134	123,648
Salt River.....	45,974	648
San Carlos.....	1,610,240	327,600
San Xavier.....	71,264	4,908
	<u>18,586,504</u>	<u>922,229</u>
<b>National Forests</b>		
Apache .....	679,432	142,897
Coconino .....	1,741,649	210,710
Coronado .....	1,317,289	266,772
Crook .....	1,422,777	239,165
Kaibab .....	1,773,221	205,918
Prescott .....	1,265,500	263,166
Sitgreaves .....	802,534	132,845
Tonto .....	2,410,610	428,025
	<u>11,413,470</u>	<u>1,889,498</u>
<b>Private, state, and public domain Agric. Adjust. Admin.</b>		
Apache County.....	1,419,000	390,912
Cochise County.....	570,000	171,204
Coconino County.....	1,158,000	299,928
Gila County.....	16,000	8,448
Graham County.....	151,000	51,672
Maricopa County.....	433,500	98,112
Mohave County.....	127,175	27,132
Navajo County.....	1,219,000	342,120
Pima County.....	627,300	199,476
Pinal County.....	1,014,275	284,472
Santa Cruz County.....	274,960	112,080
Yavapai County.....	1,470,000	490,212
Yuma County.....	4,000	816
	<u>8,484,210</u>	<u>2,476,584</u>
<b>Soil Conservation Service</b>		
Cochise County.....	1,721,212	320,352
Coconino County.....	209,000	23,434
Graham County.....	1,268,000	131,892
Greenlee County.....	426,356	75,336
Santa Cruz County.....	69,608	26,478
Yavapai County.....	232,510	63,036
	<u>3,926,686</u>	<u>640,528</u>
<b>Grazing Service</b>		
Coconio County.....	579,000	91,941
Mohave County*.....	2,581,950	368,620
	<u>3,160,950</u>	<u>460,561</u>
<b>Grand total.....</b>	<u>45,571,820</u>	<u>6,389,400</u>

\*Data for Grazing Service District 1 only.

north of the Mexican boundary. Reorganization of the classification of the sixteen species occurring in Arizona was completed and published. Studies of the Arizona and southwestern cacti were continued.

#### THE RUBBER CONTENT OF SOUTHWESTERN PLANTS

In co-operation with the Department of Agricultural Chemistry and Soils, an investigation of the rubber content of various southwestern plants was begun in March, 1942. A table of results of this investigation is given under Agricultural Chemistry and Soils (see p. 14).

#### PLANT COLLECTION AND IDENTIFICATION

Additions to the University of Arizona Herbarium included about 10,000 specimens, which were mounted and filed with the collections. About 1,000 specimens were collected by members of the staff; others were received from individuals, schools, peace officers, the State Game Department, other departments of the Agricultural Experiment Station and the Agricultural Extension Service, and such federal agencies as the Fish and Wildlife Service, the National Park Service, the Division of Grazing, the Indian Service, the Soil Conservation Service, the Forest Service, and the Bureau of Plant Industry. Most of these specimens were sent to members of the staff in exchange for identification.

The Works Progress Administration project for mounting plants and clerical and bibliographic work in the herbarium was continued into the spring of 1942. Although closing of all civilian projects in favor of defense work cut the herbarium project short, several thousands of accumulated plants were mounted and placed in the herbarium, and others were prepared for exchange when they were determined to be duplicates. Work on the index of taxonomic literature was continued by the W. P. A. and later by a new permanent member of the herbarium staff. About 4,000 cards were added to the collection.

#### ECONOMIC VALUE OF NATIVE PLANTS

##### **Yucca**

Observations have been continued on a planting of *Yucca elata* started in 1939. Development of the plants has been extremely variable, apparently because of genetic differences in the parent material, but the information obtained gives an idea of the rate of growth of the species under cultivation. Four representative plants were dug on December 9, 1941, to obtain data on relative development of roots and tops (Table 8). The largest of these plants is shown in Plate I.

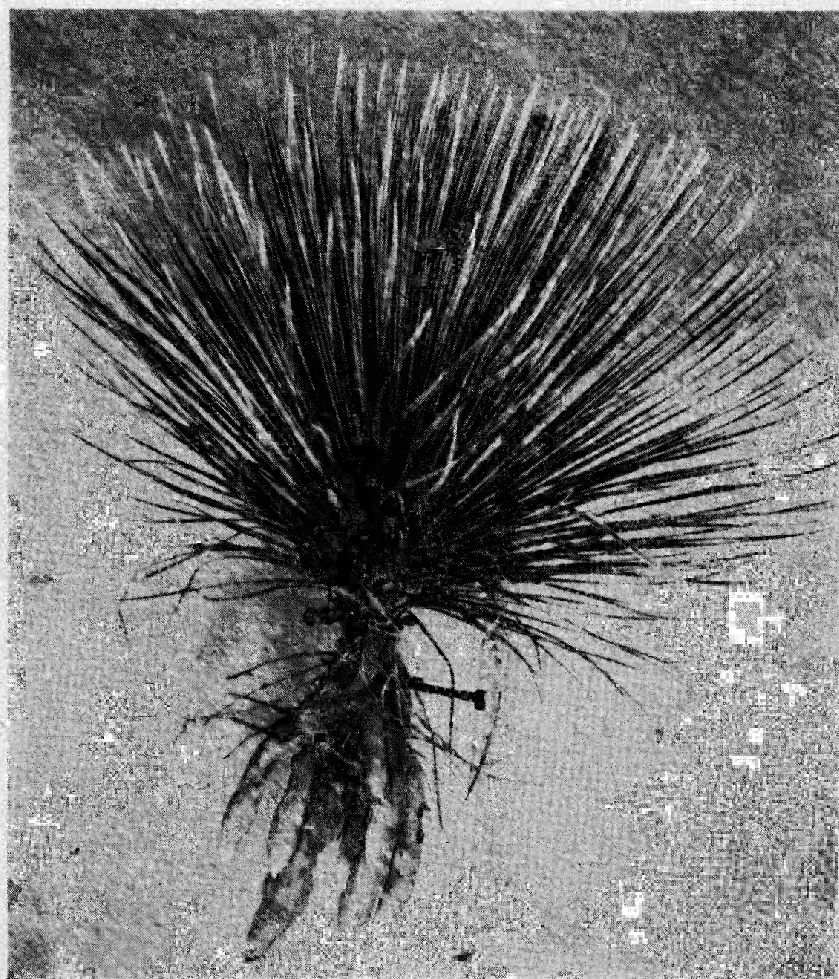


Plate I.—Plant of *Yucca elata* showing development of leaves and rhizomes 2 years after planting.

#### Other plants

Studies with *Simmondsia chinensis* (coffeeberry), *Haplophyton cnicoidum* (cockroach plant), and *Rumex hymenosepalus* (can-aigre) have been continued. In addition, several other native plants have been collected and shipped to various research organizations where they are under study as sources of medicinal and toxic materials. All phases of this project will be expanded during the coming year.

TABLE 8.—MEASUREMENTS OF YUCCA ELATA PLANTS 2 YEARS AFTER PLANTING.

Height of plants.....	<sup>a</sup> 20 inches*
Length of leaves.....	<sup>a</sup> 15 inches*
Top weight (crown and leaves).....	<sup>b</sup> 1287 grams†
Weight of rhizomes.....	<sup>b</sup> 1722 grams†

\*Average of 73 plants in the field.

†Average of 4 plants harvested.

## SUGAR BEET SEED PRODUCTION

Since the beginning of sugar beet seed growing in Arizona in 1935, it has been recognized that lack of sufficient chilling during the winter was one of the principal factors responsible for low yields in some seasons. During the past year, through the co-operation of the Horticulture Department, it has been possible to examine thermograph records of air temperatures in the Salt River Valley for the 7-year period from 1935 to 1942. Preliminary results from this study show that while sugar beet seed yields are roughly correlated with the number of hours of chilling temperatures (45 degrees F. and below), they are much more closely correlated with the number of hours of "effective temperature" obtained by subtracting the hours of high temperature (80 degrees F. and above) from the chilling temperatures. The relationship between effective temperature and sugar beet seed yields is shown in Table 9.

TABLE 9.—EFFECTIVE TEMPERATURE\* AND YIELD OF SUGAR BEET SEED.

	1935- 36	1936- 37	1937- 38	1938- 39	1939- 40	1940- 41	1941- 42
Effective temperature....	345	687	522	836	197	211	832
Yield of seed (pounds per acre).....	1057	1549	1347	1917	689	1477	1800†

\*As used here, "effective temperature" means hours 45° F. and below, minus hours 80° F. and above for the period from October 1 to May 31.

†Estimated yield.

## DAIRY HUSBANDRY

## NORMAL GROWTH OF DAIRY CATTLE IN ARIZONA

This project was begun in August, 1939, to determine rate of normal growth for different breeds of dairy cattle maintained under conditions in southern Arizona. These data are of value for purposes of comparison in experimental work and to ascertain whether abundant sunshine and a favoring climate result in greater growth here than elsewhere.

A comparison of the figures in Table 10 with average data collected at several experiment stations throughout the country



TABLE 10.—AVERAGE WEIGHT OF DAIRY HEIFERS IN STATION HERD.

Breed	Birth	3 mos.	6 mos.	9 mos.	12 mos.	15 mos.
Holsteins .....	102	236	433 (18%)*	612	770 (17%)	893
Jerseys .....	49	131	251 (none)	385	473 ( 2%)	557
Guernseys .....	63	162	336 (24%)	458	573 (17%)	665
		18 mos.	21 mos.	24 mos.	27 mos.	30 mos.
Holsteins .....		1004 (16%)	1068	1216 (14%)	1403	1525
Jerseys .....		639 ( 3%)	722	817 ( 8%)	925	.....
Guernseys .....		744 (12%)	799	926 (13%)	979	.....

\*Figures in parentheses represent increase of Arizona figures over average for United States.

and summarized in the twentieth edition of *Feeds and Feeding* shows our data for the Holstein and Guernsey breeds to average approximately 16 per cent higher, while for Jerseys this difference averages only 3 per cent.

#### THE STOP-MILKING METHOD OF DRYING OFF COWS

Since early 1941 a study has been made of the practicability of the stop-milking method of drying off cows in the Experiment Station herd. This method, which involves complete cessation of milking, was first recommended by the Minnesota Station in 1933 following observation on a limited number of cows. Dairy-men have been slow to adopt it and a majority still follow the practice of intermittent milking. The reasons usually given are fear of damaging the cow's udder, producing mastitis, effect on next lactation, etc.

In the Arizona Experiment Station herd each cow on the date she is to be dried is placed in dry lot, where all feed is removed except water and a part ration of hay, and she is kept under observation until all swelling has gone out of the udder. She is then returned to the herd and allowed on pasture and heavier feeding.

During the past year and a half twenty-two cows whose production was sufficient to warrant close observation as to its effects, have been dried by the stop-milking method. This practice has been found very satisfactory, saving in labor, and with no ill effects on udders observed beyond temporary swelling which persisted only for a few days. Maximum daily production in cows dried off by this method was 27 pounds for Holsteins, 19 pounds for Jerseys, and 17.5 pounds for Guernseys.

#### PASTURE INVESTIGATIONS

During the past year the work on analysis of clippings from successive pasturings of barley, oat, and Sudan pasture has been continued. Square meter plots in representative fields at the University farm have been clipped just prior to pasturing. The data are presented in Table 11. All analyses were made through co-operation of the Department of Agricultural Chemistry and Soils.

TABLE 11.—ANALYSES OF BARLEY, OAT, AND SUDAN GRASS PASTURE CLIPPINGS (DRY BASIS).

been taken as requirements were purchased. Analyses were made through the co-operation of the Department of Agricultural Chemistry and Soils.

The common opinion among dairymen that first and late cutting hay is most desirable for milk production tends to be substantiated by the limited analyses in the table. Both these cuttings (first and fourth) show a significantly higher average protein content than do intermediate cuttings.

#### BACTERIAL STUDIES ON THE CLEANING OF THE MILKING MACHINE

Comparison of the effect of the weekly and daily disassembling of the milking machine on the bacterial count of the milk as given in the Annual Report ended July 1, 1941, has been continued during the present year. The average of the counts made to date is 18,768 bacteria per c.c. for the daily disassembling and 12,297 for the weekly. Bacterial counts were made weekly throughout the year with the two methods alternating every 4 to 6 weeks. This gave a comparison of the two methods for different times of the year.

Several dairymen in the state are now using the weekly method and without exception make favorable reports. The daily saving in time amounts to about 30 minutes to an hour for a 2-unit machine, depending on the person operating the machine and facilities available. There is also a material saving in the rubber inflations and hose, because weak alkali solutions preserve rubber while chlorine solutions are detrimental.

