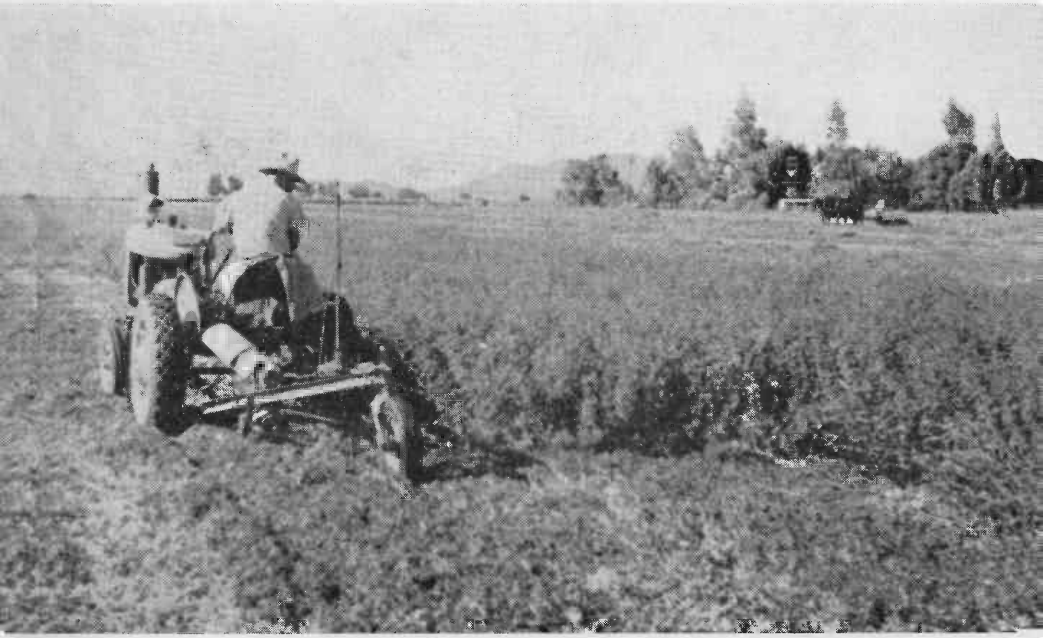
# FIFTY-FOURTH ANNUAL REPORT FOR THE YEAR ENDING JUNE 30, 1943



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

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W. G. HOYMAN, Ph.D. — Assistant Plant Pathologist

**POULTRY HUSBANDRY DEPARTMENT**

HARRY EMBLETON, B.S. — Poultry Husbandman
HUBERT B. HINDS, M.S. — Associate Poultry Husbandman

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*On leave.
†In co-operation with United States Department of Agriculture, Bureau of Plant Industry.
‡On military leave.
§Resigned during fiscal year.

January 1, 1944

*President Alfred Atkinson*
*University of Arizona*

DEAR SIR:

I have the pleasure of presenting herewith the Fifty-fourth Annual Report of the Arizona Agricultural Experiment Station for the fiscal year ending June 30, 1943. 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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# FIFTY-FOURTH ANNUAL REPORT

P. S. BURGESS, *Director*
R. S. HAWKINS, *Vice-Director*

## INTRODUCTION

At this writing the United States has been at war for one and a half years. Total war changes our mode of life, our methods of production, and our ways of distribution. It also changes our agricultural research programs. Some new projects with emphasis on wartime needs have been initiated, and some of the older projects were revised to correlate them with national requirements or to speed up certain phases to obtain quicker results. But much basic, long-time research must be completed if investment in time and money is not to be lost, and several of these projects, while initiated some years ago, now are making definite contributions to present production. Peacetime research forms the backlog which pays wartime dividends.

Some of our newer studies include: plant nutritional factors as related to soil productivity, methods of economizing in use of labor and machinery in crop and livestock production, labor population in Arizona and availability for farm employment, studies of underground water availability and water-supply forecasting, the production and utilization of tamarisk, factors affecting seed setting and quality of soybeans, seed production of the Russian dandelion (rubber plant), disease resistance of guayule, the effect of conditions and production methods on yield and quality of guar seed, the pasture finishing of beef cattle, the range resources of Arizona, the quick cleaning of milking machines, the nutritive and economic value of irrigated pastures in the dairy ration, the breeding and production of vegetable seeds, the growing of herb crops, nutritional factors affecting the commercial value of citrus fruits, the nutritional value of Arizona-produced foods, and the development of wilt-resistant alfalfa. It has been estimated by the Office of Experiment Stations of the United States Department of Agriculture that approximately 77 per cent of the activities of the state stations now are contributing to the war effort.

As the war progresses, farmers and ranchers become more and more indispensable to the victory effort. The food and fiber requirements of our armed forces and lend-lease have greatly increased, while the oversupply of at least the food materials has ceased to exist. But a short time ago, science and the growing efficiency of the American farmer were blamed for the great surpluses of farm products and for the farmer's failure to adjust production to consumption. Now the reverse is true, and maximum demands for practically all his commodities are being made

in the face of drastic shortages of farm labor, machinery, and materials. This is where scientific knowledge, gained by our experiment stations and the U.S. Department of Agriculture, comes in. It is most fortunate that agricultural research was not curtailed during the long depression period. In fact, the federal department actually expanded its production research and research on the industrial utilization of farm products by establishing thirteen new regional laboratories and experiment stations during the years 1936, 1937, and 1938. Our state experiment stations also continued to function normally during the depression, with but few appropriation cuts. As a consequence we now have priceless information on such subjects as: more economical plant and animal production; dehydration, quick-freezing, and other newer methods for food preservation, packaging, and storage; rubber substitutes; new insecticides, fungicides, and chemical fertilizers; vitamin, trace-element and hormone needs, and many others.

The work of our Experiment Station was considerably broadened during the past year by the addition of a 40-acre citrus orchard located in the Salt River Valley about 9 miles southeast of Phoenix. This facility was made available through the generosity of the citrus growers and packers of this district, and the most welcome gift will make possible a much more intensive and detailed study of the many problems affecting citrus production in this area.

A number of changes in personnel have taken place during the year. The following staff members have resigned or were given leaves of absence for war service:

Helen E. Archer, Laboratory Assistant in the Department of Human Nutrition
B. Ellen Dietz (Davison), Ph.D., Research Assistant in Animal Pathology
H. G. Johnston, Ph.D., Associate Entomologist
W. E. Martin, Ph.D., Associate Horticulturist
Max E. Robinson, Assistant Animal Husbandman
*H. G. Reynolds, M.S., Research Assistant in Range Ecology
*Charles Homer Davis, Ph.D., Assistant Agronomist
*Robert Hilgeman, B.S.A., Associate Horticulturist
*Harold C. Schwalen, M.S., Associate Agricultural Engineer

The following new appointments were made:

W. P. Bitters, Ph.D., Assistant Horticulturist
Emily C. Caldwell, M.S., Assistant Nutrition Chemist
A. B. Caster, Ph.D., Assistant Agricultural Chemist
W. W. Jones, Ph.D., Associate Horticulturist
Robert C. Keswick, Assistant Horticulturist
Marion L. Kline, B.A., Research Assistant in Animal Pathology

*On leave, war service.

This Fifty-fourth annual report presents in summarized form a report of progress on the present research program of the Arizona Agricultural Experiment Station, including the work being done at the substations in the Salt River and Yuma valleys. Bulletins, mimeographed reports, and technical articles issued during the year are available for more detailed results than can be included in an annual report.

# RESULTS OF THE YEAR'S RESEARCH

## AGRICULTURAL CHEMISTRY AND SOILS

### SOIL MOISTURE

The study of soil moisture is a major project of the Department, research on which is being published in a series of bulletins. Four of these have already been published. One important discovery was the observation that the maximum puddling of soil occurs when it is cultivated at a moisture content approximating the moisture equivalent. One character of the puddled state is that the soil moisture becomes bound and less available to plants. A fifth bulletin in this series was submitted for publication during the year, *Technical Bulletin 100,* entitled "Studies in Soil Structure: V. Bound Water in Normal and Puddled Soils." A sixth is in preparation and deals with water binding by individual soil constituents.

Most of the work during the past year has dealt with the identification of the clay minerals which comprise the colloidal clay fraction. For this purpose the colloidal fraction has been separated, by dispersion and sedimentation, from five typical Arizona soils. These soils are the Pima clay, Gila fine sandy loam, Palos Verdes sandy loam, Tubac clay loam, and Mohave loam. The clay fraction so separated was saturated with calcium, washed with methanol, and dried. These clays are now being subjected to complete ultimate analysis, and from these data a calculation of the theoretical composition of the clay layer lattices present will be made. Additional evidence by X-ray diffraction analysis and thermal decomposition will be used to deduce the dominant clay minerals. The water-binding characteristics of these clays, determined by the dilatometer, will be correlated with their mineral composition.

### GYPSUM AS A SOIL CORRECTIVE

Alkali soil reclamation in the West was pioneered by E. W. Hilgard, and he was the first to employ and advocate the use of gypsum as a soil corrective. After more than fifty years, gypsum still maintains its position as one of the best-known soil correc-

tives. In Arizona it has been used for at least thirty years; and while its value has been demonstrated in many parts of the state, some cases have been reported where it has failed to give the desired improvement. In view of this a study has been inaugurated designed to obtain some fundamental information on the influence of different soil types on the corrective value of gypsum. Usually failure is not the fault of the gypsum, for its reaction with the soil is a contact reaction; and unless mechanical means are provided to accomplish this contact one cannot expect results. During the past year several areas have been examined which are of interest.

**Casa Grande-Holt Ranch**

In 1930 a reclamation demonstration was installed on this ranch by K. K. Henness, County Agricultural Agent, and P. S. Burgess, representing the Experiment Station. The soil in this problem area is classified as Casa Grande loam (brown silted phase) and is shown in its original desert condition in Plate I. The land was plowed, borders were thrown up, and gypsum was applied at the rate of 1 ton per acre, as shown in Plate II. The gypsum was worked into the soil and the area flooded, as shown in Plate III, and it has been under continual cultivation since that time (grains, sesbania, alfalfa). In June, 1943, samples of soil were taken from the gypsum-treated area, the control area which was cropped but received no gypsum, and the native desert area, a slick spot, adjoining the demonstration on the south. Throughout the

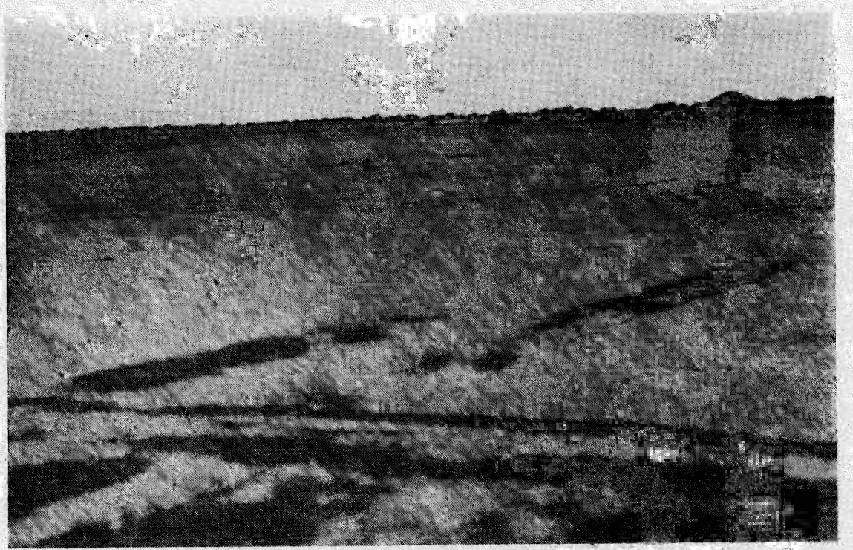

Plate I.—Condition of area before reclamation.