During the month of August bacterial counts were made on 12 different days, using the weekly method and merely rinsing the machine thoroughly with cold water after milking. After the rinsing, teat cups and hose were removed from the unit, placed on the solution rack, and filled with a 0.5 per cent lye solution. The pails and head of the machine were washed with a brush in warm washing-powder water, rinsed in hot water, and placed on the rack to dry. The bacterial count for the 12 days averaged 5,916.

During September and October a study was made of the value of the chlorine rinse previous to milking. Weekly disassembling was used and the machine was treated in the regular way for this method, except that during 4 weeks the machine was rinsed with plain water instead of chlorine water just previous to milking. The average bacterial count when chlorine was used was 3,375, while with the plain water rinse the average count was 3,900.

No conclusions should be made until there is a large number of comparisons. The above data, however, indicate that if the pails and head of the machine are efficiently washed and the teat cups and hose are filled with 0.5 per cent lye solution between milkings, the method of rinsing the machine both before

and after milking is not of much importance if the bacterial count is a reliable criterion of the quality of milk. It is assumed, of course, that the water supply will be free from contamination.

#### SERUM-SOLIDS CONTENT OF MILK

In co-operation with the Department of Agricultural Chemistry, a study is being made of the influence of breed, feed, season of year, and period of lactation on the serum-solids content of milk. Some 860 milk samples have been analyzed in this work to date. Six hundred forty samples were from individual cows, and 220 were from twelve different herds.

For a year, complete monthly analyses of the milk from two Holsteins and two Guernseys have been made. In this work analyses were made for fat, acid, lactose, protein, ash,  $P_2O_5$ , CaO, Cl, and total solids. The density and pH were also determined. Two hundred sixty milk samples from twenty different cows have been analyzed for fat, density, acid, lactose, protein, chlorine, and total solids, while 320 samples from forty-five different cows have been tested for fat, acid, and total solids. In each case the milk samples were taken monthly.

Two hundred twenty milk samples from eleven different herds have been analyzed for fat, acid, lactose, protein, chlorine, and density. These samples were from herds in Maricopa County and represent a 2-year period. The individual milk samples are from cows in the University herd and represent the Holstein, Jersey, and Guernsey breeds. The herds represent both purebreds and grades of the above-named breeds.

Considerable data have been collected and some definite analysis during the coming year will be made.

### ENTOMOLOGY AND ECONOMIC ZOOLOGY

#### RANGE RODENT INVESTIGATIONS

The Arizona cottontail in the vicinity of Tucson proved to be less plentiful than was hoped for, and some attention was therefore given to the life-history of the Arizona round-tailed ground squirrel.

#### WATER RELATIONS OF DESERT ANIMALS

The first draft of a bulletin on this subject has been made, and it is hoped it will be completed during the present fiscal year.

Work on both the above projects was somewhat curtailed by the demands of the next, below.

#### THE GRASSHOPPER PROJECT

Completion of an extensive manuscript on the grasshoppers and other Orthoptera of the state took a very considerable

amount of the time of the department head to the very end of the fiscal year, when at last a 120-page bulletin came off the press. This bulletin<sup>8</sup> treats of 282 species and varieties of Orthoptera, as follows: 19 cockroaches, 8 praying mantids, 7 walking sticks, 248 grasshoppers and crickets. Four plates and 11 text figures, mostly full page, with numerous keys, aid in identifying the more important species.

#### SCALE INSECTS

Continued work on the scale insects of Arizona is progressing steadily but without much of special interest to report, since this investigation involves long and tedious routine work, especially in the preparation of microscopic slides and the subsequent identification of species. The relation of certain species to rodents is being investigated, and a special effort to collect certain obscure and little-known species which severely damage forest trees met with success.

The black-margined aphid, *Monellia costalis*, was numerous on pecan trees in the Yuma district. Determinations of relative abundance throughout the summer in different groves, and on different varieties of pecan, showed that although there are continued fluctuations the maximum population was present about August 25. Relative abundance of predatory enemies was investigated and life-history studies continued. In experiments on control (co-operative with the Horticulture Department) it was attempted to eradicate the sex forms by October dusting but without success. For general control work the following dust mixture seems fairly satisfactory:

Nicotine sulphate.....	4 pounds
Soda ash.....	4 pounds
Hydrated lime.....	100 pounds

The black-margined aphid was found for the first time in the Tucson area in July, 1941. This discovery of the aphid near at hand simplified the determination of important points in the life-history, such as (1) the appearance of sexual forms in the fall, (2) fall disappearance of aphids from the trees and, (3) first appearance of young aphids on the trees in spring—from overwintering eggs.

#### BIOLOGY AND CONTROL OF THE COTTON PEST, *CREONTIADES FEMORALIS*

Previous biological work and several years have shown that *Creontiades femoralis* has a distinct preference for cotton as a host plant, and it leaves alfalfa or other host crops as soon as cotton begins to bloom in early summer. Populations then build up rapidly, and serious damage is done during August and September. Due to war-work-program duties, the work in 1942 was

<sup>8</sup>Ariz. Agr. Exp. Sta. Tech. Bull. 93, June, 1942.

restricted to control experiments, continuing the promising leads developed in 1941 with two new materials. Population records show a considerably better control of insect pests from these materials than from standard sulfur-Paris green. Since the cotton has not yet been picked, yield tests are not available. Meantime, the project is being completed and a full report by bulletin will be made as soon as possible.

## HORTICULTURE

### CHANGES AT THE TEMPE DATE GARDEN

The value of the old Tempe Date Garden for horticultural research has been decreasing for many years. The palms planted in 1900 were for the purpose of determining which varieties were best suited here. This was accomplished many years ago and some ten or twelve commercial varieties have come to be recognized. Because of the wide number of varieties and their scattered location in the garden, it is not possible to devise plots with which to study the present important problem of reducing maturity losses. Also, the land on the garden not included in the old variety planting has been occupied by seedling palms so that no space has been available for studies with other crops.

The situation is intensified by the fact that in the more than 40 years since the date garden was founded, many changes have occurred in the horticulture of the Salt River Valley. All these have tended further to outmode the date garden. For one thing, the date industry itself has not developed to the extent originally anticipated. On the other hand, a large expansion of the vegetable industry has been centered around the growing of out-of-season fresh vegetables for shipment to consumption centers. Some 20,000 acres of citrus have come into production with attendant problems of yield and quality of fruit. Grapes, berries, nuts, and miscellaneous fruits have assumed an importance comparable with that of dates.

For the past 5 years efforts have been made to gear the date garden and its activities more closely to present-day horticultural needs of the Salt River Valley. Definite accomplishments in this direction have been made during the past year. Through the co-operation of the W.P.A. the seedling palms were removed from the west 10 acres of the garden. This land is now devoted to research on vegetables and similar crops. The vegetable-breeding program will be especially facilitated by having this land available. A small greenhouse has been constructed near the laboratory. This is a valuable addition to the research facilities, particularly with the vegetable crops, and will be useful for other lines. The three members of the Horticulture Department located in the Valley now have headquarters at the date garden and use the laboratory, greenhouse, storage, and other facilities

jointly. Thus, the date garden is now a general horticultural research center, with dates receiving minor attention.

#### DATE STUDIES

##### **The date situation**

More than 40 years have elapsed since Old World varieties of dates were introduced into the Southwest and first efforts made to commercialize this crop. With the changes at the Tempe Date Garden (see above) it is appropriate that an account be taken of the status of date growing.

At the present time there are less than 400 acres of dates in Arizona. This acreage is almost entirely in the Salt River Valley; there are perhaps 20 acres in the Yuma Valley. Commercially the crop is still of minor importance. However, individual palms are grown around many homes where they provide fruit for family use and enhance the appearance of the home site. Similarly the date palm now contributes much to the interest and beauty of southern Arizona.

Thus, while the date is serving a useful purpose in the warmer parts of the state, the industry itself has clearly not enjoyed the growth which was anticipated for it. There are several reasons for this, but the most important one has to do with climatic features, especially rainfall during the latter part of the summer while the fruit is ripening and is easily damaged by rain or even high humidity. Some varieties are more susceptible to damage than others. For example, it has long been recognized that the Deglet Noor could not be fruited successfully in the Salt River Valley largely because of rain damage. On the other hand, such varieties as Kustawi, Khadrawi, Halawi, Maktoom, and Zahidi have been among the more successful. But even these varieties have had moderate to severe loss in 8 of the last 13 years. Favorable ripening with slight loss occurred in only 5 seasons.

Several types of paper and cloth protectors have been developed which somewhat reduce the extent of the damage, but the loss from rain damage remains the outstanding problem of the date industry of the Salt River Valley. There is also some evidence that a greater amount of summer heat than obtains in the Salt River Valley favors the production of a higher quality of fruit. The accompanying table shows rainfall and temperatures for several points in the desert Southwest.

It can readily be seen that if a low rainfall during growth and ripening of the fruit and if large amounts of heat during the summer favor commercial date production, then of the various desert areas the Salt River Valley is one of the least adapted for date growing.

##### **The 1942 date season at the Tempe Date Garden**

Date blossoming was exceptionally early, beginning in February. A light crop of fruit was set on many varieties, particularly Hayany, Sayer, and Khadrawi. Mean temperatures throughout

the growing season averaged 2.5 degrees below normal which delayed ripening until mid-September. Light rains in late July and early August caused severe checking of Hayany fruit but did only slight damage to other varieties. September and early October were without rain, so ripening took place under ideal conditions. In some varieties a reduction in grade occurred, due to the separation of the skin from the flesh.

TABLE 13.—AVERAGE RAINFALL AND TEMPERATURE JUNE TO OCTOBER, INCLUSIVE, AND NUMBER OF HOURS PER YEAR WHEN TEMPERATURES ARE ABOVE 80° F.

	Rainfall*	Temperature*	Hours above 80°†
Brawley .....	.58	83.4	.....
Indio .....	.89	87.0	3,159.5
Blythe .....	1.53	81.9	.....
Yuma .....	1.56	84.6	2,683.0
Phoenix .....	3.16	82.9	2,287.5

\*From U.S. Weather Bureau records.

†From thermograph data, compiled by Horticulture Department.

#### The 1942 date season at the Yuma garden

This year through arrangements with a commercial grower it was possible to fruit the palms in a more systematic way than at any time in the 10 years since they were planted. Some off-shoots still remain on several varieties. There was some difficulty in pollination giving rise to a poor set of fruit in some instances. One rain occurred on August 9; otherwise, the season was ideal for date maturity.

Ripening of fruit began about the middle of August and continued through November. Fruit on the various varieties matured in approximately the following order: Khadrawi, Hayany, Sayer, Iteema, Tadala, Kustawi, Halawi, Gush, 16-23, Braim, Apdamdon, Maktoom, Zahidi, Deglet Noor, and Hellila.

Exceptionally high quality fruit of Khadrawi, Maktoom, 16-23, and Hellila varieties were produced. This seems significant because these cover the entire range of ripening season from early to late. Hayany fruits were of poor quality because of checking. Deglet Noor fruits were affected with checking and blacknose.

### VEGETABLE CROP STUDIES

#### Lettuce fertilization

Studies of the response of lettuce to band-placed commercial fertilizers and to manure have been continued.

Again, the differences in yield between plots on the Mesa farm receiving various commercial fertilizers were less than the differences between the manured and nonmanured plots. Size of head was markedly increased by the application of manure, but



TABLE 14.—SUMMARY OF 1942 DATE SEASON AT TEMPE DATE GARDEN.

Variety	Date blossomed	Date ripened	Per cent loss and condition
Apdamdon	Mar. 5	Sept. 5	5—good; separation of skin from flesh
Bent Kebala	Feb. 25	Sept. 20	5—good; separation of skin from flesh
Braim	Mar. 28	Sept. 20	5—good
Deglet Noor	Mar. 15	Oct. 5	25—checking, shrivel
Halawi	Mar. 10	Sept. 10	10—loss of grade from shrivel
Hayany	Mar. 20	Sept. 5	85—checking, blacknose
Iteema	Mar. 15	Sept. 20	20—moderate checking
Khadrawi	Mar. 1	Sept. 5	15—premature ripening, shrivel
Khir	Feb. 20	Sept. 5	5—good, separation of flesh from skin
Kustawi	Mar. 5	Sept. 15	10—good, separation of flesh from skin
Maktoom	Apr. 1	Oct. 1	20—darkening around calyx
Rhars	Mar. 5	Sept. 2	35—checking, calyx end rot, fermentation
Sayer	Mar. 25	Sept. 25	20—darkening at calyx, separation of skin from flesh
Saidy	Mar. 27	Oct. 10	10—slight shrivel
Tadala	Mar. 20	Sept. 15	15—checking, separation of skin from flesh
Zahidi	Mar. 25	Sept. 20	5—very good
16-23	Mar. 1	Sept. 20	20—checking, severe separation of skin from flesh

11-48 ammonium phosphate was the only commercial fertilizer which appreciably increased the percentage of 5 dozen sizes.