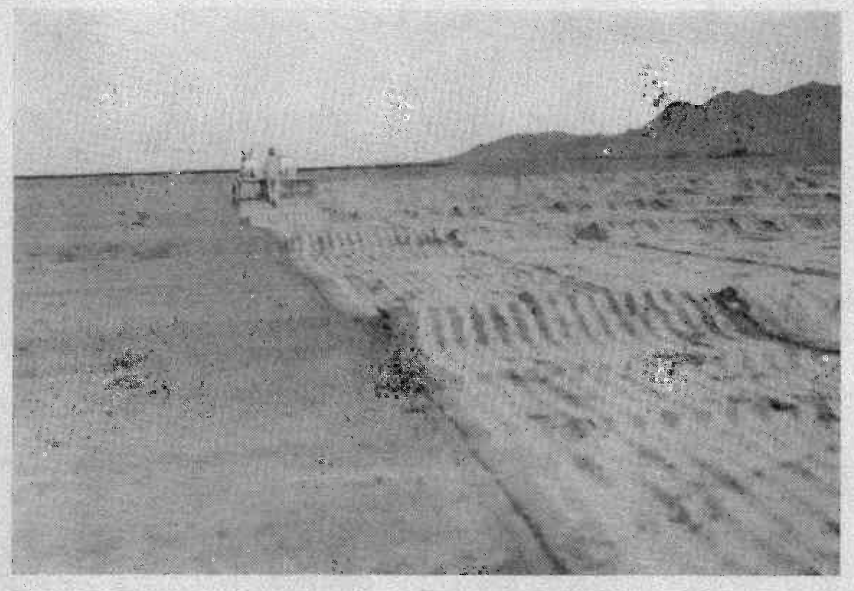

Plate II.—Spreading gypsum across borders, 1 ton per acre.

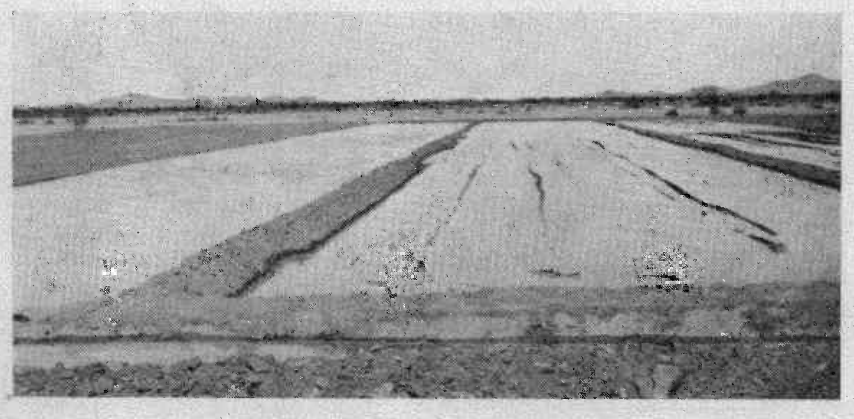

Plate III.—Flooding land after gypsum application.

intervening period of twelve years this area has shown outstanding improvement from the gypsum treatment. The analyses of these soil samples are given in Table 1. The data show that the salinity, to a depth of 4 feet and after twelve years, is still less in the gypsum-treated area. There is no black alkali in the surface 2 feet, and the clay is 77 per cent aggregated as compared with only 45 per cent in the area which received no gypsum and 40 per cent in the bare desert floor.

Plate IV.—First crop, grain, after gypsum treatment.

TABLE 1.—RECLAMATION EXPERIMENT HOLT RANCH, SOIL ANALYSES.

| | pH value | Total salts p.p.m. | Per cent aggregation of clay | Black alkali |
|---|---|---|---|---|
| **Reclaimed area—gypsum** | | | | |
| 1st foot | 8.30 | 770 | 77 | None |
| 2nd foot | 8.60 | 685 | | None |
| 3rd foot | 8.65 | 795 | | Trace |
| 4th foot | 8.65 | 1,065 | | Trace |
| **Control area—no gypsum** | | | | |
| 1st foot | 8.80 | 2,695 | 45 | Trace |
| 2nd foot | 8.50 | 3,610 | | Trace |
| 3rd foot | 8.35 | 3,940 | | None |
| 4th foot | 8.10 | 7,525 | | None |
| **Bare desert area south of experiment** | | | | |
| 1st foot | 8.50 | 2,355 | 40 | Trace |
| 2nd foot | 8.35 | 2,695 | | Trace |
| 3rd foot | 8.30 | 3,350 | | None |

**El Frida (Cochise County)**

Several deposits of high-grade gypsum are located in Cochise County. In view of this it is widely used there as a soil corrective. The soils from several gypsum-treated areas in this county have

been examined, of which two are of special interest. The nature of the soil trouble in both cases was a compact subsoil layer. They were both noncalcareous nonsaline, neutral to slightly acid soils, and both were definitely improved in productivity by the gypsum. The analyses of the soil samples from these areas are given in Table 2. The results obtained with these soils show that the corrective value of gypsum in structurally deteriorated soils is not confined to conditions arising from salinity or black alkali. There is nothing in the analyses of these soils that would indicate the need for gypsum, but presence of the compact layer was shown in the behavior of the soil tube as the samples were being taken.

TABLE 2.—ANALYSES OF SOIL SAMPLES, GYPSUM-TREATED AREAS, COCHISE COUNTY.

| Depth of sample | pH at moisture equivalent | pH 1:10 soil-water ratio | Total salts p.p.m. soil |
|---|---|---|---|
| Gardner ranch—samples from area improved by gypsum | | | |
| 1 ft. | 6.95 | 7.50 | 95 |
| 2 ft. | 7.25 | 8.05 | 115 |
| 3 & 4 ft. | 7.45 | 8.25 | 110 |
| Gardner ranch—samples from adjoining bare desert area | | | |
| 1 ft. | 5.70 | 6.40 | 110 |
| 2 ft.* | 6.75 | 7.20 | 115 |
| Grizzle orchard—samples from area improved by gypsum | | | |
| 1 ft. | 6.85 | 7.80 | 300 |
| 2 ft. | 7.00 | 8.30 | 110 |
| 3 ft.* | 7.50 | 8.30 | 90 |
| 4 ft. | 7.60 | 8.35 | 125 |

*Location of compact subsoil layer.

## RUBBER PLANT INVESTIGATIONS

The survey of desert plants for their rubber content, which was begun last year in co-operation with the Department of Botany and Range Ecology, has been extended to include 167 samples to date, representing approximately 125 individual species indigenous to Arizona, southern California, and New Mexico. A partial list of the most promising species is given in Table 3.

A considerable number of tests have been made on guayule, *Parthenium argentatum*, from various localities and different conditions of cultivation. The rubber content was found to vary between 0.83 and 6.65 per cent. The plants were supplied from the Enzenberg test plots at Sonoita and the Yuma Mesa Experimental Farm. Various factors, such as elevation, soil, and rainfall conditions, are known to affect the rubber content of plants

TABLE 3.—PER CENT RUBBER AND PER CENT RESIN-OIL-WAX IN SOME SPECIMENS COLLECTED DURING SURVEY FOR RUBBER-BEARING PLANTS.

| Scientific name | Common name | Locality | Acetone* extract, per cent | Benzene† extract, per cent |
|---|---|---|---|---|
| *Amsonia hirtella* | ..... | Animas, N.M..... | 19.68 | 2.41 |
| *Asclepias erosa* | Desert milkweed | Colorado River, Ariz. | 16.68 | 5.44 |
| *Cynanchum*, sp. | Asiatic dogbane | S.C.S. Nursery, Tucson, Arizona.... | 10.20 | 3.40 |
| *Cryptostegia grandiflora* | Rubber vine | Cultivated, Yuma, Arizona ..... | 11.92 | 6.74 |
| *Funastrum cyanchoides* | Gum vine | Salt River Valley, Arizona ..... | 13.74 | 3.04 |
| *Garrya wrightii* | Silk tassel bush | Santa Catalina Mts. | 25.14 | 2.54 |
| *Guardiola platyphylla* | ..... | Santa Catalina Mts. | 11.37 | 2.33 |
| *Lachnostoma Arizonicum* | ..... | ..... | 9.00 | 3.30 |
| *Periploca graeca* | Silk vine | Phoenix, Arizona..... | 12.29 | 4.08 |
| *Solidago altissima* | Goldenrod | Santa Catalina Mts. | 11.93 | 3.68 |
| *Tecoma stans.* var. *angustatum* | Yellow trumpet flower | Santa Catalina Mts. | 8.58 | 3.82 |

*Per cent resins, oils, waxes.
†Per cent rubber.

growing on the desert in their native habitat and variations are possible between species of the same genus growing under identical conditions. This study has not been carried far enough with any one species in different localities or different species of the same genus to justify general conclusions regarding the relative rubber content of the plant families included in this study. The observed rubber content of some groups—such as the Euphorbiaceae, or spurge family, which includes the leading commercial rubber plants of the world—was found to be disappointingly small in the samples studied, as they were of the order of 0.1 to 0.2 per cent.

## VERTICAL ZONATION OF GREAT SOIL GROUPS ON MT. GRAHAM[1]

Data collected during the past five years on this subject were published as *Technical Bulletin 99*. In addition to a summary of the results of this investigation given in the *Fifty-third Annual Report*, it was generally concluded that the successive soil types on Mt. Graham, Arizona, representing as they do a climatic variation between that of the cold, highly humid forest and that of the hot, dry desert, were in conformity with the system of great soil groups. The general principle that the soil profile represents a summation of climatic, topographic, and vegetational factors which affect soil formation was substantiated and evidenced by the physical, chemical, and biological factors which characterize the soil profile. The relationship of soil characteristics to vegetative cover enumerated in this study should prove of value in the management of Arizona range lands, as it is a factor of increasing importance in wartime when land use for increased production of

[1]Conducted in co-operation with the Soil Conservation Service of the United States Department of Agriculture.

essential food products is intensified and dangers of permanent injury through poor use must be avoided.

## ACIDULATED FERTILIZERS

The H-ion or OH-ion concentration of the soil solution is a major factor in the nutrition of plants, especially in strongly alkaline or strongly acid soils. In view of this, much research in the Department has dealt with soil-reaction studies. Since most plants are known to prefer growth media with *p*H values close to neutrality, preferably slightly on the acid side, and a large proportion of the alkaline-calcareous soils of the state have values of *p*H 8.0 or higher, some crops growing in these soils should obviously be at a disadvantage. In order to meet this contingency, so-called acidulated fertilizers have been developed in the Department. The use of such fertilizers has now been under study for ten years.

During the past year the accumulated data were prepared for publication as a technical bulletin. Among the crops studied in the field were citrus, carrots, lettuce, cotton, and flax, while a number of others were studied under greenhouse conditions. In most cases acidulation of the fertilizer was accomplished by mixing sulphur with the fertilizer materials. The effect of such fertilizer on ion absorption by the plants was determined by chemical analyses of plant samples. These analyses showed a definite increase in absorption of micronutrient elements and a frequent increase in absorption of macronutrient elements when fertilized with the acidulated fertilizer.

## BORON INVESTIGATIONS

The systematic sampling of soils, water, and vegetation for boron analysis has been continued this year in the study to determine whether boron deficiency or excess is a problem in Arizona.

The "soil dilution" method, which has been previously described, is being used for testing boron deficiency in soils. In this method, pots of sand and sand-soil mixtures are planted to sugar beets. When the beets develop seed there is an unusually heavy demand for boron. If the soil is deficient, either because boron is lacking in the soil or by virtue or its being diluted with sand, the plant shows the usual boron deficiency symptoms of dying and turning black at all the growing tips. In the six soils being studied, 5 per cent of soil in the soil-sand mixture was sufficient to cure the boron symptoms noted in the control plants (sand cultures).

One of the soils tested came from the Griffin farm in Yavapai County. This soil, recently laid down from Oak Creek sediments and weathered from the red sandstone in the vicinity, is very sandy in texture and was suspected of being boron deficient.

In Table 4 the boron content of the leaves and the condition of the crop on the different sand-soil ratios is given.

TABLE 4.—THE BORON CONTENT OF SUGAR BEET LEAVES GROWN ON SOIL AND SAND MIXTURES.

| Per cent soil | Per cent sand | Boron in leaf (p.p.m.) | Crop notes |
|---|---|---|---|
| 0 | 100 | 7.5 | B. deficient |
| 5 | 95 | 15 | Normal |
| 10 | 90 | 32 | Normal |
| 25 | 75 | 28 | Normal |
| 50 | 50 | 28 | Normal |
| 100 | 0 | 41 | Normal |

In this particular case 5 per cent of soil corrected the boron deficiency of the sand and the nutrient solution. Evidently the first assumption that the soil was boron deficient could not be substantiated. Other soils are under investigation at present.

It is supposed that the high lime and *p*H of arid soils ameliorate the toxic effect of irrigating field crops with water containing relatively high concentrations of boron. One method of investigating this problem has been to grow alfalfa in 1-gallon pots containing Gila clay loam. Duplicate sets of pots were irrigated with water containing boron in concentrations of from 1 to 12 parts per million. The alfalfa was cut periodically when it reached the early bloom stage and was analyzed for boron. Six cuttings were made during the year. Plants grown in pots receiving no boron contained on the average 70 p.p.m. of boron; those receiving 1.0 p.p.m. of boron showed more vigorous growth and better color than those growing in the control pots. The average boron content of these plants was 185 p.p.m. Two and 3 p.p.m. of boron in the irrigation water seemed to act as a stimulant, but 4 p.p.m. was definitely toxic. The plants receiving 12 p.p.m. of boron in the irrigation water were seriously affected. Leaf margins were badly burned, and the dry matter produced was only about half that produced in the pots receiving 2 p.p.m. of boron. The plants grown in the 10 and 12 p.p.m. pots attained a boron content as high as 2,000 p.p.m.

## CHEMICAL ANALYSES OF RANGE GRASSES

At the request of the National Observational Nursery of the Soil Conservation Service, and in co-operation with them, a study was made of the lignin content and feeding value (roots and tops) of forty-two samples of grass. Lignin is considered of importance because it contributes to the humus content of the soil. Feed analyses were made to ascertain the nutrient value. The samples represent grassss being used to revegetate the ranges. Most of the

samples were taken in this state, but some from other states were used to note the influence of climate on chemical composition. In some cases samples of the same grass were taken at different stages of growth. The data are being published in bulletin form by the Soil Conservation Service, where a discussion of the significance of the data will be presented. They are presented in Table 5 for the purpose of recording them in an Experiment Station publication and for the interest of local readers.

## FACTORS INFLUENCING THE NODULATION OF SOYBEANS IN ARIZONA SOILS[2]

Soybeans have been observed to lack nodules in many Arizona soils, even after inoculation with *Rhizobium japonicum*. Experiments are being conducted in both field and greenhouse to determine how best to remedy this situation. One location for these experiments is on the Campbell Avenue University Farm, Tucson. This location was chosen since the soils have a tendency toward salinity, and it was deduced worthy of investigation to determine whether the high salt contents of many Arizona soils might not be a contributing factor to the absence of root nodules and the fixation of atmospheric nitrogen.

The growth of soybeans in the experimental field was erratic, varying from no growth at all to excellent. In many instances the plants were stunted and yellowed and had on the leaves brown spots which appeared to be sunburn injury. Tests for the total soluble salt contents and *p*H values of soil samples taken to a depth of 6 inches from different parts of the field had shown results which would lead one to expect a fair growth of soybeans over the entire border. The highest total soluble salt content was 2,000 p.p.m., and the *p*H values varied from 7.4 to 8.2. Soil samples collected for more detailed analysis showed that the growth and nodulation of the soybeans was in direct correlation with the presence of calcium and sodium nitrates in the soil. Nitrate contents from the locations where the soybeans made little or no growth varied from 800 to 2,100 p.p.m. Good growth was obtained on soils with nitrate contents which varied from 28 to 600 p.p.m. No other neutral salts in appreciable quantities were found in this location.

The significance of this finding is that the accumulation of nitrate may be a contributing factor to the lack of nodulation found on soybeans grown in these locations.

## THE EFFECT OF FIELD APPLICATIONS OF ORGANIC MATTER ON THE PROPERTIES OF ARIZONA SOILS[3]

Studies on the influence of alfalfa, filaree, and native grass straw, both as a mulch and incorporated, under both range

[2]Conducted in co-operation with the Agronomy Department.
[3]Conducted in co-operation with the Soil Conservation Service of the United States Department of Agriculture.

TABLE 5.—CHEMICAL ANALYSES OF RANGE GRASSES.

| Plant | Date harvested | Age | Character of sample | Location | Per cent | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Lignin* | Lignin nitrogen† | Ash* | Protein* | Fat* | Fiber* | N.F. ext.* |
| 1. *Andropogon scoparius*.. | 12/ 3/42 | 4 yrs. | top | Tucson | 12.11 | .089 | 8.50 | 2.38 | 1.28 | 34.88 | 52.96 |
| 2. *Andropogon scoparius*.. | 12/ 3/42 | 4 yrs. | dry leaves | Tucson | 11.91 | .137 | 15.02 | 2.69 | 2.09 | 31.66 | 48.54 |
| 3. *Andropogon scoparius*.. | 12/ 3/42 | 4 yrs. | mature green leaves | Tucson | 11.36 | .171 | 12.41 | 4.37 | 2.25 | 28.73 | 52.24 |
| 4. *Andropogon scoparius*.. | 12/ 3/42 | 4 yrs. | roots | Tucson | 15.87 | .345 | 25.40 | 7.81 | 1.32 | 21.57 | 43.90 |
| 5. *Dactylis glomerata*..... | 12/ 4/42 | 1 yr. | top | Tucson | 6.42 | .241 | 18.85 | 15.75 | 2.98 | 23.59 | 38.83 |
| 6. *Dactylis glomerata*..... | 3/24/43 | 1 yr. | roots | Tucson | 8.05 | .258 | 52.82 | 5.50 | 0.34 | 14.05 | 27.29 |
| 7. *Eragrostis chloromelas* | 12/ 2/42 | 4 yrs. | dry leaves | Tucson | 10.51 | .166 | 8.46 | 4.06 | 2.75 | 34.74 | 49.99 |
| 8. *Eragrostis chloromelas* | 12/ 2/42 | 4 yrs. | green leaves | Tucson | 10.36 | .313 | 7.12 | 8.88 | 2.28 | 33.11 | 48.61 |
| 9. *Eragrostis chloromelas* | 12/ 2/42 | 4 yrs. | top | Tucson | 11.41 | .209 | 7.76 | 6.06 | 2.67 | 34.90 | 48.61 |
| 10. *Eragrostis chloromelas* | 3/24/43 | 4 yrs. | roots | Tucson | 18.30 | .397 | 16.65 | 7.33 | 0.87 | 29.35 | 45.80 |
| 11. *Eragrostis curvula*..... | 12/ 1/42 | 4 yrs. | dry leaves | Tucson | 11.92 | .167 | 6.34 | 4.43 | 2.65 | 34.22 | 52.36 |
| 12. *Eragrostis curvula*..... | 12/ 1/42 | 4 yrs. | mature green leaves | Tucson | 11.39 | .296 | 5.17 | 7.36 | 3.79 | 31.52 | 52.16 |
| 13. *Eragrostis curvula*..... | 12/ 1/42 | 4 yrs. | top | Tucson | 12.21 | .145 | 4.94 | 3.68 | 1.84 | 36.30 | 53.24 |
| 14. *Eragrostis curvula*..... | 3/24/43 | 4 yrs. | roots | Tucson | 20.20 | .474 | 19.16 | 7.00 | 1.51 | 31.30 | 41.03 |
| 15. *Eragrostis curvula*..... | 12/ 3/42 | 2 yrs. | roots | Tucson | 13.50 | .289 | 20.90 | 5.25 | 0.32 | 30.96 | 42.57 |
| 16. *Eragrostis curvula*..... | 12/ 3/42 | 1 yr. | roots | Tucson | 9.69 | .191 | 39.50 | 4.50 | 0.11 | 24.10 | 31.79 |
| 17. *Bouteloua curtipendula* | 12/ 3/42 | 2 yrs. | top | Tucson | 10.71 | .130 | 13.98 | 3.50 | 1.23 | 32.95 | 48.34 |
| 18. *Bouteloua curtipendula* | 12/ 3/42 | 2 yrs. | roots | Tucson | 13.85 | .185 | 27.16 | 5.50 | 1.64 | 28.99 | 36.71 |
| 19. *Panicum virgatum*..... | 12/16/42 | 4 yrs. | roots | Tucson | 13.56 | .132 | 4.89 | 12.40 | 3.92 | 28.86 | 49.93 |
| 20. *Eragrostis chloromelas* | 11/12/42 | ..... | hay | Mesa | 11.40 | .303 | 6.88 | 6.88 | 3.06 | 35.07 | 48.11 |
| 21. *Eragrostis curvula*..... | 11/22/42 | ..... | hay | Mesa | 9.90 | .257 | 7.03 | 9.81 | 3.02 | 32.84 | 47.30 |
| 22. *Bouteloua curtipendula* | 11/18/42 | 8 mos. | new growth forage | San Antonio, Texas | 10.42 | .306 | 19.65 | 10.11 | 1.83 | 27.81 | 40.60 |
| 23. *Eragrostis chloromelas* | 11/18/42 | 8 mos. | new growth | San Antonio, Texas | 10.48 | .301 | 7.81 | 10.42 | 3.00 | 34.47 | 44.30 |
| 24. *Bouteloua filiformis*..... | 11/18/42 | 7 mos. | forage | San Antonio, Texas | 9.77 | .340 | 14.87 | 9.00 | 1.95 | 30.45 | 43.73 |
| 25. *Eragrostis lehmanniana* | 10/11/42 | 7 mos. | forage | San Antonio, Texas | 10.10 | .385 | 8.45 | 8.81 | 1.71 | 37.50 | 43.53 |
| 26. *Eragrostis curvula*..... | 11/18/42 | 8 mos. | forage | San Antonio, Texas | 12.42 | .356 | 6.65 | 9.45 | 4.41 | 32.41 | 47.08 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 27. *Andropogon scoparius*.. | 11/18/42 | 1½ yrs. | forage | San Antonio, Texas | 10.50 | .397 | 11.46 | 12.60 | 3.55 | 28.14 | 44.25 |
| 28. *Panicum antidotale*..... | 11/18/42 | 7 mos. | forage | San Antonio, Texas | 8.78 | .253 | 12.44 | 12.80 | 1.78 | 29.91 | 43.07 |
| 29. *Eragrostis curvula*..... | 11/25/42 | ..... | forage | Rock Hill, S.C. | 11.21 | .437 | 4.94 | 13.53 | 3.26 | 28.24 | 50.03 |
| 30. *Eragrostis curvula*..... | 11/18/42 | ..... | forage | Louisiana | 12.01 | .243 | 4.55 | 10.31 | 2.93 | 33.14 | 49.07 |
| 31. *Eragrostis curvula*..... | 11/19/42 | ..... | forage | Louisiana | 10.82 | .179 | 4.29 | 5.62 | 2.67 | 32.46 | 55.32 |
| 32. *Eragrostis curvula*..... | 11/24/42 | 1½ yrs. | forage | Texas King Ranch | 14.52 | .211 | 5.24 | 5.45 | 2.26 | 34.63 | 52.42 |
| 33. *Eragrostis lehmanniana* | 11/24/42 | 1½ yrs. | forage | Texas King Ranch | 12.91 | .334 | 6.81 | 6.57 | 1.69 | 34.60 | 50.35 |
| 34. *Paspalum notatum*..... | 11/24/42 | ..... | ..... | Texas King Ranch | 11.81 | .260 | 12.57 | 4.32 | 1.81 | 32.01 | 49.29 |
| 35. *Andropogon ischaemum*..... | 11/24/42 | ..... | ..... | Texas King Ranch | 12.58 | .152 | 10.31 | 3.50 | 0.96 | 37.52 | 47.71 |
| 36. *Eragrostis curvula* 1.... | 1/27/43 | ..... | ..... | Maryland | 13.51 | .282 | 4.17 | 8.75 | 1.84 | 36.30 | 48.94 |
| 37. *Eragrostis curvula* 2.... | 1/27/43 | ..... | ..... | Maryland | 14.18 | .307 | 4.32 | 8.00 | 1.96 | 32.58 | 53.14 |
| 38. *Eragrostis curvula* 3.... | 1/27/43 | ..... | ..... | Maryland | 11.80 | .269 | 6.51 | 7.50 | 1.79 | 34.22 | 49.98 |
| 39. *Eragrostis curvula* 4.... | 1/27/43 | ..... | ..... | Maryland | 13.66 | .226 | 5.68 | 6.40 | 1.20 | 40.34 | 46.38 |
| 40. *Eragrostis curvula* 5.... | 2/19/43 | ..... | ..... | Maryland | 11.51 | .297 | 5.66 | 14.65 | 2.72 | 31.10 | 45.87 |
| 41. *Eragrostis curvula* 6.... | 2/19/43 | ..... | ..... | Maryland | 11.17 | .405 | 3.91 | 9.12 | 2.51 | 35.30 | 49.16 |
| 42. *Eragrostis lehmanniana*..... | 12/ 2/42 | 1 yr. | composite sample | Tucson | 10.60 | .169 | 7.57 | 4.70 | 1.63 | 32.80 | 53.30 |