As one measure of nitrogen and phosphorus availability in the fertilizers, plants were removed and analyzed at various stages of growth. The different commercial fertilizers gave up about the same amount of nitrogen and phosphorus. They all supplied more of each when used in combination with manure.

In co-operation with the Agricultural Chemistry Department studies were made through the fall lettuce season of the pH, nitrogen, and phosphorus in soils receiving the different fertilizers. The pH of manured soils tended to be lower than that of the nonmanured, but the commercial fertilizers had no significant effect upon pH. Plots receiving no commercial nitrogen fertilizer were very low in nitrate-nitrogen.

CO<sub>2</sub>-soluble phosphate was present in greatest quantities on the manured plots. Plots receiving treble superphosphate or 11-48 ammonium phosphate were higher in phosphorus at the end of the growing season than plots receiving this element in any other form.

Additional experiments carried on during the fall and spring in co-operation with lettuce growers in the Salt River Valley corroborated previous results showing 11-48 ammonium phosphate to be one of the better fertilizers for lettuce when it is band-placed at the time of seeding.

#### **Lettuce quality and maturity**

The effects of irrigation and time and rate of nitrogen application on the fall lettuce crop were studied this year. Growth was markedly increased by increasing the number of irrigations. However, a sodium nitrate side dressing in mid-November gave about the same increase in rate of growth as did double irrigation. Where overirrigation was combined with heavy applications of nitrogen, the plant reached commercial maturity very rapidly; but the heads were soft and open, and seed stalks formed prematurely.

#### **Cantaloupe breeding and selection**

Approximately 2,900 acres of the Arizona 45 cantaloupe were grown in the Salt River Valley in 1942. Under this acreage it proved to be a uniform and desirable strain of the No. 45. Because of the uncertainty of the melon outlook in a war economy, no increase of the seed was made in 1942.

Efforts have been continued toward the developing of new varieties, and several now in the sixth or seventh generation of selection give promise of being quite superior to the Imperial 45. Eleven of these strains were tested by individual growers in the spring of 1942. Two selfed lines showing special promise for Yuma were increased there in the fall of 1942 and will be planted in isolation on larger fields in the spring of 1943.

#### **Lettuce breeding and selection**

Seven generations of single plant selection and inbreeding have now resulted in fixed strains of Imperial 152 and 615 lettuce especially adapted to Arizona. Field tests during the past 2 seasons have indicated that the Arizona strains are pure, productive, and of desirable quality. On the basis of these tests the Central Arizona Grower-Shipper Association financed the production of a relatively large quantity of foundation stock in 1941. This was released in September, 1942.

Hybridization between 615 and 152 followed by selection and inbreeding has resulted in at least two promising strains. This material, now in its fifth generation, appears somewhat resistant to mildew and is early maturing. The heads are large, compact,

round, and smooth based. Most selections are essentially Imperial 152 in type with the added vigor of Imperial 615. Grower tests will be conducted in 1942-43.

Selections from hybrids made by the United States Department of Agriculture have resulted in at least one (1-41068M) strain of promise to Arizona growers.

#### Winter vegetables on the Yuma Mesa

Winter vegetables were grown on the Yuma Mesa for the fourth consecutive season. As in previous years, tomatoes proved to be the most promising crop.

Sweet corn was successful when planted August 10 to 25. The percentage of culls was greatest from the August 25 planting. Ioana, a variety similar to Golden Cross Bantam, yielded more heavily than the latter in both plantings.

Peas remain a promising fall and early winter crop on the Mesa. Varieties most adapted are the Little Marvel, Morse 60, Morse Market, Gilbo, and Giant Stride.

Onions of the Crystal Wax and Bermuda type yielded approximately 8 tons per acre. These yields are based on a plant spacing of 4 inches in the row, and 16 inches between rows on a 42-inch bed.

As in previous years, carrots on the Mesa were of exceptional size, quality, and color, but the tops tended to be small. Tests with broccoli, cauliflower, cabbage, and lettuce were not successful.

#### Vegetable variety trials

Tests of new strains and varieties of vegetables were continued in the various elevations during 1941-42. A few new varieties can be added to those listed in the report of 1941. These, together with their adaptations, are shown in Table 15.

TABLE 15.—NEW VEGETABLE VARIETIES.

Kind and variety	Elevation	Season
Beans (pole)		
Blue Lake.....	3,000-6,000	Summer
Beans (bush)		
Commodore .....	3,000-6,000	Summer
Plentiful .....	100-2,000	Fall and spring
Cabbage		
Marion Market.....	100-2,000	Winter
	4,000-7,000	Summer
Corn		
Seneca 60 x C13....	5,000-7,000	Summer
Tomato		
Stokesdale .....	100-1,500	Spring and fall (brushed)
Watermelon		
Klondike R7.....	100-2,000	Winter and spring
	3,000-4,500	Summer

### **Watermelon varieties in relation to *Fusarium* wilt**

The *Fusarium* wilt disease has caused marked reductions in yields of watermelons in the important producing areas of Arizona. Its effects can best be minimized by the use of resistant varieties. Of these the Klondike R7, developed by the University of California, is among the best. It has not been popular in Arizona because of unreliable quality and because many strains sold as R7 have not shown a high degree of resistance.

In 2 years' trials conducted co-operatively with the Plant Pathology Department on wilt-infected soil in the Yuma Valley, the greatest resistance was found in the original strain as released by the University of California. Commercial strains of the R7 varied widely in resistance. The standard Klondike variety was most susceptible of all those tried.

### **Sweet potato selection and varietal trial**

In 1939 hill selections were made in a commercial field of Porto Rico sweet potatoes. Subsequent tuber and hill selection for three generations at the Mesa Experimental Farm resulted in the isolation of a higher-yielding, better-shaped, and better-colored strain. This strain was increased at the Mesa farm in the summer of 1942 and released to the sweet potato growers of the Salt River Valley in November, 1942.

### **Vegetable and herb seed production**

Continued trials indicate that Arizona may produce certain vegetable and herb seeds to advantage, and especially the hardy annuals and biennials which are planted in the fall and produce seed the following spring.

In the lower elevations where relatively little chilling occurs, beets, broccoli, cauliflower, endive, lettuce, anise, coriander, fennel, dill, marjoram, basil, and celery appear to be adapted. In higher elevations, cabbage, onions, carrots, Brussels sprouts, and caraway have possibilities. Sage has produced seed satisfactorily at both low and higher elevations, but it makes the best growth in the latter.

### **Control of corn ear worm**

Studies on the control of corn ear worm were made in the fall of 1941 in co-operation with the Entomology Department. Mineral oil alone or with 0.2 per cent pyrethrum or with 0.2 per cent dichlor-ethyl ether was applied in the tip of the ear 4 days after silking. Application was made with a squirting type of oil can, and about  $\frac{1}{2}$  teaspoonful of the material was applied to each ear. All the materials gave from 93 to 95 per cent clean ears, whereas without treatment only 66 per cent were clean. The cost for treating was nominal.

## CITRUS STUDIES

**Winter temperatures in Salt River Valley citrus groves**

The study of temperature situations in Salt River Valley citrus districts has now been carried through five winters. The information obtained is assuming increased importance with the recognition of the merits of the Valencia orange in the Salt River Valley and of the need for holding grapefruit until spring for marketing.

A summary of the data on ceiling temperatures is significant. Since 1938 there have been 57 nights when the ground temperature dropped to 30 degrees or below. On most of these nights there was a warm ceiling temperature. It appears that the use of blowers to mix the warm upper air with the cooler lower air might be practical, particularly during November and March.

**Quality and yield of grapefruit**

The fifth year's results have again shown that yield and quality are influenced by nitrogen situations within the tree. Also, irrigation practices through the summer and fall have again influenced the market quality of the fruit at harvest. It is now believed that nitrogen nutrition, together with moisture relations, is the chief factor in the problem of yield and quality of Arizona grapefruit. The best quality is associated with a declining nitrogen content of the tree and with ample irrigations through the spring, summer, and fall.

Under the conditions on the Yuma Mesa, winter application of 1 to 2 pounds of nitrogen per tree, depending upon the culture involved, has maintained satisfactory production. Where such fertilization is accompanied by a summer grass cover, either permanent or annual, the fruit has colored earlier and is of higher market quality.

Such a program in Salt River Valley trials has not always improved fruit quality or hastened coloration. This has been especially true where nitrogen is present in the irrigation water, or when corral manures have been applied abundantly in the past. Orchards on heavy soils seem to be slow to respond. In these cases the trees have generally remained green into the fall, indicating that nitrogen supply was not sufficiently restricted by the cover crop. It must be emphasized that summer cover crops are effective in improving quality and hastening coloration of the fruit only if a control of the nitrogen content of the tree is obtained through their use. An extension of the studies on ways to achieve nitrogen control under the conditions in the Salt River Valley is greatly needed.

**The effect of winter nitrogen upon fruit deterioration**

The possibility that nitrogen applied during the winter months may cause grapefruit on the tree to lose grade has long been

questioned. It is becoming of greater importance in the Salt River Valley with the tendency to carry the fruit on the tree until late spring and early summer. Studies during the past year have shown no significant influence of either early or late nitrogen applications upon quality deterioration, fruit size, or nitrogen composition of old fruit remaining on the tree until May. At the same time leaf analysis showed that the nitrogen was taken up by the tree and that it migrated to the leaves in amounts anticipated from the treatments employed.

#### **Grapefruit fertilization**

Fertilizers were applied in the grapefruit fertilization plots on the Yuma Mesa as in the past. This marks the seventh consecutive winter that these differential fertilizers have been applied. Consistent results have been seen each year. As previously reported, nitrogen is the only fertilizing element that has been effective in influencing yields. The studies are now being brought to a close.

#### **Fruiting of the Washington navel orange**

Studies on navel oranges have been continued through the fourth season on the Yuma Mesa. Treatments employing winter nitrogen applications, together with a spring and summer cover crop, have maintained good yields of early coloring fruits, although excessive summer starvation appears to retard development of the red color. Half of the trees in each plot were pruned severely in 1938 and have been pruned each winter since by removing weak wood. This treatment reduced yields the first year, and they have not yet equalled that of trees where no pruning was done and all suckers were allowed to remain on the tree.

A thrips control (tartar emetic) spray has been applied to all plots and guard rows. This has improved the commercial quality of the fruit and, what appears to be more significant, it has given a more fruitful character of shoot growth and normal, healthy leaves.

The studies clearly suggest that the cause of the commonly known failure of navel oranges to produce well in Arizona is not entirely climatic but may be in part nutritional and have to do with the character of growth and vigor of the tree.

### **PECAN STUDIES**

#### **The pecan situation in the Yuma Valley**

Several more pecan orchards have been removed in the Yuma Valley during the past year. As previously reported, this is largely because of the marginal quality of nuts often obtained from those varieties which were widely planted during the 1920's and early 1930's. A number of orchards, especially Burkett, Halbert, and Kincaid, have been top-worked to Mahan, Delight, and Suc-

cess. Experience on the experimental farm continues to encourage the rebuilding of trees from a single bud placed on a sucker forced out low down on the tree. This method economizes on labor and gives a well-shaped tree.

Elimination of one factor contributing to poorly filled nuts was attempted on the experimental farm in 1942 by dusting all trees for control of the black-margined (honey dew) aphid. The characteristic poorly filled nuts were again obtained under conditions of extreme shade and high nitrogen nutrition through the summer. However, the general quality of nuts, especially Burkett, was better than for the past several years. This is believed to be in part due to the better control of aphid and perhaps to cooler weather in October.

Each year it has been possible to produce nuts of satisfactory commercial quality in the plots on the experimental farm receiving treatment designed toward this end. This was true in 1942 of both Burkett and Mahan, which in commercial orchards gave rather indifferent quality. It is coming to appear that because of high summer temperatures, and possibly other factors which make the Yuma Valley marginal for pecan filling and maturity, the control necessary to bring about good nut filling is too exacting for many commercial handlers. It continues to be evident that in the higher and cooler valleys such careful control is not necessary.

#### **Delayed foliation treatment**

Studies on overcoming delayed foliation through the use of a dinitro-o-cyclohexylphenol spray applied during the winter months have been continued. Repeated applications to Burkett trees on February 16 and 23 and March 3 gave the best results. A single application made on February 16 was almost as effective as the repeated applications. A single application made on February 23 also gave considerable response, but a single application made on March 3 had little effect. A powdered form of the material was less effective.

This year for the first time trees of the Success variety showed a definite advancement in time of bud break when sprayed with the dinitro compound. This early breaking unfortunately was not followed by an increase in production. Since the Success is adapted to the Yuma area in so far as nut quality and maturity are concerned, it would be most valuable to increase yields through treatments to overcome delayed foliation.

#### **Pecan varieties**

As reported for a number of years, pecan varieties which are tolerant to high temperatures in the winter for yield and in the summer for quality of nuts are the only ones which can hope to succeed in the warmer valleys of the state. New varieties are being introduced as rapidly as possible and the performance of older ones carefully noted. The Delight is proving to be among

the best. The Humble tree is so dwarfed as to be objectionable in this variety, which is otherwise well adapted.