*Analyses expressed on water-free (oven-dry) basis.
†Per cent lignin nitrogen in water-free (oven-dry) grass.

(natural) and irrigated soil conditions, on the properties of Arizona soils were continued during the past year. The observation that surface mulching of organic materials strikingly increases infiltration, decreases runoff, and practically eliminates soil erosion was emphasized by the results of this investigation. Filaree or native grass straw scattered lightly over the surface of range soils affects enough of an increase in soil moisture to increase the perennial grass cover substantially.

Under irrigated soil conditions mulching also proved its value in better moisture retention, increased aggregation, increase in microbial activity, and greater decreases in *p*H values than when organic materials were incorporated completely with the soil. This emphasizes the need for developing methods whereby crop residues and other organic debris can be used in the form of a mulch on Arizona soils.

It has been observed that mulching of organic materials on the surface of the soil is effective in improving water penetration by preventing the packing effect of falling rain drops on the soil surface. The extent of this ameliorative effect is difficult to measure because of the inadequacy of present methods. Consequently, much time during the past year was spent on the development of such a method. To date the results are far from completed but point toward our being able to use a technic somewhat as follows: An undisturbed sample of soil is taken in a copper cylinder directly from the field, impregnated with "leucite" monomer or other plastics, allowed to solidify, and, from the resulting solidified soil block, sections are cut out and mounted on a glass slide, and thin sections are ground therefrom. By microscopic examination or microprojection onto a ruled scale, it is then possible to note the arrangement of the particles of soil within the section and to determine quantitatively the extent of puddling at the soil surface and the influence of different treatments thereon. This method, which is a modification of some currently in use for other purposes, is still under investigation and when completed should have application not only to the problem of surface-soil sealing by rainfall on range lands, but to the problems of irrigated soils, particularly to that of the puddling brought about by various farm machinery.

## FEEDS AND FERTILIZERS

The head of the Department of Agricultural Chemistry and Soils is by law responsible for the administration of the Feed and Fertilizer Control laws. This work has been seriously handicapped by the withdrawal of members of the staff for military service. In spite of this, during the year 1942, 336 samples of mixed feeds, 40 of cottonseed meal, 20 of mineral feeds, and 52 of commercial fertilizers were collected from stocks on sale in the state and analyzed in the laboratory. In addition, the head of the Department served on advisory committees to the State

War Board, which handled problems arising from the shortages and in the allocation of available materials. The records of the office, showing volume of state sales and shipment into the state of materials used in the manufacture of feeds and fertilizers, were of great value in working out the problems arising from the shortages, especially in making allocations.

## LYSIMETER STUDIES

This is a long-time project and was started in 1930 to determine the effect of different crop rotations on the nitrogen balance of soils under arid conditions. Two sets of lysimeters were filled with Gila clay loam and Mohave clay respectively and planted to a six-year rotation. This included one year each of cotton, wheat and hegari, and wheat, and three years of alfalfa. In addition to this, wheat and hegari were grown on each soil every year in a separate set of tanks.

Irrigation water was applied in sufficient amounts adequately to care for the water demands of the plants.

The Gila soil, which is a river bottom soil, has produced larger crops than the Mohave soil, which was a raw desert soil when put in the lysimeters in 1930. The weight of nitrogen removed by crops was more than 20 per cent greater than that removed from the Mohave soil over the twelve-year period. The total weight of dry material removed from the tanks containing Gila soil was greater by about 6 per cent than that taken from the tanks containing Mohave soil for the same period. There was a tendency, however, in later years, for the crop yields on Mohave soil to approach or exceed those on Gila soil.

A matter of extreme interest and importance is the change in the nitrogen content of the soils. The Gila soil, which originally contained 0.085 per cent of nitrogen, has been reduced to the average level of 0.075 per cent. The Mohave soil, which originally contained 0.052 per cent of nitrogen, has shown an increase to 0.077 per cent, or slightly higher than the nitrogen level now prevailing in the Gila soil. It may be true that under cultivation the present nitrogen content is in equilibrium with the environmental forces prevailing under the conditions of the experiment. Tests have shown that Azotobacter are very active, especially in the Mohave soils. The actual nitrogen gain (including nitrogen removed in crops) over the twelve-year period for the Gila soil was 1,619 pounds per acre, while during the same period the Mohave soil gained 6,368 pounds per acre.

The two tanks containing Gila and Mohave soils, which were not in the rotation but which were planted to wheat and hegari every year, have also yielded information of value. These tanks included neither fallow nor rotation with legumes. Under the conditions of this test crop yields have gradually declined on both soils. The Gila soil has decreased in total nitrogen content from

0.085 to 0.063 per cent during the twelve-year cropping period, while the Mohave soil has increased in total nitrogen content from 0.052 to 0.067 per cent; yet the dry weight of crop produced for the entire period, expressed in pounds per acre, was 207,774 on the Gila soil and 193,029 on the Mohave soil. This is strong evidence of greater nitrogen fixation by Azotobacter in the Mohave soil.

Information obtained on the use of irrigation water tends to confirm the fact that within certain limits an increase in the amount of water available for alfalfa will increase the yield of the crop.

This experiment is being continued in its present form for another rotation before changes, such as fertilization, will be considered.

## PROTEIN AND PHOSPHATE CONTENT OF ALFALFA HAY, YUMA MESA

During the past few years the Department has analyzed a large number of samples of alfalfa hay taken from the new experimental farm on the Yuma Mesa. These samples were submitted for analysis by the Agronomy Department. Most of them have been taken from successive cuttings and from differently fertilized experimental plots. They are of interest in showing the nutritional quality of hay grown there. Analyses of the samples taken between June, 1941, and April, 1942, are given in Tables 6 and 7, together with sampling dates, each date representing a crop of hay harvested. The amount of treble superphosphate per acre added as fertilizer is also given in the tables.

The analyses show an increase in protein and phosphate content of the hay from fertilization with superphosphate and considerable variation in the protein and phosphate content of different cuttings.

## FLUORINE

The Department has discontinued extensive research on the fluoride content of Arizona waters, but considerable interest continues over the state. During the year, 246 samples of drinking water were analyzed for fluoride content. Co-operation is being continued with the Pima County Preventorium, where a bone filter is in use, to determine the capacity of bone filters, the effect of repeated regeneration on the activity of the bone, and bone losses during regeneration. The Department has also co-operated with the War Relocation Authority in solving their fluorine problem at Rivers, and with the cities of Douglas and Tombstone in their search for water supplies low in fluorides.

TABLE 6.—PROTEIN IN ALFALFA FROM YUMA MESA—PER CENT AIR-DRY BASIS.

| Plot no. | Lbs. treble super per acre | | | 1941 | | | | | | 1942 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1939 | 1940 | 1941 | June 7 | July 5 | Aug. 5 | Sept. 6 | Oct. 20 | Dec. 6 | Mar. 5 | Apr. 25 | Av. |
| E 3 | None | None | None | 13.1 | 13.6 | 15.1 | 16.0 | 15.1 | 15.6 | 16.8 | 12.5 | 14.7 |
| E 4 | 150 | None | None | 13.8 | 13.7 | 16.5 | 16.3 | 16.0 | 16.2 | 15.5 | 14.0 | 15.3 |
| E 5 | ..... | 100 | 100 | 14.6 | 14.5 | 17.0 | 16.9 | 17.4 | 15.4 | 16.8 | 14.4 | 15.8 |
| E 6 | ..... | 200 | 200 | 14.1 | 13.6 | 16.1 | 16.1 | 17.1 | 17.6 | 18.0 | 13.0 | 15.7 |
| E 7 | ..... | 300 | 300 | 14.2 | 12.8 | 16.6 | 16.6 | 16.6 | 15.6 | 18.2 | 13.9 | 15.5 |
| E 8 | 150 | None | None | 14.4 | 13.6 | 15.4 | 15.4 | 16.6 | 15.4 | 14.4 | 12.6 | 14.7 |
| E 9 | ..... | 100 | None | 13.0 | 14.0 | 15.9 | 15.5 | 17.1 | 14.3 | 16.0 | ..... | 15.1 |
| E10 | ..... | 200 | None | 13.5 | 12.1 | 15.8 | 15.9 | 16.4 | 14.7 | 16.9 | 12.9 | 14.8 |
| E11 | ..... | 300 | None | 14.4 | 13.0 | 16.5 | 16.4 | 16.4 | 16.0 | 14.9 | 12.0 | 15.0 |
| F 3 | ..... | None | 100 | 14.4 | 14.9 | 13.4 | 16.0 | 15.1 | 18.8 | 17.4 | 13.9 | 15.5 |
| F 4 | ..... | 100 | 200 | 14.2 | 14.8 | 16.0 | 17.4 | 15.7 | 17.0 | 17.6 | 13.0 | 15.8 |
| F 5 | ..... | 100 | 200 | 15.5 | 15.9 | 15.9 | 17.4 | 15.4 | 17.7 | 18.3 | 12.4 | 16.0 |
| F 6 | ..... | 100 | 600 | 16.6 | 14.2 | 15.7 | 17.1 | 16.9 | 17.4 | 17.9 | 12.1 | 16.0 |
| F 7 | ..... | 100 | 400 | 16.1 | 14.1 | 15.8 | 18.2 | 16.9 | 16.3 | 17.1 | 11.4 | 15.8 |
| F 8 | ..... | 100 | 100 | 15.1 | 14.5 | 15.4 | 16.3 | 16.2 | 16.5 | 15.5 | 14.8 | 15.6 |
| F 9 | ..... | 100 | 200 | 15.9 | 14.6 | 17.4 | 17.4 | 15.6 | 17.0 | 16.9 | 12.7 | 16.0 |
| F10 | ..... | 100 | 400 | 15.6 | 12.9 | 16.5 | 16.0 | 15.7 | 18.7 | 15.4 | 14.1 | 15.2 |
| F11 | ..... | 100 | 600 | 15.7 | 15.1 | 14.7 | 16.4 | 16.0 | 18.8 | 16.0 | 11.3 | 15.5 |
| Av. | | | | 14.7 | 14.0 | 15.9 | 16.5 | 16.2 | 16.6 | 16.7 | 12.3 | ..... |

TABLE 7.—PHOSPHATE ($P_2O_5$) IN ALFALFA FROM YUMA MESA—PER CENT AIR-DRY BASIS.

| Plot no. | Lbs. treble super per acre | | | 1941 | | | | | | 1942 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1939 | 1940 | 1941 | June 7 | July 5 | Aug. 5 | Sept. 6 | Oct. 20 | Dec. 6 | Mar. 5 | Apr. 25 | Av. |
| E 3 | None | None | None | 0.23 | 0.34 | 0.33 | 0.37 | 0.33 | 0.37 | 0.35 | 0.23 | 0.32 |
| E 4 | 150 | None | None | 0.22 | 0.34 | 0.46 | 0.39 | 0.34 | 0.35 | 0.33 | 0.25 | 0.34 |
| E 5 | None | 100 | 100 | 0.31 | 0.39 | 0.46 | 0.42 | 0.38 | 0.37 | 0.38 | 0.32 | 0.38 |
| E 6 | None | 200 | 200 | 0.32 | 0.38 | 0.45 | 0.47 | 0.51 | 0.50 | 0.42 | 0.29 | 0.42 |
| E 7 | None | 300 | 300 | 0.39 | 0.45 | 0.57 | 0.46 | 0.47 | 0.43 | 0.45 | 0.38 | 0.45 |
| E 8 | 150 | None | None | 0.25 | 0.34 | 0.57 | 0.34 | 0.33 | 0.31 | 0.32 | 0.26 | 0.30 |
| E 9 | None | 100 | None | 0.23 | 0.29 | 0.36 | 0.34 | 0.34 | 0.33 | 0.32 | ..... | 0.32 |
| E10 | None | 200 | None | 0.25 | 0.27 | 0.36 | 0.39 | 0.32 | 0.30 | 0.27 | 0.25 | 0.30 |
| E11 | None | 300 | None | 0.30 | 0.33 | 0.36 | 0.42 | 0.41 | 0.31 | 0.28 | 0.23 | 0.33 |
| F 3 | None | None | 100 | 0.28 | 0.34 | 0.39 | 0.44 | 0.46 | 0.45 | 0.44 | 0.32 | 0.39 |
| F 4 | None | 100 | 200 | 0.30 | 0.34 | 0.44 | 0.43 | 0.39 | 0.33 | 0.37 | 0.24 | 0.36 |
| F 5 | None | 100 | 200 | 0.34 | 0.38 | 0.46 | 0.46 | 0.42 | 0.39 | 0.42 | 0.26 | 0.39 |
| F 6 | None | 100 | 600 | 0.39 | 0.51 | 0.55 | 0.56 | 0.36 | 0.40 | 0.47 | 0.32 | 0.45 |
| F 7 | None | 100 | 400 | 0.38 | 0.44 | 0.53 | 0.50 | 0.48 | 0.42 | 0.46 | 0.28 | 0.43 |
| F 8 | None | 100 | 100 | 0.32 | 0.39 | 0.43 | 0.43 | 0.38 | 0.36 | 0.40 | 0.35 | 0.38 |
| F 9 | None | 100 | 200 | 0.35 | 0.45 | 0.48 | 0.45 | 0.39 | 0.41 | 0.42 | 0.28 | 0.40 |
| F10 | None | 100 | 400 | 0.38 | 0.41 | 0.57 | 0.54 | 0.57 | 0.47 | 0.46 | 0.35 | 0.47 |
| F11 | None | 100 | 600 | 0.39 | 0.57 | 0.51 | 0.55 | 0.54 | 0.44 | 0.50 | 0.32 | 0.48 |
| Av. | | | | 0.31 | 0.39 | 0.46 | 0.44 | 0.41 | 0.39 | 0.39 | 0.29 | ..... |

### MISCELLANEOUS

For many years Tombstone has been obtaining water from the Huachuca Mountains, a distance of 26 miles. Since the supply was inadequate and the Army desired the pipe line, it became necessary for the town to find a new source of water. The Department co-operated in this endeavor. Water samples from a number of sources were analyzed, and this analysis resulted in the location of a suitable new supply.

During the establishment of Army camps in the state, the Department co-operated by analyzing available sources of water. Forty-eight samples were analyzed. The Department has also co-operated with the Army in making emergency analyses of materials involved in suspected sabotage cases.

## AGRICULTURAL ECONOMICS AND RURAL SOCIOLOGY

### LABORERS IN ARIZONA AVAILABLE FOR FARM WORK

Chief emphasis was laid upon determining the numbers and locations of laborers in Arizona available for work on irrigated farms in the year 1943. The greatest numbers of these workers were located on irrigated farms and in small towns (under 2,500 population) within irrigated districts. Where on April 1, 1942, 21,200 farm laborers were estimated to be available in these locations, only 18,200 could be found on April 1, 1943. It is believed that this reduction in numbers took place largely during the months of May, June, July, and August, 1942, and that no recovery of workers came from the temporary and insufficient influx of workers to harvest cotton during September, October, November, and December of that year.

There were additions of Mexican laborers during the spring months, and of Italian prisoners to work in the fields during the summer of 1943, but at no time were these sufficient to meet total requirements for all normal farm operations. Estimated numbers of additional hired laborers available in the state for the 1943 harvest season included: (1) Mexicans, Negroes, Indians, and whites living in Tucson, Phoenix, Mesa, Glendale, and Yuma and available to pick cotton, 2,000; (2) Youths in school in rural and urban communities in Graham, Maricopa, Pima, Pinal, and Yuma counties, the equivalent of 300; (3) Indians from southern and central Arizona reservations, 2,000. These, together with the estimated laborers on farms and in rural towns April 1, 1943—18,200. A total of 22,500 laborers were therefore available within the state. These are the numbers that apparently will be available as the cotton harvest gets under way. This will be earlier in 1943 than usual because of large stub-cotton acreages. Peak requirements during late November will exceed 40,000 workers for all purposes; thus the indicated deficiency of harvest laborers from the above sources is over 18,000. This is on the assumption

that enough workers are being put in the field to harvest 80 per cent of the cotton crop by December 14, 1943, and that other requirements, such as for truck crops, will be met.

Estimates of hired labor requirements published in Arizona Experiment Station Mimeographed Report 52, February, 1943, were made in accordance with announced production goals—goals which will not be attained because of extensive changes made by the farmers in the face of difficulties which it seemed impossible to overcome.

## COST-OF-PRODUCTION DATA

A predominantly one-enterprise type of farm has been the rule in southern Arizona irrigated farming throughout the entire farming history of the area. The amount and kind of diversification found on certain small farms was studied in the year 1941-42. A summary of the records kept for 1941 and 1942 is available in the office of the Department. These records have been used as a basis for cost-of-production data and studies and reports on machinery use, land use, and labor use on small farms in Arizona.

## LARGER RETURNS PER MAN AND PER MACHINE

Study was made of the possibility and means of making more efficient use of the machinery available on farms. A block sample method of survey, by type-of-farming areas, was used. In all, 348 farmers were interviewed. These farmed about 10 per cent of the cropped land in the three major irrigated farming counties of the state—Maricopa, Pinal, and Yuma counties. At the time of the study in 1942, much of the farm machinery in the state was relatively new. This was especially true of tractors and of the machinery used in vegetable production. A rapid rate of the wearing out of machinery was indicated. Calculations were made to show the number of usable machines of each size and type in each of the three counties. A grouping of the data indicated the extent to which larger farms tend to make more efficient use of machinery. Farmers in these areas were dependent in a great degree on custom machinery work, particularly in Maricopa and Pinal counties. In late 1942, however, the trend was away from custom work because of the difficulty in securing labor. Fair rental rates were calculated for machines most likely to be rented.

The information secured from this study has been used by those charged with the administration of the machinery-rationing program in Arizona. The findings were published in "Sharing Farm Machinery"—*Arizona Experiment Station Bulletin 187*, published in January, 1943. A more detailed manuscript was prepared in typewritten form for administrative use.