#### MISCELLANEOUS

The Jewell and Waldo peaches on trial in the Salt River Valley continue to give evidence of high resistance to delayed foliation and suitability for that area. The plums did not fruit this year, apparently because of frost injury at blossoming, so no record of performance could be obtained. The Shalil rootstock continues to perform well in several parts of the state. Commercial nurseries are now offering standard varieties on this understock. On the Yuma Mesa the fig stock (PI52406) continues to thrive in nematode-infested soil. The tapioca plant also does well on the Yuma Mesa. However, since starch can probably be produced more cheaply from sweet potatoes and with new technological developments which make it possible to use sweet potato starch for mucilages and other products which formerly required tapioca, it is unlikely that tapioca growing can become important.

#### HUMAN NUTRITION

##### VITAMIN C CONTENT OF CANTALOUPE

Cantaloupes are produced in Arizona during the season of the year in which Arizona-grown citrus fruit is scarce and therefore higher priced as well as poorer in quality. The Human Nutrition Department therefore became interested in investigating the comparative vitamin C value of cantaloupe and citrus and the relationship of such factors as differences in variety, ripeness or maturity, etc.

Co-operation of Doctor Finch, Head of the Department of Horticulture, was sought and a plan was developed to study the factors outlined as follows:

1. Varietal differences—including Arizona Strain No. 45, Commercial Strain No. 45, Superfecto, A.Z. or Hale's Best, green-fleshed strains, and honey dews, honey balls, casabas, etc. All were picked at full slip, shipped to Tucson, and stored at room temperature until edible.

2. Effect of different soil fertilization—including nitrogen side dressing, phosphate side dressing, and nitrogen and phosphate side dressing.

3. Effect of stage of maturity—including first harvest when fruit is green but almost full grown; second harvest at one half slip stage; third harvest at full slip stage immediately analyzed; fourth harvest picked at full slip, stored in refrigerator for 5 days and then at room temperature until soft, ripe, and edible.

4. Effect of light intensity during growth—including (a) fruit from vines in full sun, (b) in shade of trees, (c) grown



under cloth shade. All these cantaloupes were Arizona Strain No. 45 picked at full slip in the Salt River Valley, shipped to Tucson at once, and stored until soft, ripe, and edible.

Fifteen fruits representing each point of difference in this plan outlined by the Horticulture Department were collected and shipped to the Department of Nutrition where the analysis was made of the vitamin C content of each fruit. Duplicate sections of the cantaloupe were cut, the rind removed, and the ascorbic acid extracted in 3 per cent metaphosphoric acid in the Waring Blender, which reduces the solid tissue to a pulpy suspension.

The Morrell method of measuring ascorbic acid was used. It consists of adding 2-6 dichlorophenolin dophenal dye to an aliquot of the extracted juice and noting the amount of bleaching of color in an Evelyn photoelectric colorimeter.

The results of these analyses will be tabulated, interpreted, and prepared for publication at an early date.

#### THIAMIN (VITAMIN B<sub>1</sub>) METABOLISM IN RATS

The investigation begun last year on the thiamin metabolism of rats fed a vitamin B-free diet supplemented with different levels of thiamin hydrochloride (5 micrograms to 40 micrograms daily) has been continued. The same technique previously reported was followed. The tissue saturation was measured by the per cent recovered in the urine of a test dose (300 micrograms B<sub>1</sub>) fed the rat, the urine collected for 24 hours following the ingestion of the test dose, and the thiamin content of the urine determined by the thiochrome method. About 20 micrograms thiamin hydrochloride daily seemed to be needed before tissue saturation began. If less than 20 micrograms B<sub>1</sub> was fed daily the response to the test dose was very low, showing highly unsaturated tissues. This fact was supported by bio-assays run on the muscle meat of rats that had been fed 5, 10, 20, 30, and 40 micrograms B<sub>1</sub>HCl daily for several months. The flesh from rats fed 5 and 10 micrograms B<sub>1</sub> daily contained practically no thiamin (the test rats gained practically no weight), while the flesh from the rats fed 20 micrograms B<sub>1</sub> daily contained some thiamin and that from the rats fed 30 and 40 micrograms B<sub>1</sub> was a fair source of vitamin B<sub>1</sub>.

A new series of test animals was started, using sixty males and sixty females which from the time they were weaned were fed a vitamin B<sub>1</sub>-free diet supplemented by 5 to 60 micrograms thiamin hydrochloride daily. Although in all cases the young growing rats excreted but a small percentage of the test dose, those fed 20 micrograms B<sub>1</sub> or less excreted a fairly constant amount while those fed over 20 micrograms B<sub>1</sub> excreted more as the supplement increased. When about 4 months old, these rats were mated. The response of their young to a test dose was small and very similar to that of the parents. When the young were 12

weeks old, they were killed and their livers were analyzed for thiamin. Although the analyses are not completed, the work so far again indicates that 20 micrograms B<sub>1</sub> daily is a dividing level. The livers of young receiving less than 20 micrograms B<sub>1</sub> daily had a fairly constant content of thiamin (about 10 micrograms B<sub>1</sub>/HC1) while the thiamin content of the livers of the rats receiving 20 micrograms B<sub>1</sub> daily jumped to about 20 micrograms B<sub>1</sub>, and the amount increased slowly as the daily dietary level increased.

After the first litter was weaned, half of the adult rats were killed and the heart, liver, kidneys, and some muscle from the hind legs were removed and analyzed separately for thiamin. Again the analyses are not complete, but so far the B<sub>1</sub> content of the hearts was found to be the highest per gram and varied the least between the different supplemental levels of any of the organs analyzed, while the thiamin content of the livers varied the most.

Reproduction studies are still in progress for the rest of the adult rats. To ascertain the thiamin status of the young, two rats from each litter are killed when weaned and their livers analyzed for thiamin. As yet no conclusions can be drawn from this work.

#### NUTRITIONAL STATUS OF SCHOOL CHILDREN

##### In regard to vitamin B<sub>1</sub>

In order to have information as to the nutritional status of typical school children resident in Tucson in respect to vitamin B<sub>1</sub>, simple tests were carried out, the methods of which have been previously studied in this laboratory. In the method developed, the significance of the urinary excretion of vitamin B<sub>1</sub> is based upon the assumption that tissue saturation can be considered a satisfactory criterion of an optimal nutritional status. It is on this basis that it has been concluded that considerable confidence can be placed in the response of a subject to a test dose.

The method followed, therefore, has consisted in the measurement of the urinary excretion of thiamin in a 4-hour period in the morning following the emptying of the bladder (8 A.M. to 12 noon) on two days. The first day's excretion served as a measure of the resting excretion level. On the second day, a test dose of 5 mg. of crystalline thiamin hydrochloride was consumed with the same breakfast at the same time. The percentage excretion of this test dose, which is indicative of the tissue saturation, therefore served as a measure of nutritional status. Six to 7 per cent or more is believed indicative of good nutrition status, whereas a lesser amount may be considered suboptimum.

The test was made upon a group including 67 Spanish-American children of low economic status in grades 1 to 6, and on a group of 41 American children of high economic status.

TABLE 16.—VITAMIN B<sub>1</sub> SATURATION TEST ON SCHOOL CHILDREN.

Per cent test dose excreted	Spanish-American (67)		American (41)	
	Number	Per cent	Number	Per cent
Less than 4.....	38	57	9	22
Less than 6.....	22	33	12	29
Above 6.....	7	10	20	49

It appears that undersaturation of the body tissues in vitamin B<sub>1</sub> exists in a high percentage of both groups of children. Only 10 per cent of the Spanish-American group tested gave evidence of very good nutritional status in this respect. The undersaturation of the tissues of such a high percentage of Spanish-American children was surprising, considering the fact that dried beans (commonly pinto) play such a large part in their diet. All the common varieties of dried beans are considered to be excellent food sources of thiamin. However, the New Mexico Agricultural College has reported appreciable loss of thiamin (as shown by bio-assay) in pinto beans when soaked and cooked with alkaline tap water or soda. The long, slow cooking methods used by Mexican families in the preparation of frijoles may result in even greater loss in B<sub>1</sub> value. Further investigation along this line is under way.

It is not so surprising that the tests of approximately 50 per cent of the American children of higher income families suggested a suboptimal intake of vitamin B<sub>1</sub>. It is more generally recognized now that the nutritional status of many American people is suboptimum in vitamin B<sub>1</sub> because of the use of patent white flour and highly milled cereals in preference to whole-grain products which have higher thiamin content.

It may be interesting to call attention again to the fact that more than 80 per cent of the sixty rural women tested last year excreted in excess of 7 per cent of their test doses of thiamin, showing, therefore, tissue saturation with respect to vitamin B<sub>1</sub> indicative of an excellent nutritional status as regards this vitamin. Undoubtedly the teachings of the Agricultural Extension Service have promoted the use of such foods as whole wheat, legumes, and wheat germ, which are high in vitamin B<sub>1</sub>. The recent practice of enriching white flour with thiamin will probably improve the nutritional status of the entire population.

#### In regard to vitamin C

A similar test of saturation of body tissues with vitamin C was made in the same two groups of school children. On the first morning the 4-hour urinary excretion of ascorbic acid was measured when no test dose was given (the result being indicative of resting level), and on the second day 100 mg. of crystalline ascorbic acid was given with the same breakfast. (No fruit or other vitamin-C-rich foods were allowed.)

It is recognized that the measurement of ascorbic acid in blood plasma is a more reliable criterion for judging tissue saturation with respect to vitamin C than is the measurement of the 4-hour excretion of a test dose. However, it is apparent that the more crude clinical test used in this investigation gave evidence of a suboptimum state of nutrition resulting from a low intake of vitamin-C-rich foods.

TABLE 17.—VITAMIN C SATURATION TESTS ON SCHOOL CHILDREN.

Per cent test dose excreted	Spanish-American (69)		American (41)	
	Number	Per cent	Number	Per cent
None .....	59	86	18	44
10 to 20.....	9	13	11	27
Above 20.....	1	1	12	29

The results presented in Table 17 show that a high percentage of both groups of children had a very poor nutritional status as regards vitamin C. Eighty-five per cent of the Spanish-American group and 44 per cent of the American group of children excreted practically none of the test dose of crystalline ascorbic acid, thus showing that they were far below tissue saturation with respect to vitamin C. It is evident, therefore, that there was a deficiency in the regular intake of foods rich in vitamin C. Although Arizona produces citrus fruits which are excellent sources of this vitamin, it appears that the use of these foods was not extensive.

#### SUPPLEMENTAL FEEDING OF SCHOOL CHILDREN SHOWING FOLLICULAR CONJUNCTIVITIS

A year ago the State and Pima County Health departments called attention of the University Department of Nutrition to a high incidence of an eye disease in elementary school children. This disease, now called follicular conjunctivitis, had for years been observed to exist chronically and had frequently been confused with trachoma.

A relation of a dietary deficiency to this eye abnormality was suggested and a plan outlined to investigate the possible causes. With the approval of Dr. L. Howard of the Pima County Public Health Department and Mr. R. Morrow, Superintendent of the Tucson Public Schools, a preliminary survey of the eye condition of all the children in grades 1 to 6 in the local schools was made by the school and public health nurses. Six thousand, six hundred forty-eight children were examined, and 1,241, or approximately 19 per cent, were reported by these nurses to have abnormal eye defects. It is interesting to note that the incidence and severity of defects was highest among Mexican children and lowest among Negroes.

The interest of local ophthalmologists was then aroused and Dr. E. H. Brown, Dr. Dake Biddle, Dr. C. S. Linton, and Dr. F. H. Maury generously offered their services in a re-examination of these children and diagnosed and graded the severity (1 to 3 positive) of this type of folliculosis.

Approximately 700 children were finally included in a supplemental feeding program designed to gain information as to the possible nutritional cause of the eye disorder.

Groups of children were matched as well as possible as to severity of eye disease or follicular conjunctivitis, age, sex, and economic status.

Group 1 serving as negative controls received no food supplement. Group 2 received vitamin A alone; group 3, vitamin A plus riboflavin; group 4, vitamin A plus the vitamin B complex as the extract of brewers yeast, type 41 furnished gratis by Standard Brands Incorporated; group 5, vitamin A plus vitamin B complex plus vitamin C; group 6, riboflavin alone; and group 7, B complex alone.

These supplemental feedings were administered by the teachers under the supervision of the school nurses and with the consent of the parents and school principals, 5 days weekly for approximately 3 months ending in May, 1942.