## PRICES IN THE WAR EFFORT

The place which the price received by producers has in influencing production and in giving the farmer and rancher a fair return relationship with industry has come to the fore in the year 1942. From the Department's files and from current data, relationships between cost of production and financial returns were prepared, both tabularly and graphically, and the results of these studies have been used in a number of ways. They were used as the basis for the formulation of the 1943 American-Egyptian cotton insurance program of the Department of Agriculture and by the Office of Price Administration in its determination of egg prices in Arizona; they were also used in connection with the Office of Price Administration study of milk and cream prices.

A special study of the relationship between cost of production and financial returns was made of the Arizona dairy industry. In July, 1943, the cost of dairy feed, adjusted for seasonality, was 250 per cent of the 1935-39 cost; the labor cost in the dairy industry was 220 per cent of the 1935-39 period; and the combined index of dairy costs, 236 per cent of the base period. Compared with that, the price received for fat in Grade A milk in the Phoenix area was only 195 per cent of the price in the base period; the price of fat in Grade D milk, 199 per cent of the base period; and the price of fat in churn cream, 182 per cent of the base period price.

A publication entitled "Arizona Agriculture, 1943: Production, Income, and Costs" was issued in February, 1943, showing prices and production trends in respect to about ten major agricultural commodities produced in Arizona. One feature of the report was an analysis of the distribution of the 107 million dollars of Arizona farm and ranch cash income in 1942. Twenty-two per cent was paid out for hired labor; 10 per cent covered interest; 9 per cent was spent on machinery; and another 9 per cent on packaging costs, which included ginning and wrapping of cotton, sacks for grain, crates, and packing of vegetables. Irrigation water took 5 per cent of the returns, while property taxes took about 2 per cent.

## THE IMPACT OF WAR ON ARIZONA COMMUNITIES

War has hit all communities, but the impact differs with the size of the community. Smaller communities have been most severely depleted of able-bodied men, of teachers, nurses, doctors, and of business services. Larger communities have gained in numbers, high wages, institutional support, and in civilian defense organization. High schools in the larger communities have suffered the greatest losses of pupils to industry, but their losses of able teachers have not been so severe as in the smaller communities. *Esprit de corps* is high in larger communities, but the sense of utter need to win this war without regard to individual advantage appears to be most generally evident as the size of the

community decreases. This will to win seems to depend upon the informal organization of human endeavor that characterizes families and neighborhoods rather than upon *esprit de corps* in large demonstrations. It is the putting forth of the will to bring to a successful end the struggle that is costing the blood of their own and their neighbors' sons.

It is believed that smaller communities, such as the site of factories and war industries in small units, bring the workers closer to the realities of the cost of war. Their environment also reduces the influence of political and labor bosses and is singularly free from the fanfare of wartime. More movement to small communities as locations for war industries would halt the closing of small businesses, reduce the costs of formal enforcements and regulation, and tend to equalize the distribution of professional persons and services. The training of youth would take precedence over high pay, a short day, and drink. Costs of war production would be reduced. Total government would have little chance of fastening itself upon the nation as a whole.

It may be added that postwar adjustments will be more easily made in small than in large communities.

The results of this part of the study in community organization were prepared for the Thirty-seventh Annual Meeting of the American Sociological Society, December, 1942, and published in the *American Sociological Review,* June, 1943.

## AGRICULTURAL ENGINEERING

### GROUND-WATER STUDIES

**Upper Santa Cruz Valley**

Almost negligible flood flows in the Santa Cruz River during the winters of 1941-42 and 1942-43 provided but little opportunity for recharge of the ground-water basin of the upper Santa Cruz. As a result, the water levels at all points along the river were the lowest on record before the summer rains of 1943. Throughout most of the Upper Santa Cruz Valley, above-normal runoff during the summer months of 1943 recharged ground-water supplies sufficiently to more than offset the effect of the summer irrigation draft. In the vicinity of the Nogales city pumping plant and between Continental and Tucson, local areas of heavy pumping show water levels slightly lower than at the beginning of the 1943 pumping season. With the possible exception of the Sahuarita area where some new land has been developed during the past two years, there has been little change in the irrigated acreage in this part of the Santa Cruz basin.

**The Cortaro-Marana district**

Pumping draft from the Cortaro area for the three-year period 1941-43, inclusive, will amount to approximately 72,000 acre-feet, which is considerably in excess of the normal recharge to this part of the ground-water basin. The water levels in January, 1943, following the 1942 pumping draft of about 27,000 acre-feet, were the lowest on record for the beginning of the pumping season. In July, 1943, the static water level at the continuous water-level recorder on Well 16-C2 reached a depth of 102.5 feet below the ground surface; this was slightly more than the lowest point reached in 1942. Actual pumping lifts in 1943 were but little greater than in 1942 because the pumping season was spread over a longer period without the usual concentrated pumping draft during the summer months. Summer flood flows in the Santa Cruz River were also effective as sources of recharge to certain parts of the area immediately adjacent to the river. Thus, although a residual lowering of approximately 5 feet occurred as the result of the 1942 pumping draft, the water level, as indicated by Well 16-C2, was only 2 feet lower at the end of the 1943 season than at the corresponding time in 1942.

During the past twenty-two years of continuous pumping operations in this area there have been only three years in which the recharge has been sufficient to result in material recovery of the water table above that of the previous year. Its almost continuous lowering, amounting to an average of about 45 feet within the pumping area, has occurred in this period. Resulting underdrainage of the valley side slopes has required the deepening of many of the shallow domestic and stock wells and in a few cases has required the drilling of wells in new locations where the only water stratum has been uncovered. Further material lowering of the water table in the pumping area is not expected, since unwatering of the best part of the aquifer has already occurred and well capacities have been greatly reduced. From this standpoint, even if not from the standpoint of economic lift, it appears that the economic limit to which the water level should be lowered has been reached. Although no further residual lowering in the pumping area occurs, the underdrainage of the valley slopes may be expected to continue until the water table reaches a position of equilibrium.

In the Marana area a recovery of 0.4 feet was indicated by water-level measurements at a limited number of wells in January of 1943. Pumping draft in this part of the Cortaro-Marana district amounted to about 3,000 acre-feet in 1942. However, by the end of September, 1943, the pumping draft for the year had exceeded 10,000 acre-feet, and it may be expected that significant lowering of the water table may result.

**The Eloy district**

This study is the continuation of investigations reported in *Technical Bulletin 87* and in subsequent annual reports.

The total area under irrigation in the crop year 1942 was 46,360 acres, an increase of 4,500 acres over the 1941 area. This new land was cleared and leveled and wells were drilled for irrigation water supply in the face of the admittedly rapid lowering of the water table and despite the excessive pumping lifts which already were too high for the raising of cotton, the principal crop of the district. The total area in the crop year 1943 is only 37,700 acres, as some wells have been abandoned and others are out of use. The ultimate remedy for present conditions will be a great reduction of area and a change to truck crops.

Although water-level measurements in 1942 were taken the middle of February, it was found that many farmers were already operating their pumping plants; pumping for irrigation was begun about a month earlier than in the previous year. The 1942 data, therefore, are unreliable, since equilibrium of the water table requires a long period of rest.

The analysis of the ground-water supply, however, can be made for a period of two years, from February, 1941, to February, 1943, ignoring the 1942 measurements. The volume of ground unwatered during the two-year period was 1,670,000 acre-feet. The total quantity of water pumped in the two-year period, as determined by indirect methods, was 282,000 acre-feet. The equation (see *Technical Bulletin 87*) becomes: $1{,}670{,}000\ S + N = 282{,}000$, in which S is the specific yield of the ground and N is the "new" water or replenishment of the supply during the two years. If the same value of S is assumed for the ground unwatered as that of the overlying ground unwatered in 1936-38, then the quantity of water taken from storage (the reduction or loss in the volume stored) was 186,000 acre-feet, and the quantity of new water was 96,000.

In the early studies in 1936-39, the quantity of inflow, mostly along the Santa Cruz Valley trough, was determined to be of the order of 40,000 acre-feet for the two years. This leaves 56,000 acre-feet of new, replenishment water, which must have been due to downward percolation from the irrigation ditches and the irrigated fields. It is 20 per cent of the quantity of water pumped. If it is distributed over the two years in proportion to the quantities pumped, then the downward percolation loss in 1941-42 was 26,000 acre-feet, and in 1942-43 it was 30,000.

It is notable that two thirds of the water pumped was taken from the stored supply, which had been accumulating for thousands of years.

The average lowering of the water table at ninety-five wells for the two years was 12.8 feet.

Water-table measurements in summer are erratic and misleading, but because the midsummer pumping is on a twenty-four-hour, seven-day schedule, the pumping lifts are stabilized and are comparable. The average pumping lift for a score of wells where good records are kept increased from 212 feet in July, 1941, to 218 in July, 1942, while the average pump discharges decreased from 2,020 to 1,910 gallons a minute. Fewer good records were available the following year, but they indicate the same trend.

**Little Chino Valley**

The drawdown effect of the heavy seasonal draft upon the ground-water basin during the summers of 1942 and 1943 was particularly noticeable in the lower or north end of the artesian area. The artesian pressure surface at the end of the 1943 irrigation season was 11.3 feet lower than it was in the spring. This marked seasonal lowering in the area of artesian wells and pumping plants with low lifts was reflected in decreases in discharge of from one third to one half of their normal capacities. The effect was not so pronounced in the south fringe of the water basin in the vicinity of the Mormon Church, where the seasonal lowering averaged only 6.8 feet. Pumping lifts in this part of the area range from 100 to 200 feet, and therefore the effect upon pump discharges is as yet but little.

Residual loss in artesian pressure or lowering in water level between April, 1941, and April, 1943, in the north end of the area amounted to 2.9 feet and to only 1.6 feet in the south end. The larger part of this lowering occurred as the result of the 1942 season's draft. It may be expected that the residual lowering due to the 1943 draft will be at least as great as that of 1942.

Wells along Granite Creek and in Lonesome Valley, as much as 5 miles east of the present irrigated area, showed a residual lowering of 1.3 feet during this same period. But few wells have been drilled in the southwest part of Little Chino Valley and depths to water are over 300 feet. Only a few water-level measurements have been made in this part of the valley, and they have shown no effect of the draft in the artesian area.

The residual loss in pressure or lowering in the water table in the irrigated area of only a foot or so per year when considered for only a period of a few years does not appear impressive. But in conjunction with probable increased development of the area and resulting accelerated rate of annual residual lowering, the picture looking forward ten or twenty years into the future has serious implications.

**Other pump-irrigation districts**

The developing of a new district east of Magma and about 7 miles northwest of Florence has been given attention, especially

with respect to the source of water supply. Initial development in this area began in 1940 when three wells were drilled and equipped in time for summer crops. In 1943 approximately 9½ sections of land were in crops. The water supply is from deeply drilled wells equipped with deep-well turbine pumps and natural-gas engines. At the present time there are in the area ten 20-inch wells, ranging in depth from 450 to 650 feet, in an excellent ground-water aquifer. Normal pump capacities are between 1,500 and 2,800 gallons per minute, with drawdowns averaging between 15 and 20 feet. In May, 1943, the static water level ranged from 143 feet on the west side of the area to 208 feet on the east side. At the request of state officials, the Department recommended that no more state lands be leased for agricultural use in this area, since additional wells would be drilled and pumped in competition with those now existing.

## DUTY OF WATER FOR COTTON

Data on the use of water in the irrigation of cotton were given in the Forty-ninth Annual Report. The duty, both monthly and annual, for long-staple cotton in 1942 on eight large farm units, with eighteen large pumping plants in all, is given in Table 8. The pump discharges were in all cases measured through Sparling water meters and are reliable. The farm managers were experienced cotton growers. All measurements were at the wells.

The early irrigations prior to planting aggregated about a foot of water in depth, while the heavy irrigating was restricted to the four summer months—the maximum in July and August. In five cases the last irrigation extended into the first week of October.

Except on farms 4, 6, and 8, the sandy soils required more water than the heavy soils. Excepting Farm 3, the best yields were on the heavy soils. The low duty on Farm 2 was due in part to high seepage losses in the canal, which is 2 miles long.

Assuming 15 per cent ditch and waste losses, the average duty shown in Table 8 would be equal to a 3.6-foot depth on the land, which it is believed is about right for long-staple cotton on deep, fertile soil. In theory, less water would be sufficient; but in practice, perfect distribution and at just the right times is not possible. Several cases of unjustifiable tail-water losses were observed.

## PHYSIOGRAPHY OF ARIZONA VALLEYS

In *Technical Bulletin 77* the physiography of the valleys of Arizona (and neighboring states) was analyzed and related to the ground-water supply and to other features of Quaternary history. A physiographic map of a limited area about Tucson was presented in that publication. It is desirable to extend the map-

TABLE 8.—DUTY OF WATER AND YIELDS FOR LONG-STAPLE COTTON ON EIGHT FARMS IN THE ELOY DISTRICT, 1942.

| Farm | Acres | Acre-feet per acre | | | | | | | | | | Bales per acre | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | The year | | |
| 1 | 430.7 | 0 | .45 | .35 | .33 | .60 | .69 | .63 | .59 | .09 | 3.73 | .39 | Silty clay loam soil. |
| 2 | 959.8 | .13 | .80 | .82 | .40 | .74 | .60 | .81 | .76 | .15 | 5.21 | .26 | Fine sandy loam soil. Long canal with high seepage loss. |
| 3 | 606.0 | 0 | .98 | .03 | .59 | .98 | 1.03 | .97 | .64 | 0 | 5.22 | .40 | Fine sandy loam soil. |
| 4 | 308.0 | 0 | .33 | .56 | .11 | .40 | .71 | .70 | .64 | .06 | 3.51 | .24 | Fine sandy loam soil |
| 5 | 843.3 | .29 | .52 | .53 | .25 | .50 | .73 | .79 | .70 | .20 | 4.51 | .28 | Silty clay loam and loamy fine sand soils. |
| 6 | 1,418.4 | .26 | .63 | .38 | .54 | .72 | .70 | .65 | .60 | .28 | 4.76 | .45 | Silty clay soil. |
| 7 | 817.2 | .39 | .29 | .16 | .33 | .55 | .55 | .56 | .47 | 0 | 3.30 | .35 | Silt loam and silty clay loam soils. |
| 8 | 968.4 | 0 | .55 | .13 | .54 | .62 | .60 | .60 | .73 | 0 | 3.77 | .27 | Fine sandy loam and loamy fine sand soils. |
| Av..... | | .13 | .57 | .37 | .39 | .64 | .70 | .71 | .64 | .10 | 4.25 | .... | |

Note: On all eight farms Sparling water meters were installed on the pump discharge pipes; therefore, the water was measured accurately.

ping to entire valleys. One of the basic studies is the longitudinal section along the trough of a valley showing the stream-bed or flood-plain profile in each time period. This has been attempted for both the San Pedro and the Santa Cruz valleys, and the longitudinal sections are nearing completion.

The three important surfaces above the bottomland are those of the transitional periods between aggradational and degradational periods of time. They have been named the University, the Cemetery, and the Jaynes surfaces (or valleys). Remnants of the University, or oldest, surface are likely to be at some distance back from the trough of the present valley, and the position on the longitudinal section is found by a study of cross-sectional profiles, the lines of which must be extended.

There is considerable disparity between the University profile and that of the present valley. It appears that where the valley lies not far from high mountains with extensive drainage and at the junctions of main tributaries, great quantities of outwash were poured into the valleys—more than could be carried away on the flatter grades of the Santa Cruz itself.

Thus, the great height of the University valley floor above the present bottomland to the south of Tubac was due to the combined effects of Sonoita Creek, Nogales Wash, Peck Wash, Josephine Canyon Wash, and the nearness of the mountains on both sides. The lower course of Sonoita Creek is entrenched deeply below the University; at 8 miles above its mouth, where the evidence is very clear, the depth is nearly 700 feet.

North of Tubac the depth of the present valley below the University valley floor decreases rapidly to Amado and more slowly to the northward, so that at Tucson the depth is about 100 feet and at the mouth of the Canada del Oro Wash, about 75 feet. A vast volume of detrital material, and of lost fertility, is represented in the lowering of the valley surface since mid-Quaternary time.

## THE TAMARISK TREE AND ITS WOOD

### Preservative treatment of tamarisk fence posts

These investigations concerning tamarisk fence posts were begun in 1934. In June, 1942, equal numbers of green, freshly cut, and air-dried posts were treated as follows: one lot of each with wood-tar creosote, one with coal-tar creosote, and one with permatox A, a 5 per cent solution of pentachlorphenol. A small lot was treated with zinc chloride by the tire-tube method. This method is not to be recommended, however, because it was found that the time and labor cost involved are relatively high.

The posts were set in the ground in October. One half of each lot was set on the University Farm, 3 miles north of the campus, and the other half on the Page-Trowbridge half section (owned by the University) 30 miles north of Tucson. The conditions at the

Farm are those of irrigated fields; those at the second location are a fair average for cattlemen's fence lines.

The posts were set at 4-foot intervals, to a depth about an inch less than the depth of treatment, and each post was marked with a metal identification tag. Inspection will be made once a year.

Inspection of the posts set in 1935 was made in December, 1942. Each post was tested by a pull of 50 pounds with a dynamometer applied at a point 2 feet above the ground, a test used at the Oregon State College. All the posts withstood this test, including No. 60 in the Kinne east fence line and the untreated posts. A more severe test should be adopted.

The posts set in the spring of 1935 were distributed and set in four places—the Kinne farm (Coolidge), Jaynes Station, Esmond, and the University Farm. Two posts on the Kinne farm were broken by heavy falling limbs during a windstorm in the summer of 1942. One of them became lost and no report on its condition was obtainable. The other was broken 5 inches below the ground line and the upper part was placed in a shed. At the time of inspection the lower part was dug up. Neither part showed any decay. An end was sawed off; the cross section was found thoroughly creosoted, and moving liquid creosote was observed—after over 7 years in the ground. The two pieces were reset on the University Farm. Otherwise, all treated posts were in good condition. (One small, weak post at the Farm had been removed by the Southern Pacific Company inspector in January, 1940.)

Untreated posts cut in May, 1940, were set in January, 1941, two each at Esmond and Jaynes. In December, 1942, they were much decayed and showed termite injury.

All but one of the posts set in the fall of 1935 were serviceable, and most of them were firm in the ground. Post No. 60 was decayed from the ground line to the butt and was removed.

**Plantings of tamarisk trees for saw logs**

Plantings of *Tamarix aphylla* were made in March, 1942, 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 cut. One planting of six plots was made on sandy soil, another of three plots on clay loam soil with sandy subsoil. The total number of cuttings was 2,951, of which 960 were from the University campus.

The young shoots on odd-numbered rows were thinned to one, the strongest, on each plant in June; the even-numbered rows were thinned similarly in September. The average height on September 9 was 73 inches and on May 3, 1943, it was 125 inches; many trees, however, were over 12 feet in height.

Differential practices and conditions include: the growth on different soils, the effect of time of thinning the shoots, the effect of the spacing in the row, comparative growth of local cuttings and

Tucson cuttings, methods of thinning to obtain a "forest stand," and the effect of discontinuing irrigation so that the water supply must be obtained from the ground water, which stands at about a 5-foot depth.

Measurements of height and circumference at the crown were taken May 3, 1943. They indicate that cuttings from Tucson and Yuma are equally good if the cuttings are protected against drying; that thinning of the shoots should be deferred until September or October; that pruning the first winter is necessary to cut back or remove large limbs which compete with the central stem, but the lower part of the trunk should not be stripped; and that tamarisk grows well on both light and heavy soils. The most outstanding conclusion, however, is that close spacing in the row—2- or 3-foot intervals—insures tall, straight stems, while wider spacing—8 or even 5 feet—produces a large percentage of poorly shaped trees with no straight, vertical stem.

Records of growth of selected trees reveal that the rate of growth is nearly uniform from the end of March to the middle of October. There was no growth in November, December, and January, but there was definite increase in height in February, which increased in rate through March.

### MISCELLANEOUS

At the request of the U.S. Veterans Administration, an investigation as to the possibility of developing a ground-water supply for the hospital at Prescott was made. A field reconnaissance study of the Prescott district was made and a report prepared in which the possibilities for ground-water development in the various local areas were discussed.

## AGRONOMY

### COTTON

#### Irrigation

Previous work covering seven years of experimentation demonstrated conclusively the value of pushing early plant growth by means of early irrigation following planting and maintaining abundant moisture supplies during the fore part of the season. Some indications were also obtained that more limited supplies of soil moisture were desirable for the latter part of the season. The earliness with which irrigation should be started, the best time to change from abundant to limited soil moisture, and the extent to which soil moisture should be limited remained to be determined. The irrigation experiments for 1942 were devoted to the solution of these three points.

Cotton irrigated May 12, six weeks after planting, grew more rapidly than that irrigated for the first time eight weeks after planting. It also produced a significantly larger early crop than the cotton irrigated later, although the total production was not consistently greater.

Changing from abundant soil moisture to more limited supplies in early July tended toward earlier production and greater total production than where this change was made three weeks later.

Irrigating during the last half of the season when the soil moisture still remained 2 per cent above the wilting point produced slightly more cotton than did irrigating at the wilting point. These differences in yield were not significant in 1942.