Eye examinations were made by the ophthalmologists at the outset, in the middle, and again at the conclusion of the experimental period. A cursory examination of the records does not indicate that any of the above-listed treatments is specific for the cure of follicular conjunctivitis although a general improvement in health was noted, and the eyes of many of the Spanish-American children, especially, were clearer, less inflamed, and less infected. These observations appear to be contrary to those of Sandel *et al* of Florida who reported that "deficiency of vitamin A appears to be the specific factor concerned in the development of follicular conjunctivitis in school children."

#### PECANS AS A SOURCE OF VITAMIN B<sub>1</sub> AND B<sub>2</sub>

Pecans are an important crop in certain sections of Arizona. Information on the vitamin-B-complex value of pecans is very limited. A study of their B<sub>1</sub> (thiamin) and B<sub>2</sub> (riboflavin) content was undertaken, therefore, in order to determine their value as compared with other food sources of these important vitamins.

Four varieties were included in parts of this study — namely, Western Mesa, Mahan, Halbert, and Humble. Analyses were made by chemical methods following the thiochrome method discussed in detail by R. T. Conner and C. J. Straubs, "Determination of Thiamin by the Thiochrome Reaction."<sup>9</sup> As the high

<sup>9</sup>*Anal. Ed. J. Ind. and Eng. Chem.*, Vol. 13, p. 380, 1941.

fat content of pecans interfered with the hydrolysis of the thiamin B complex, it was first found necessary to remove the fat by extraction in a Soxhlet extractor. After extraction of free thiamin by hydrolyzing the B complex in pecans with the aid of the enzyme, clarase, it was oxidized to fluorescent thiochrome by alkaline ferricyanide. The degree of fluorescence which is proportional to the free thiamin was then measured by the Pfaltz Bauer Fluorophotometer.

The riboflavin content of the pecans was measured by a similar procedure, except that great care was followed to prevent loss by exposure to light in carrying out the analysis in semidarkness. These analyses of known amounts of pure crystalline thiamin and riboflavin were subjected to all the experimental procedures in order to function as standards.

In order to check the accuracy of the chemical assay methods, biological assay of the thiamin content of Mahan, Halbert, and Humble pecans was carried out, using the Sherman rat-growth method which was modified and used by L. E. Booher and E. R. Hartzler and reported in "The Vitamin B<sub>1</sub> Content of Foods in Terms of Crystalline Thiamin."<sup>10</sup> Young rats weighing 35 to 45 grams were kept on a vitamin-B-deficient diet composed of extracted casein, agar, codliver oil, autoclaved yeast, O. and M. salt mixture and cornstarch until they were stationary in weight. At that time one male and one female rat from each litter were used as negative controls and were continued on the B-free diet without supplements of any kind. The remaining rats from each litter were given supplements of thiamin chloride or of pecans for an experimental period of 4 weeks duration. The average weekly weight increases were calculated for each rat receiving a supplement of pecans at  $\frac{1}{2}$ -,  $\frac{1}{3}$ -, 1-, and 2-gram levels and compared with the positive control litter mates of the same sex fed  $\frac{1}{2}$ , 3, or 5 micrograms of reference standard crystalline thiamin chloride. Approximately 250 animals were used in these tests.

Results of the findings are summarized in Table 18.

Pecans may be considered in general as excellent sources of thiamin but relatively poor sources of riboflavin. It is interesting

TABLE 18.—VITAMIN B<sub>1</sub> AND B<sub>2</sub> IN ARIZONA PECANS.

Variety	Bio-assay		Chemical assay			
	Micrograms B <sub>1</sub> /100 gms.	I.U./100 gms.	Thiamin		Riboflavin	
			Micro- gms./100	I.U.	Micro- gms./100	I.U.
Halbert	550	183	533	178	184	61
Mahan	950	317	944	315	63	21
Western Mesa	.....	.....	800	266	71	24
Humble	500	166	.....	.....	.....	.....

<sup>10</sup>Tech. Bull. No. 707 U.S.D.A., 1939.

to note in this connection that the Halbert variety, although lower in thiamin content than the other varieties of pecans tested, was a much better source of riboflavin. Comparison of the thiamin content of the pecans included in this study with the thiamin value of some other common foods analyzed by bio-assay and published by Booher of the Bureau of Home Economics of the U.S.D.A. may be seen in Table 19.

TABLE 19.—VITAMIN B<sub>1</sub> ASSAY VALUE OF FOODS.\*

Food	Vitamin B <sub>1</sub> —Thiamin					
	Excellent sources		Fair sources		Poor sources	
	Micro-grams/100 grams	IU/100	Micro-grams/100 grams	IU/100	Micro-grams/100 grams	IU/100
Bananas .....	.....	.....	.....	.....	18	54
Green snap beans.....	.....	.....	.....	.....	24	72
Dried limas.....	170	510	.....	.....	.....	.....
Navy beans.....	.....	.....	128	384	.....	.....
Corn meal.....	.....	.....	101	303	.....	.....
Eggs, yolk.....	.....	.....	118	354	.....	.....
Oatmeal.....	270	810	.....	.....	.....	.....
Peas.....	.....	.....	130	390	.....	.....
Peanuts	.....	.....	.....	.....	.....	.....
Whole roasted.....	.....	.....	78	234	.....	.....
Whole raw.....	350	1,005	.....	.....	.....	.....
Potatoes.....	.....	.....	.....	.....	62	106
Rye.....	.....	.....	156	468	.....	.....
Wheat, whole, hard.....	.....	.....	175	525	.....	.....
Tomatoes.....	.....	.....	.....	.....	26	78
Pork chops.....	455	1,365	.....	.....	.....	.....
Prunes.....	.....	.....	60	180	.....	.....
Oranges.....	.....	.....	.....	.....	26	78
Carrots.....	.....	.....	.....	.....	24	72
White flour, patent.....	.....	.....	.....	.....	29	87
Cabbage.....	.....	.....	.....	.....	27	81
Squash, buttered.....	.....	.....	.....	.....	16	48

\*From Tech. Bull. No. 707, U.S.D.A.

#### VARIATIONS IN THE VITAMIN B<sub>1</sub> (THIAMIN) CONTENT OF PINTO BEANS

In co-operation with the Department of Agronomy of the New Mexico Agricultural College, which is engaged in breeding pinto beans of high nutritive value, the Nutrition Department has begun chemical analyses of the thiamin content of approximately 200 different samples of pinto beans. Duplicate analyses have been carried out following the thiochrome method of Conner and Straubs previously described in this Annual Report. Analyses of 65 different bean samples which have been completed at this time show a thiamin content ranging from 495 to 990 micrograms per 100 grams. These figures are based upon a recovery of approximately 90 to 95 per cent following the thiochrome method of chemical assay.

#### PLANT BREEDING

##### ALFALFA

On October 24, 1941, twenty-three progenies of common alfalfa were planted from selfed seed. These progenies were the most

promising sorts among the 225 lines seeded in the fall of 1940. (See page 74, Annual Report, 1941.) Owing to a shortage of labor during the summer of 1942, it was not possible to make the necessary cuttings and cultivations for a further study of the 225 lines which were planted in October of 1940. Consequently, in the selfing work studies were confined to the twenty-three progenies seeded in the fall of 1941. Twelve of these progenies made sufficient growth for taking selfed seed during the summer of 1942. It is planned to take selfed seed from the other eleven progenies in 1943 in order to continue the selfing studies with the entire 1941 seeding. These progenies have attained a high degree of uniformity with reference to plant type, winter growth, and seed setting. The uniformity shown by most of these progenies for the major factors desired in a commercial alfalfa has not materially changed after a second generation of selfing. Since they have now been selfed from 4 to 6 generations, it is assumed that they are genetically pure for the essential characters of a productive alfalfa variety. The seed of each will be increased sufficiently for yield tests, both for seed and hay, under field conditions.

## COTTON

### Upland cotton breeding

During the past few years particular attention has been centered on increasing the length and strength of Santan Acala. This breeding work is carried on in co-operation with the U.S.D.A. Field Station at Sacaton, with progeny rows and parent seed being grown in the Queen Creek district of the Salt River Valley.

Figure 3 shows the progress made in increasing the length of lint of the breeding stock from 1937 to 1941, inclusive. The percentage of lint in each 8-inch-length class for each of the years concerned is shown. These data were obtained by sorting a ten-seed sample from each of the plants selected, and each curve in the figure represents the average of from 107 to 250 plants. A shortening of the fiber of the plants selected in 1940 over those selected in 1938 and 1939 was probably due to a water shortage. Better growing conditions in 1941 brought out considerable improvement in fiber length, as is shown in Figure 3, by the increase in the percentage of lint in the classes longer than 15/16 inch and the corresponding decrease in the shorter classes.

Selections of Santan have been made for carrying on the work in 1943, but these have not yet been tested in the laboratory. The work will continue with these selections, since Santan will probably be grown until a variety with a longer and stronger fiber can be produced.

Field selections have been made each year from the best-looking progeny rows grown. Final laboratory selections have



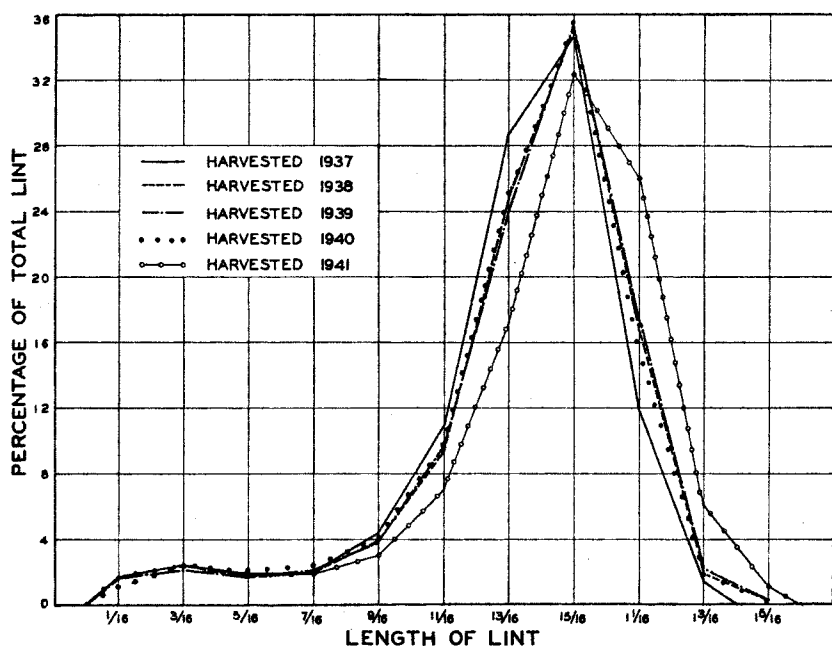


Figure 3.—Percentage of lint in the length-classes of Santan plants selected from the breeding plot from 1937 to 1941, inclusive.

been made mainly on the basis of the yield of the progeny row and the length of the fiber of the individual plants. For the past 2 years the strength of the fiber also has been used as a basis for final selection. This work has not been carried on for a sufficient length of time to show any results. However, differences of as much as 22.5 per cent in strength have been found between progeny rows of Santan, while a difference of 14.8 per cent has been found between families.

The same type of work is being carried on at the Yuma station with the Stoneville variety. Strength tests of the Stoneville breeding stock show a difference of 20.0 per cent between progeny rows and 9.2 per cent between families. The same tests show that the average Stoneville plant grown at Yuma has lint 24.4 per cent stronger than the average Acala plant grown at Queen Creek.

In 1941 a total of 45 crosses was made between 18 varieties grown at Tucson. The  $F_1$  plants of these crosses were grown at Tucson in 1942. Selfed seed was secured from these plants and will be planted at Mesa in 1943 so that the segregating generation may be grown under more severe conditions than exist at Tucson. Back crosses have been made on some of the  $F_1$  plants, and these will also be grown at Mesa in 1943.

### The long-staple crosses

In the summer of 1941, approximately 1,200  $F_2$  plants were grown from the cross, 120 on Pima. Selfed seed was taken from 203 plants of this  $F_2$  population. Among other things, weight of 100 seeds, lint percentage, and lint index were determined for each of these 203 selfed plants. Lint index, which is a measure of lint abundance on the seed, may be summarized for these plants as follows:

24 plants, or 12 per cent, had a lint index of from 5 to 6.

145 plants, or 71 per cent, had a lint index of from 6 to 7.

34 plants, or 17 per cent, had a lint index of 7 or above.

Seventy-seven plants of  $F_1$  Pima x 120 back crossed on Pima also were grown. The distribution of lint indexes for these plants was as follows:

20 plants, or 26 per cent, had a lint index of from 5 to 6.

57 plants, or 74 per cent, had a lint index of from 6 to 7.

0 plants, or 0 per cent, had a lint index of 7 or more.

The lint index of Pima, average of 5 individual plant determinations, was 5.67, while that of 120, average of 7 individual plant determinations, was 7.12. The average weight of 100 seeds of Pima was 13.2 grams, and the average weight of 100 seeds of 120 was 12.4 grams.

These data clearly indicate that lint abundance is a heritable character and that its inheritance is comparatively simple, since 17 plants per 100 were recovered in the  $F_2$ , which had a lint index equal to that of strain 120, the abundant parent. It is also of interest to note that 16 plants among 203  $F_2$  selected plants had a lint fineness equal to that of Pima,<sup>10</sup> some of which had a lint index equal to that of strain 120.

### WHEAT

Preliminary yield testing and seed increase with 100 progenies derived from three double crosses (see Annual Report, 1940, p. 88) were conducted in 1941-42. Each of the three double crosses was grown in bulk for 5 generations without selection in order to produce as many homozygous types as possible for selection. At this time 236 head selections were made from the three double crosses, and the 100 progenies tested and increased in 1941-42 represent the selected progenies from those obtained from the original head selections. These progenies were grown in rows, and the grain produced on 50-foot lengths was used for a preliminary yield test in comparison with Baart. Eleven progenies with strong straw and high stooling, which were as productive as Baart, were selected for further testing in 1942-43 when sufficient grain will be available for replicated yield tests.

<sup>10</sup>The fineness determinations of these plants were made by Mr. H. J. Fulton, and Mr. William Thomas of the United States Department of Agriculture Field Station, Sacaton, Arizona.

### Crosses for rust resistance

The first back-crossed generation of Baart on Hope was grown, and crosses were made for growing the second back-crossed generation in 1943, Baart being the recurrent parent.

Timopheevi (common) wheat derivatives obtained from the United States Department of Agriculture, which are highly resistant to rust, were crossed with Baart 38 in an attempt to combine the Hope type of resistance in Baart 38 with that of the Timopheevi species.

### SOYBEANS

Beginning in 1937, sixty varieties of soybeans from the United States Department of Agriculture and six southern states were planted at Tucson for the purpose of finding suitable parents for creating by hybridization a soybean adapted to southern Arizona. From previous experience of those who had attempted to grow soybeans in Arizona, it was recognized that shattering would be an important factor. Consequently, nonshattering was given most attention among these varieties. It was believed that if a nonshattering sort could be found, this quality could be combined by hybridization with high seed yield and other desirable qualities found in the shattering varieties, provided the nonshattering sort was low yielding and otherwise undesirable. Since all the sixty varieties shattered too much for growing commercially, nonshattering plants were selected where they could be found in any of these varieties. A single nonshattering productive plant was observed in the row of the Mamredo, a variety obtained from the Mississippi Experiment Station. The progeny of this nonshattering Mamredo plant has been grown continuously since the year of its selection, 1937, and it has proved to be almost completely nonshattering. Plate II shows a portion of a row of this variety grown at Tucson in 1942. While no adequate yield tests of this new soybean have been made, due to a lack of seed, the number of pods set on the plants that do not shed indicates that it may have commercial possibilities. The name Armredo has been given this selection. Sufficient seed will be available for more adequate testing in 1943, and a limited distribution of seed to growers should be possible for the 1944 crop.

### PLANT PATHOLOGY

#### BACTERIAL WILT OF ALFALFA

Bacterial wilt of alfalfa is suspected to be rather widespread in Arizona. It has been found previously<sup>11</sup> by this department in fields in the Verde, Oak Creek, and Chino districts, and in one planting near Tucson. The first observation of the disease in the Salt River Valley is here recorded.

<sup>11</sup>Brown, J. G. Alfalfa wilt. *Ariz. Agr. Ext. Cir.*, August, 1940.

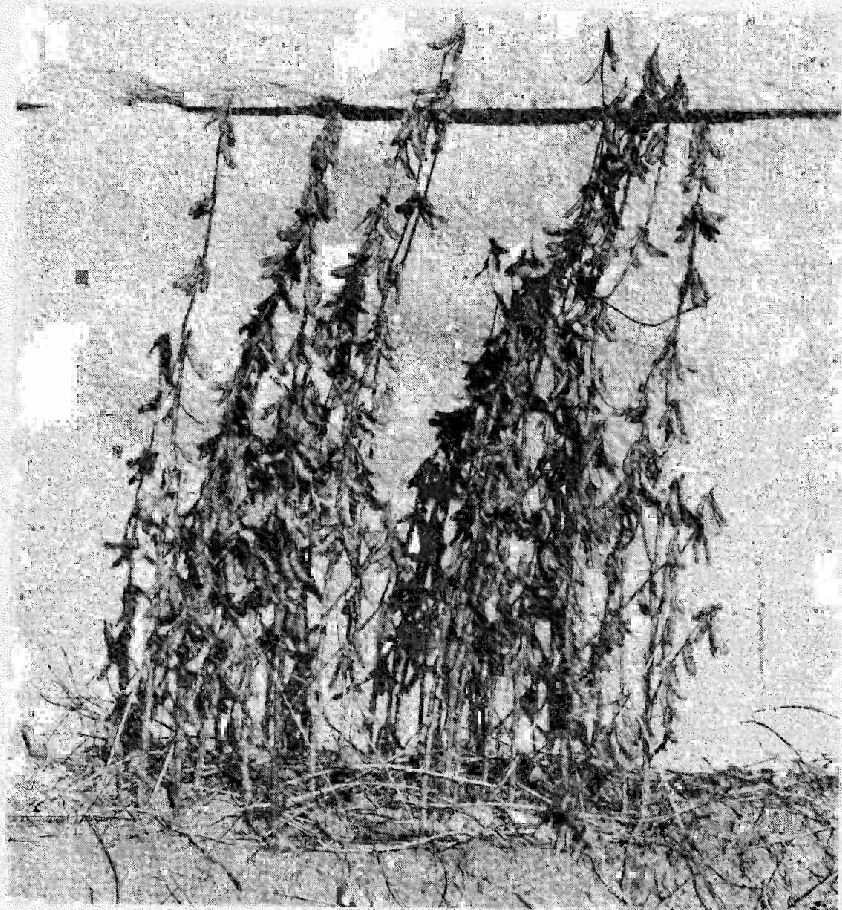


Plate II.—The Mamredo variety of soybean.

The program outlined in last year's annual report of the Arizona Station on varieties that may show resistance to the bacterium, *Phytophthora insidiosa*, the cause of alfalfa wilt, has progressed far enough to indicate that several varieties have resistance. Sufficient time has not elapsed to indicate how nearly permanent the resistance may be. Variability with respect to resistance exists within the selections that are already grown in southern Arizona.

#### PHYMATOTHICUM (COTTON OR TEXAS) ROOT ROT

Field experiments<sup>12</sup> co-operative with the Division of Fruit and Vegetable Crops and Diseases, U.S.D.A., on the control of

<sup>12</sup>Ariz. Agr. Exp. Sta. Ann. Rept. 48: pp. 84-85, 1937.

root rot in pecan orchards in the Yuma Valley continued to the end of the season of 1941. In 1942 the supplanting of parts of the experimental orchards with more profitable crops and inability to find a man qualified for field work made necessary the restriction of studies to observations on experiments already in progress.

#### **Cover crops and intercrops**

Additional data confirm the view that losses from root rot are much smaller in both treated and untreated groves where no susceptible crop is grown between the trees. One grove in which alfalfa was replanted following a change in ownership is showing a definite increase in root rot.

#### **Soil treatments**

No additional soil treatments were made in the five large orchards where extensive experiments were conducted during 1937-40, inclusive. Root rot was apparently under satisfactory control in the three best plots (80 acres each) but still was spreading in the two plots where no control had been attempted since 1938.

#### **Soil treatments before planting**

No pecan trees in the 6-acre orchard planted in root-rot-infested soil in 1937, 1938, and 1941 were killed or attacked by root rot during the past year. Trees not treated are being lost or infected in the 2-acre plot where an intercrop of alfalfa is maintained.

#### **Rotation and deep plowing**

A co-operator reduced root-rot losses in cotton to about 1 per cent in 1941 on a farm of 550 acres where root-rot infection in cotton amounted to 50 per cent in 1939. Deep plowing by a program of grain sorghums, pasture, and cattle feeding was used in 1940.

#### **Deciduous fruit trees**

Root-rot-resistant stocks for stone fruits and grapes are under test for resistance and environmental adaptation. The nematode-resistant Shalil rootstock has been found to be moderately susceptible to root rot.

### **ANGULAR LEAF SPOT OF COTTON**

Cotton seeds taken at a depth of 3 feet or less from piles at the gin, extensively cultured, gave colonies of the angular leaf spot bacterium, *Phytophthora malvacearum*. Gin piles of cotton seed usually are infested with the bacterium.

Numerous cultures of fuzzy and acid-delinted cotton seeds exclusively selected from bolls badly diseased with the angular

leaf spot bacterium gave colonies of the parasite from fuzzy seeds but from only one seed of the delinted lot. The infected seed had a broken coat.

#### GERMINATION OF TREATED AND UNTREATED COTTON SEEDS UNDER SEVERE CONDITIONS

Sulfuric acid delinted and fuzzy cotton seeds of Acala variety from a common lot were planted at three depths in puddled soil. The pots were submerged in water and tapped to drive air out of the soil. Only heavy (sinker) delinted seeds were used, and the fuzzy seeds were selected also for plumpness and size as well as possible, considering their covering of lint. The first planting on February 14 was followed by a second on March 12 and a third on May 5, in order to cover a wide range of temperatures. The pots remained in the open from the time of planting. Air temperatures were recorded on a thermograph. Unusually high temperatures at midday in May and June resulted from a southern exposure between two heat-radiating and reflecting walls.

Measured with an osmometer<sup>13</sup> connected with a mercury manometer, water diffused through the seed coat (testa) of acid-delinted seeds at a maximum rate more than twelve times faster than the rate through the coat of untreated fuzzy seeds. Application of ethyl mercury phosphate to the surface of the coat did not affect the rate of diffusion of water through the latter.

#### CITRUS DRY ROOT ROT<sup>14</sup>

Soil treatments similar to those developed for the control of *Phymatotrichum* root rot have been tested for dry root rot of citrus by treating all visibly infected trees in three commercial groves in 1938, 1939, and 1940. Response to treatment is generally prompt and lasting. Recently a new outbreak of the disease killed five trees and severely damaged two others in the untreated part of the block of tangerines that received attention in 1938. Only one of the tangerines treated 4 years ago died, and that tree had received manure only.

Inoculation into roots of healthy sour orange and rough lemon trees of species of *Fusarium* isolated from diseased citrus roots has thus far failed to produce the typical severe and fatal form of the disease. A study of possible predisposing factors leading to severe damage from dry root rot indicates that the commonest and perhaps the most important is periodic or chronic deficiency in soil moisture due either to shallow soil of poor water-holding capacity or an irrigation system that fails to secure penetration.

Much less dry rot of citrus was evident during the season than appeared the previous year.

<sup>13</sup>Ariz. Agr. Exp. Sta. Ann. Rept. 48:80, 1937.

<sup>14</sup>Ariz. Agr. Exp. Sta. Ann. Rept. 49:71; 50:93.

TABLE 20.—GERMINATION OF FUZZY AND ACID-DELINTED COTTON SEEDS IN PUDDLED SOIL UNDER A WIDE TEMPERATURE RANGE.

Nature of seed	Date planted	Date reading	Period (days)	Range, air temps., F°	Per cent germination at:		
					1 in.	1½ in.	2 in.

Series 1							
Fuzzy	Feb. 14	Feb. 28	14	26-86	15	0	0
Acid-delinted	Feb. 14	Feb. 28	14	26-86	20	10	0
Fuzzy	Feb. 14	Mar. 16	30	26-90	15	5	0
Acid-delinted	Feb. 14	Mar. 16	30	26-90	30	10	10
Fuzzy	Feb. 14	Mar. 26	40	36-110	35	15	15
Acid-delinted	Feb. 14	Mar. 26	40	36-110	60	35	10
Fuzzy	Feb. 14	Apr. 7	52	40-110	35	15	15
Acid-delinted	Feb. 14	Apr. 7	52	40-110	70	40	10

Series 2							
Fuzzy	Mar. 12	Mar. 26	14	34-110	5	5	5
Acid-delinted	Mar. 12	Mar. 26	14	34-110	15	5	10
Fuzzy	Mar. 12	Apr. 7	26	40-110	35	15	15
Acid-delinted	Mar. 12	Apr. 7	26	40-110	60	35	10
Fuzzy	Mar. 12	May 5	54	49-122	50	15	20
Acid-delinted	Mar. 12	May 5	54	49-122	90	45	35
Fuzzy	Mar. 12	May 14	63	50-128	50	15	20
Acid-delinted	Mar. 12	May 14	63	50-128	90	50	35

Series 3							
Fuzzy	May 5	May 17	12	50-128	20	15	5
Acid-delinted	May 5	May 17	12	50-128	40	25	20
Fuzzy	May 5	May 24	19	50-132	25	25	10
Acid-delinted	May 5	May 24	19	50-132	40	40	30
Fuzzy	May 5	May 30	25	50-132	25	25	15
Acid-delinted	May 5	May 30	25	50-132	45	45	30
Fuzzy	May 5	June 7	33	55-138	25	25	15
Acid-delinted	May 5	June 7	33	55-138	50	50	30
Fuzzy	May 5	June 14	40	55-142	25	25	15
Acid-delinted	May 5	June 14	40	55-142	60	50	35

## CITRUS BROWN ROT GUMMOSIS

The most widespread and severe outbreak of brown rot gummosis (*Phytophthora citrophthora*) in the past 18 years in the state occurred during the spring and summer of 1942. Control measures checked the disease, but not before many trees were seriously girdled. The outbreak was apparently correlated with the wet winter of 1940-41.

INFLORESCENCE BLIGHT OF DATE PALM<sup>15</sup>

Inflorescences from palms in the University Date Garden cultured in the laboratory, gave *Fusarium moniliforme* and *F. semitectum*. Losses due to fusarirose, based upon cultures, were reported to be almost entirely confined to Rhars variety, in which they were heavy. In other date orchards losses due to fusarirose were mostly in palms of the Sayer variety and were estimated as high as 50 per cent in some plantings.

## GUAYULE RUBBER PLANT AND DISEASES

Aside from the major importance of the guayule plant (*Parthenium argentatum*) as the most promising available source of natural rubber in this country, it may also prove valuable as a "money crop" on soils infested with destructive plant parasites. Preliminary cultural and field experiments with guayule seedlings in their second year indicate immunity of the plant to attack by *Sclerotium rolfsii*, strong resistance or immunity (one insect-injured seedling attacked in a planting of 14,000) to *Phymatotrichum omnivorum* (the Texas root-rot fungus), and marked resistance to *Heterodera marioni*, the root-knot nematode.

GIANT CACTUS NECROSIS<sup>16</sup>

*Erwinia carnegieana* n. sp., the cause of bacterial necrosis of the giant cactus, produced the disease in a healthy cactus into which it was inoculated after the parasite had remained more than 42 days in soil that it reached from a sick plant. The bacterium has not yet killed seedlings of the giant cactus inoculated with it. Inoculations of different species of prickly-pear cactus were corked off before the bacterium could gain a foothold.

## BACTERIAL ROT OF SANSEVERIA

All plants of Sanseveria in a campus greenhouse were killed by a bacterial rot during the winter of 1941-42. Rootstocks of

<sup>15</sup>Brown, J. G. and Karl D. Butler. Inflorescence blight of the date palm. *Jour. Agr. Res.* 57:313-18, August 15, 1938.

<sup>16</sup>Lightle, Paul C., Standring, Elizabeth T., and J. G. Brown. A bacterial necrosis of the giant cactus. *Phytopathology* 32:303-13, April, 1942.



affected plants became pale yellow, soft, and water soaked, the roots dry and hard; the leaves rotted and bent at the soil line. From the decayed tissues was isolated a bacterium in pure culture that produced the rot when inoculated into healthy plants. The parasite generally agreed in morphological and physiological characteristics with the description of *Phytomonas restructans* that is listed by Elliott as a variety of *Erwinia carotovora*.

#### BACTERIAL CANKER OF OLEANDER

Dead, brown leaves on small branches of oleander drew attention to cankers on the latter. The lesions were rough, cracked, with a grayish tan surface and dark brown showing through the cracks. A bacterium that was cream color at first, sayal brown in 5 days, and snuff brown later, was isolated in pure culture on agar from the leaves. The isolant caused similar cankers after inoculation into healthy branches of oleander from which it was re-isolated.

#### DISEASES NEW TO ARIZONA

The following are believed to be here reported from Arizona for the first time: Root rot (*Phymatotrichum omnivorum*) on *Cassia tomentosa* and *Ephedra sinica*, from Pima County; sclerotinose (*Sclerotinia sclerotiorum*) of *Chrysanthemum* spp. (hardy), *Linaria*, *Ranunculus*, and flax, from Maricopa County; root knot (*Heterodera marioni*) on *Peniocereus greggii* and *Kitingia* sp., from Pima County; bacterial rot of *Sanseveria fasciculata* and bacterial canker of *Nerium oleander* appear to be unreported in literature.

#### DISEASES UNUSUALLY PREVALENT

Downy mildew of lettuce (*Bremia lactucae*), Maricopa County; black stem rust (*Puccinia graminis tritici*) of wheat, for second consecutive year, and crown rust (*Puccinia coronata*) of oats, in Maricopa County; and bacterial gall (*Phytomonas savastanoi*) of oleander, in Pima County, were unusually prevalent.

#### POULTRY HUSBANDRY

##### BREEDING INHERITANCE STUDIES

In a project dealing with breeding, work was carried on along five different lines: high egg production, low egg production, long-continuous laying, large egg size, and small egg size.

**Developing a high egg-producing strain**

It has been definitely established that a high-egg individual or flock produces eggs more economically than low-egg individuals or flocks. In the present war emergency, which is demanding an increase in egg production, any information from an experimental source which will throw light on this question will be of definite value.

During the last 10 years this department has carried on projects involving all possible types of matings, from close inbreeding to double outcrossing. It was found that inbreeding definitely lowered vitality, increased mortality, decreased egg production, and increased losses in incubation and brooding, and that the mating of unrelated bloods from good production stock with this weakened foundation produced offspring which in successive generations were as good as or better than the original foundation.

As an indication of the success of a system of selecting high production and passing it on through outcrossing, with the use of the above system twenty hens were this spring selected as breeders which had an average egg production the first year of 277 eggs for the group. The individual egg productions were 250, 254, 265, 273, 274, 298, 298, 291, 288, 288, 262, 277, 279, 272, 265, 300, 282, 289, 281, and 260 eggs.

**Developing a low egg-producing strain**

In order to develop a base or measure for the purpose of checking values of male birds for their ability to transmit egg production, a low-producing strain is being established.

**Developing a high egg-laying strain for consecutive years**

The establishment of a strain capable of laying at a high rate over a succession of years would be of untold value to the poultry industry. At present 2 years is considered the useful life of a hen, with considerably less egg production in the second than in the first year. The extent to which long, high production has been accomplished is indicated in Table 20, which represents the make-up of the breeding pen for this work in the spring of 1943.

**Establishing a strain for large eggs**

Eggs are marketed by grades, and grades are established by weight with a higher price paid for large eggs. It is therefore obvious that the greater the percentage of large eggs produced, the more profitable will be the endeavor. Definite progress has been made along this line with the average weight of the eggs close to 25 ounces to the dozen.

**Establishing a strain for small eggs**

The purpose of this phase of the breeding work is the same as that for the selection of a low egg-producing strain, except that the smallness of the egg is stressed.

TABLE 21.

Hen no.	Eggs				
	1st yr.	2nd yr.	3rd yr.	4th yr.	5th yr.
U 318.....	242	202	207	207	211
V 193.....	234	210	182	220	.....
V 338.....	251	221	190	204	.....
W 372.....	272	220	202	.....	.....
W 583.....	278	200	203	.....	.....
X 466.....	284	240	.....	.....	.....
472.....	290	249	.....	.....	.....
503.....	269	234	.....	.....	.....
522.....	266	239	.....	.....	.....
531.....	325	256	.....	.....	.....
535.....	294	231	.....	.....	.....
Average .....	273	227	196	210	211

## POULTRY FEEDING

As a result of the war, many feedstuffs that commonly have been used in feed mixtures for poultry have become scarce, costly, or even unavailable. On the other hand, there are large supplies of some materials, as well as some comparatively new feedstuffs, that may be used in poultry feeds.

In view of this situation, a group of emergency rations was formulated. The feedstuffs selected were those that in all probability will be available for a considerable period. The following rations were used:

Pen 1, University of Arizona laying ration (check)

## Mash

100 pounds bran	25 pounds alfalfa meal
100 pounds corn meal	25 pounds buttermilk, dried
100 pounds ground oats	25 pounds bonemeal
100 pounds shorts	15 pounds oystershell
100 pounds meat scraps	15 pounds charcoal
25 pounds linseed meal	5 pounds salt
25 pounds fish meal	

## Scratch

200 pounds whole wheat	200 pounds hegari
200 pounds cracked corn	100 pounds whole oats

Green cut alfalfa, or barley, was fed as a green feed once a day.

The following pens were fed the University of Arizona ration, modified as indicated:

Pen 2, no milk; alfalfa meal doubled.

Pen 3, no milk; commercial B-G concentrate added.

Pen 4, no milk or wheat products; rice bran and soybean meal added.

Pen 5, no milk or fish meal; alfalfa meal increased.

For the period November 1, 1941, to September 1, 1942, the average egg production per bird was at the following rate: Pen 1, 56.9 per cent; Pen 2, 60.5 per cent; Pen 3, 59.1 per cent; Pen 4, 56.1 per cent; and Pen 5, 58.5 per cent.

Economy of production was lowest in Pen 5 and highest in Pen 4. Other lots were intermediate.

Total feed consumption to date corresponds quite closely to the number of hen days. This suggests that palatability was not a factor in any of the rations tested.

These data indicate that wheat products are to be desired in a laying ration. Also, that other ingredients may be successfully substituted for dried milk and fish meal, provided they supply sufficient protein and vitamins.

An additional ration utilizing a greater amount of soybean meal will be included in next year's test.

#### PULLORUM AND RANGE PARALYSIS RESISTANCE

Tests for resistance to pullorum and range paralysis and routine blood testing for pullorum are being carried on with different families and breeds. Certain individual families show good resistance even when reared in contact with birds from known infected parents.

#### ENVIRONMENTAL FACTORS AND THEIR EFFECT ON THE NATURAL EGG CYCLE

Two groups of Rhode Island Red pullets were used in an attempt to determine the effect of environment on cycle, number, and size of eggs. One lot was confined in individual hen batteries in a room in which temperature, light, and ventilation were relatively constant; the other group was similarly confined in a room in which no effort was made to control these same factors. Production was more evenly distributed over the 24-hour period in the controlled group. Rate of lay and feed per dozen eggs favored the hens kept under noncontrolled conditions. Egg size was slightly larger in the control lot. This work will be continued another year.

## APPENDIX

### ANALYTICAL SERVICE

During the past year the Department of Agricultural Chemistry and Soils analyzed 3,367 samples of soils, waters, and other materials submitted to the laboratory by the agricultural industry of the state. These are tabulated in Table 22.

TABLE 22.—COMPILATION OF ANALYSES MADE IN THE DEPARTMENT OF AGRICULTURAL CHEMISTRY AND SOILS.

	Phoenix laboratory	Tucson laboratory
Soils .....	815	557
Waters .....	634	372
Fertilizers and manures....	39	20
Feed and hay samples.....	23	339
Grains .....	.....	22
Poison analyses.....	19	.....
Gypsum .....	5	.....
Milk .....	.....	247
Miscellaneous .....	169	106
	1,704	1,663

### ARIZONA EGG LAYING TEST

Arizona used the R.O.P. (Record of Performance) system several years before the National Plan came into existence. In the earlier days it was known as the Accredited Hatchery Movement. All the breeders doing R.O.P. work are entering birds in the Egg Laying Test. George Haws of Mesa entered the first test in 1922 and has had birds in every one since that time. The Gold Spot Hatchery entered its first pen in 1930. Inasmuch as there is no home trapnesting in this state to date, and all R.O.P. records are established through the medium of the Egg Laying Test, comparable results from the test should be an indication of the value that R.O.P. work in this state has been in encouraging increased egg production. Such a comparison is therefore included.

During the first 3 years, 1922-24, five-bird entries were made and results were figured on a hen-day basis where mortality did not penalize. In 1930-31, ten-bird entries were used and results were figured on a hen-day basis. Since 1939 the entries have consisted of thirteen birds and all results have been based on the entire pen which means that if a bird died, with the ruling assumed that she was still capable of laying, it brought the averages down much lower than would a hen-day basis of

TABLE 23.—AVERAGE EGGS PER BIRD PER YEAR.

George Haws		Gold Spot Hatchery	
Year	Eggs	Year	Eggs
1922-23.....	191	.....	.....
1923-24.....	218	.....	.....
1924-25.....	245	.....	.....
.....	.....	1930-31.....	198
1939-40.....	203	1939-40.....	200
1940-41.....	218	1940-41.....	236
1941-42.....	236	1941-42.....	254

figuring. In this comparison it can be seen that the stock of George Haws' White Leghorns averaged 191 eggs per bird in 1922-23. Since that time there has been a progressive increase until 1941-42, the past year, during which period his entries averaged 236 eggs per bird.

The same holds true of the Gold Spot Hatchery, which also has White Leghorns. In 1930-31, their eggs averaged 198 per bird. During the last year, 1941-42, this average had increased to 254 eggs. The Arizona Test led the seventeen similar tests in as many states in the United States.

The Gold Spot Hatchery's White Leghorns led this test with a production of 3,305 eggs and a point value of 3,483. Another entry of White Leghorns, owned by the Booth Farms and Hatchery of Clinton, Missouri, took second place, with 3,279 eggs and 3,439 points to its credit. The Foreman Poultry Farm's White Leghorns, of Lowell, Michigan, were third, with 3,407 eggs and 3,420 points.

A Rhode Island Red hen owned by the Bagby Poultry Farm of Sedalia, Missouri, was the high individual producer, having produced 320 eggs with a point value of 340 in the 357-day period. A Gold Spot Hatchery White Leghorn, of Phoenix, Arizona, was a close second, having laid 311 eggs with a point value of 339—only 0.95 of a point behind the leader. Another White Leghorn, owned by the Del Rio Farm, of Mesa, Arizona, was third, with 296 eggs and 321 points.

The percentage production of the entire test was 59.8 per cent compared with 57.8 per cent for the previous years. Twelve birds, 3.6 per cent of the 328 living at the end of the test, laid 300 eggs or more. One hundred thirty-seven, or 41 per cent, laid 251 eggs or more; and 264, or 80 per cent, exceeded 200 eggs. The average egg production of all entries on a hen-day basis was 230 eggs.

The mortality of 15.9 per cent was 3.6 per cent less than last year.

The feed consumption for the various breeds for 51 weeks was: White Leghorns, 86 pounds; Rhode Island Reds, 96 pounds;

New Hampshires, 91 pounds; Black Australorps, 85 pounds; and Barred Rocks, 87 pounds. The feed necessary in producing a dozen eggs in the test for the various breeds was: White Leghorns, 4.4 pounds; Rhode Island Reds, 5 pounds; New Hampshires, 4.9 pounds; Black Australorps, 4.9 pounds; and Barred Rocks, 5.2 pounds.

Tabulations on a national basis, including seventeen tests from sixteen states, show Arizona leading all other tests. In the different phases of these tests Arizona had the highest average egg production per individual, the highest average points per individual, was tied with New York State on a 24.9 ounces per dozen in egg size, and had the second lowest mortality. Michigan had 12.3 per cent mortality compared with Arizona's 15.9 per cent.

## SOIL SURVEY

The University has co-operated with the U.S. Department of Agriculture, Bureau of Soils, and Bureau of Plant Industry on Soil Surveys since the first survey was made in Arizona more than 40 years ago. During the past 2 or 3 years this co-operation has also included the Soil Conservation Service. An agreement of co-operation between the University, the Bureau of Plant Industry, and the Soil Conservation Service has been signed and is now in effect. Under the terms of this agreement survey proposals must be approved by all three agencies before any survey can be started. This will eliminate unnecessary duplication of effort. The University co-operates with the regional inspector on final inspection of each area and in the development of land-use-capability classifications.

During the past year the University sponsored a soil survey of Yavapai County. Practically all field work in this area has been completed. Only the farm communities of potential agricultural importance are considered in the survey, which includes about 30,000 acres.

The Silver Creek area in Navajo and Apache counties has been approved and surveyed. About 45,000 acres were originally approved for survey. Final inspection of this area has not been made.

The White Tanks area, 17 miles west of Phoenix, situated between the Agua Fria River and the White Tanks Mountains, is subject to overflow by flood waters and is in need of conservation practices. A survey of this area has been outlined and will serve as a basis for conservation planning. Four hundred twenty-five thousand acres are included in the area.

The San Francisco Peaks Soil Conservation District, Coconino County, has requested a Conservation Survey on approximately 25,000 acres of land in the vicinity of Flagstaff. Much of this land lies in small tracts scattered around the base of the mountains and is subject to overflow and erosion. The Soil Survey, which

is nearly completed, will serve as a basis for inaugurating farm practices best suited to the area.

The area included in the Pima County Soil Conservation district was partly covered in the original Bureau of Soils survey of the Tucson area. Revision of soil types, mapping on a larger scale, and the inclusion of information on slope and erosion has made it desirable to resurvey the arable soils along the Santa Cruz River, the Rillito Creek, and their tributaries. The survey has been completed and land-use capabilities worked out for each soil mapped. University facilities were used in making analyses of the soils.

The soils on the Yuma Mesa have a great deal in common with the soils on the East Mesa near the Imperial Valley, California.

The California Agricultural Experiment Station invited a representative of the Arizona Agricultural Experiment Station to participate in the final inspection and correlation of the soils in a survey completed in that area in May, 1942. A better understanding between the two states regarding the best use to which these soils should be put will result from this co-operation.

#### **Gila River War Relocation Center—Sacaton**

The War Relocation Authority requested the Soil Conservation Service to make a survey of the lands in the Japanese Relocation Center at Sacaton. This survey will be made in co-operation with the U.S. War Relocation Center. The land-use-capability classification for the surveyed area is being prepared. The area to be surveyed consists of about 16,500 acres. This survey is to be used as a guide in the subjugation program being carried on in the area.

## **SUMMARY OF STATION PUBLICATIONS**

### **TECHNICAL BULLETINS**

No. 93.—*The Grasshoppers and Other Orthoptera of Arizona*, by E. D. Ball, E. R. Tinkham, Robert Flock, and C. T. Vorhies. 117 pages, illustrated. This bulletin deals with one of the most destructive groups of insects, which includes, besides the grasshoppers, crickets, cockroaches, walking sticks, and praying mantids. Two hundred eighty-two species and varieties occurring in Arizona are listed, with brief descriptive notes, keys, and suggestions for control of the most injurious forms. Distribution in the state and food plants, so far as known, are given for each species.

### **GENERAL BULLETINS**

No. 174.—*Efficiency in the Use of Farm Machinery in Arizona*, by Ned O. Thompson. 24 pages. An analysis of machines used



and cost of such use under custom work method compared with use of farm-owned equipment. Also suggestions of machinery needed for farms in the several size classifications.

No. 175.—*Agricultural Land Ownership and Operating Tenures in Casa Grande Valley*, by Philip Greisinger and George W. Barr. 14 pages. A brief analysis of land ownership and operating problems in this new agricultural valley, with suggestions for improving the situation.

No. 176.—*Volume and Characteristics of Migration to Arizona, 1930-39*, by Varden Fuller and E. D. Tetreau. 32 pages. In cooperation with the Bureau of Agricultural Economics, U.S. Department of Agriculture. Analysis of the population in Arizona in January, 1940, which had come to Arizona since January, 1930, made it possible by comparison with Census returns to ascertain the number of persons who were in Arizona in 1930 who left the state during the decade. The population arriving since 1930 and remaining in the state was analyzed as to occupation and location in the state. These results throw much needed light upon social problems arising from high population turnover and the settlement of newcomers in Arizona.

No. 177.—*Part I: Poultry Feeding Experiments*, by H. Embleton. 19 pages. A comparison of cottonseed meal, meat scraps, and dried buttermilk for egg production, a 3-year test. Also results of 2 years of work with nutritive ratios for young chicks.

No. 177.—*Part II: Moulting and Housing Experiments*, by H. B. Hinds. 15 pages. Deals with forced moulting, platform housing, and housing in the Salt River Valley.

No. 178.—*Arizona Agriculture, 1942: Supplies, Prices, and Income*, by George W. Barr. 22 pages. Includes statement of Arizona agricultural income in 1941, by commodities; prices of agricultural commodities in the state in December, 1941, with comparisons; and discussion of acreage or prices and supplies of about ten important agricultural commodities.

No. 179.—*Arizona Farm Leases*, by E. D. Tetreau. 17 pages. Farm leasing agreements are analyzed and a flexible farm lease form provided for the use of farmers and farm agencies in preparing improved leasing contracts. Leasing practices in Arizona's major irrigated farming areas are analyzed and described.

No. 180.—*Egg Profit Calculator*, by H. Embleton. 8 pages. Tables and graph showing the cost of egg production at varying egg and feed price levels.

No. 181.—*Irrigation Requirements of Cotton on Clay Loam Soils in the Salt River Valley*, by Karl Harris and R. S. Hawkins. 38 pages. Six years of results with differential irrigation schedules with cotton are presented. Plants stimulated into rapid growth prior to heavy flowering by means of early irrigation consistently outyielded those in which the first irrigation after planting was delayed until the plants reached the wilting point. The data also indicate that cotton plants should be allowed to

reduce the soil moisture more completely between irrigations during the fruiting period than prior to this period.

No. 182.—*The Productive Capacity of Semiarid Soils and the Present Emergency*, by W. T. McGeorge. 34 pages. During the present emergency it is more imperative than ever that some extra attention be given to bringing our soils to their maximum productive capacity. In Arizona this can be accomplished by control of alkali, both white and black, by maintaining soils in good structural or mechanical condition, by the proper conservation and use of organic matter such as farm manure and other farm wastes suitable for composting, and by the economical use of fertilizers. *General Bulletin 182* was written to present information of this nature to Arizona farmers in a simple and readable form. The information is taken largely from our own research but also presents useful information of the above nature from other sources.

No. 183.—*The Cost of Production of Eggs and Pullets in Southern Arizona*, by H. Embleton. 45 pages. The results of a survey involving 52 poultry farms in southern Arizona is given, setting forth the cost factors involved in the production of eggs and pullets. An appendix of useful poultry economic information dealing with many phases of the poultry industry has also been included.

No. 184.—*Poultry Feeding and Confinement Experiments*, by H. B. Hinds. 20 pages. A study of the small grains as to their value in poultry feeding in addition to further studies on confinement rearing of chicks in battery brooders and houses.

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- Fourth annual report of the Arizona fertilizer control office. 10 pages. The Agricultural Chemist in the Experiment Station is responsible for the enforcement of the Fertilizer Control Law. This bulletin is a report of the Fertilizer Control operations for the calendar year 1941. It contains a tabulation of all the fertilizer brands registered in the state and the analyses of 63 samples taken from stocks on sale in the state.



TABLE 25.—FINANCIAL STATEMENT, 1941-42, UNIVERSITY OF ARIZONA, AGRICULTURAL EXPERIMENT STATION.

	Hatch	Adams	Purnell	Bankhead-Jones	Balance & receipts	State funds	Total
RECEIPTS							
Received from the Treasurer of the U.S.	\$15,000.00	\$15,000.00	\$60,000.00	\$13,285.16	.....	.....	\$103,285.16
State appropriations	.....	.....	.....	.....	.....	\$72,527.86	72,527.86
Main station	.....	.....	.....	.....	.....	25,923.97	25,923.97
Substations	.....	.....	.....	.....	.....	.....	.....
Balance and receipts from sales	.....	.....	.....	.....	\$41,902.07	.....	41,902.07
Total receipts	\$15,000.00	\$15,000.00	\$60,000.00	\$13,285.16	\$41,902.07	\$98,451.83	\$243,639.06
DISBURSEMENTS							
Salaries	\$13,966.84	\$10,235.05	\$38,631.98	\$ 9,234.00	\$ 736.84	\$65,845.64	\$138,650.35
Labor	75.00	2,072.74	7,589.43	1,397.71	5,541.45	15,905.14	32,581.47
Stationery and office supplies	50.80	46.23	112.57	51.21	237.39	1,098.21	1,596.41
Scientific supplies	75.20	371.93	2,973.09	81.48	321.26	955.80	4,778.76
Feeding stuffs	102.90	.....	1,643.98	3.80	8,867.02	193.57	10,811.27
Fertilizer and irrigation water	.....	140.97	517.74	.....	1,493.61	2,155.44	4,307.76
Sundry supplies	6.32	285.39	954.43	5.38	614.41	2,585.22	4,451.15
Communication service	5.27	21.31	70.73	125.46	525.77	1,182.60	1,931.14
Travel expense	256.72	1,256.26	2,503.24	1,343.76	958.60	1,760.95	8,079.53
Publications	.....	37.70	193.77	7.67	255.49	173.64	669.15
Heat, light, water, and power	.....	.....	1,104.97	559.22	2,996.24	768.18	4,984.38
Passenger carrying vehicles	.....	.....	604.43	25.64	26.97	313.62	1,425.22
Furniture and fixtures	.....	.....	32.44	61.87	.....	315.35	1,016.29
Library	.....	33.49	136.80	29.70	500.95	.....	18.00
Scientific equipment	.....	.....	18.00	.....	.....	.....	2,006.71
Tools, machinery, and appliances	46.20	376.99	1,440.98	142.54	443.72	1,268.21	3,056.80
Livestock	413.87	2.95	873.86	54.19	12,753.46	.....	12,848.46
Buildings and land	.....	.....	95.00	.....	718.30	794.87	2,286.56
Contingent expenses	.....	115.92	513.94	143.53	132.42	139.15	281.26
Unexpended balance	.....	3.07	6.62	.....	7,450.46	.....	7,450.46
Total disbursements	\$15,000.00	\$15,000.00	\$60,000.00	\$13,285.16	\$41,902.07	\$98,451.83	\$243,639.06