**Variety tests**

Coker Wilds 13 led all upland varieties in money value per acre in the 1942 Mesa Farm tests, although it was not significantly better than Santan Acala in this respect. The Deltapine varieties which led in 1940 and 1941 were considerably lower in value per acre this year, as is indicated in Table 9. Stoneville 2B was second

TABLE 9.—UPLAND VARIETY TEST DATA—MESA FARM, 1942.

| Variety | Lint per acre | Ginning per cent | Length lint* (inches) | Bolls per pound seed cotton | Strength index | Value per acre† (seed & lint) |
|---|---|---|---|---|---|---|
| Coker Wilds 13 | 756 | 31.3 | 1⅜ | 78 | 923 | $271.23‡ |
| Coker Wilds 12 | 782 | 31.9 | 1 7/32 | 82 | 859 | 267.74 |
| Acala, Santan | 1067 | 37.5 | 1 1/16 | 64 | 760 | 265.42 |
| Coker 100 | 887 | 35.5 | 1⅛ | 78 | 796 | 248.22 |
| Hartsville | 912 | 30.5 | 1 1/16 | 68 | 935 | 246.83 |
| Deltapine 12 | 1033 | 37.9 | 1 | 91 | 777 | 244.91 |
| Deltapine 14 | 1019 | 40.0 | 1 1/32 | 86 | 805 | 241.82 |
| Coker Wilds 11 | 668 | 32.0 | 1 11/32 | 77 | 903 | 238.56‡ |
| Tidewater Seabrook's | 682 | 31.4 | 1 7/32 | 78 | 840 | 234.25 |
| Tidewater 31 | 751 | 30.8 | 1 5/32 | 67 | 944 | 230.92 |
| Acala, N. Mex. 1517 | 823 | 36.2 | 1⅛ | 68 | 943 | 229.21 |
| Stoneville 2B | 893 | 34.9 | 1 3/32 | 71 | 900 | 226.32 |
| Bobshaw 12 | 697 | 33.3 | 1 3/32 | 82 | 910 | 184.08 |
| Bobshaw 2 | 608 | 35.1 | 1 3/32 | 85 | 889 | 158.46 |

*As stapled by U.S.D.A. cotton-classing office, Phoenix.

†Gross value for lint, basis Memphis Dec. 4, 1942, premiums and discounts for middling cotton, and March futures New York at 18.71 cts.; and for seed basis Phoenix at $47 per ton.

‡Since no quotations for staples longer than 1¼ inches were available, lint values for staples longer than this were calculated on the basis of premiums paid for 1¼ staples.

high in 1941 but almost at the bottom in 1942. Yields were exceptionally high this year because of the excellent control of insects through the dusting program.

**Varietal performance in Graham County**

Four varieties of cotton were grown on a commercial basis in Graham County during 1942. Representatives of the Agronomy and Plant Breeding departments visited a large number of the cotton fields of this county during the fall and early winter and discussed with the growers their experiences with the different varieties. Ginning and marketing problems were taken up with some of those connected with these phases of the cotton business and data obtained relative to the ginning and sale of Graham County cotton. Many of the growers have upon request furnished the County Agent's office with production data on the varieties grown by them. All these sources of information have been used in making up the summary of varietal performance as given in Table 10.

TABLE 10.—DATA ON COTTON VARIETIES GROWN IN GRAHAM COUNTY IN 1942.

| Variety | No. of growers | Pounds lint per acre | Ginning per cent | Picking cost per acre | Price per pound lint (cents) | Value per acre after deducting picking cost |
|---|---|---|---|---|---|---|
| Coker Wilds.... | 7 | 685 | 32.0 | $64.20 | 27 | $154.94 |
| Acala, Santan | 11 | 743 | 37.0 | 40.16 | 18 | 123.30 |
| Acala, N. Mex. 1517..... | 32 | 692 | 35.5 | 39.02 | 19 | 122.04 |
| SxP..... | 36 | 319 | 29.4 | 43.40 | 43 | 111.77 |

The data on yields of lint per acre were supplied by the individual growers. The average ginning percentages were calculated from data furnished by growers and ginners. Seed values were based upon $47 per ton, and the price per pound of lint of the different varieties was approximated after discussions with growers, buyers, and ginners. It is recognized that all growers did not receive as high a price as was indicated because of picking difficulties and attendant lowering of grades. On the other hand, some cotton brought higher prices. Picking costs were based on two cents for Santan Acala and 1517, three cents for Coker Wilds, and four cents for SxP. Here again all growers did not, of course, pay these picking prices, but it is believed that the taking into account of the comparative picking difficulties of these varieties would place them in the order used.

**Rotations**

After Salt River Valley Pima cotton growers had experienced several years of declining yields, this work was started in 1935 in

an endeavor to ascertain whether crop management or crop sequence had anything to do with the unsatisfactory yields.

One series of plots has been used to determine the influence of growing Pima cotton every year with applications of barnyard manure either annually or biennially, with applications of nitrogen and phosphorus fertilizers every other year and with no additional plant-food supplements. Neither the barnyard manure nor the commercial fertilizers increased the yields over the untreated plots during the past seven years. Plant growth, but not fruiting, was stimulated by the manure. The seven-year average annual production on these plots with cotton grown continuously, was 1,357 pounds of seed cotton per acre.

A second series of plots has been planted to a two-year rotation of cotton and wheat, with a comparison of the influence of Sesbania, sour clover, and fallow when used between the wheat and cotton crops. There have been no significant differences in yields between these plots during the past seven years, although during the latter part of this period the green manure crops did stimulate more growth in the cotton plants than did the fallow. The seven-year annual average yield of seed cotton for the series was 1,464 pounds per acre, a little more than 100 pounds higher than in the series producing cotton every year.

A third series has been devoted to four cotton-alfalfa rotations to determine the influence of variations in the number of years in which the plots have been occupied by each of these crops. Alfalfa is usually considered as a good soil-improving crop, and although no significant differences in cotton yields have been obtained with respect to the length of time the cotton was preceded by alfalfa, yields have been better than with either of the two preceding series. Cotton yields were 55 pounds per acre higher as a seven-year average than in the series in which wheat was the alternating crop and 162 pounds higher than when cotton was grown every year. The seven-year average yield of cotton for the cotton-alfalfa series was 1,519 pounds of seed cotton per acre.

The fourth and last series comprised five- and six-year rotations, including three years of alfalfa, one year of barley followed by hegari in the same year, and one or two years of cotton. Barnyard manure was applied once during the period of each rotation. These plots outyielded all others in cotton production, having produced 97 pounds of seed cotton per acre more than the cotton-alfalfa series, 149 pounds more than in the cotton-wheat-green manure or fallow series, and 256 pounds more than when cotton was grown continuously. The seven-year average yield was 1,613 pounds of seed cotton per acre.

**Length of fruiting period with respect to earliness**

There appears to be little difference in the length of the flowering period in plants which begin flowering early and those which

begin late. Early-flowering plants quit putting on flowers relatively earlier in the fall than late-flowering varieties. However, the early-flowering plants held a relatively higher percentage of their bolls during the latter part of the season than did the late-flowering plants. The three varieties studied—Acala, Coker Wilds, and Stoneville 2B—were all exceptionally consistent in this respect. All these plants were seeded at the same time.

## SEED PRODUCTION OF KOK-SAGHYZ IN ARIZONA

Plantings of kok-saghyz (Russian dandelion) were made at three locations in Arizona—Yuma, Mesa, and Tucson—and at different dates during the fall and winter of 1942-43. These plantings were made for the purpose of determining the seed production possibilities of this crop during the winter and early spring months.

Seed yields were obtained from each of the different seeding dates at Mesa and are recorded in Table 11. Seed harvests were made only every two days, and strong winds during the late afternoon often blew most of the seed away, thus making the harvested seed yields considerably lower than the amount actually produced.

TABLE 11.—YIELDS OF KOK-SAGHYZ SEED—MESA, ARIZONA, 1943.

| Planting date | Seed yields per acre | |
|---|---|---|
| | Thinned rows* (lbs.) | Not thinned (lbs.) |
| September 25, 1942 | 137† | ..... |
| October 16, 1942 | 153 | 215 |
| November 4, 1942 | 118 | 110 |
| November 20, 1942 | 149 | 145 |
| December 18, 1942 | 54 | 71 |
| January 25, 1943 | 14 | 6 |

*Plants thinned to 4 or 5 inches apart.
†Plants not thinned but averaged 7.5 inches apart.

All the plants from seedings made on or before November 20 produced seed; whereas, under conditions in the cooler regions where kok-saghyz is planted in the spring and seed harvested in the fall, it is reported that only 20 to 30 per cent of the plants bloom the first year after planting. Actual seed yields were also much higher than is obtained in the more northern regions.

The growing of kok-saghyz for rubber would probably not be profitable on the irrigated lands of southern Arizona. However, should there be a need for rapid seed increase, plantings could be made in the fall and seed harvested the following spring in time for planting in the northern states for a root crop during the summer.

## SOYBEANS

The Armredo variety of soybeans, which is the only relatively nonshattering strain of which any appreciable amount of seed is

available, produced an average yield of 23 bushels per acre at Mesa in 1942. An estimated 20 or 30 per cent of the beans were lost by shattering during harvesting operations. Other varieties produced yields ranging from 10 to 30 bushels per acre. All varieties and strains produced lower yields than in past years. In a date-of-planting test at Mesa, Armredo soybeans planted as late as June 27 were not tall enough for satisfactory yields. Additional date-of-planting and irrigation tests will be necessary in order to determine the latest date when soybeans can be planted safely for a grain crop.

## SUMMER GREEN MANURES

The effectiveness of summer-growing green manures was compared with summer fallow on the Salt River Valley Experiment Farm, using Arivat barley as an indicator crop. Barley yields were higher following guar than those following other summer legumes or fallow. The lowest yields were obtained in both years from the fallow plots, as is indicated in Table 12.

## GUAR FOR SEED PRODUCTION

Time-of-planting and method-of-irrigation trials were started with guar in the early summer of 1943 to determine the effect of such methods on seed yields. More detailed tests on row spacing, bed versus flat planting, testing of selections, and comparison of guar for seed, guar for green manure, and bare fallow on subsequent barley yields were undertaken in co-operation with General Mills, Inc., of Minneapolis, Minnesota.

Much interest has been developed during the past year in guar seed as a source of mucilage for use industrially. Seed increase plantings combined in late December, 1942, resulted in yields of 1,145 pounds per acre from a planting made on the Salt River Valley Experiment Farm on June 15, and 1,128 pounds per acre from a planting made July 21. The seed produced by the early planting was superior in quality and germination.

## FERTILIZER AND CROP TRIALS ON THE GILA PROJECT FARM

### Fertilizer tests

Results of differential treatments with treble superphosphate on alfalfa showed marked increases in yield for the heavier treatments each year. Response to applications of phosphate is much more marked on the extremely sandy soil on which the test was conducted than might be expected on average soils, but it is indicative of the phosphate needs of the more sandy soils of southern Arizona. Average yields for the three-year period are given in Table 13.

There was no significant difference in the effects on hay yields of treble superphosphate and ammonium phosphate. Average

TABLE 12.—YIELDS OF ARIVAT BARLEY FOLLOWING GREEN MANURE CROPS AND SUMMER FALLOW.

| Preceding crop | Pounds barley per acre | |
|---|---|---|
| | 1942 | 1943 |
| Guar | 3,958 | 4,203 |
| Brabham cowpeas | 3,151 | 3,644 |
| Tepary beans | 2,921 | 3,959 |
| *Crotalaria juncea* | 2,875 | 3,453 |
| Sesbania | 3,197 | 4,063 |
| Summer fallow | 2,917 | 2,648 |

TABLE 13.—INFLUENCE OF PHOSPHATE ON YIELD OF ALFALFA ON THE GILA PROJECT FARM.

| Pounds treble superphosphate applied annually | Acre yields (pounds) |
|---|---|
| None | 1,659 |
| 100 | 10,362 |
| 200 | 12,293 |
| 300 | 13,745 |

acre yields for four replications showed an increase of 1,139 pounds of hay in favor of liquid phosphoric acid applied in the irrigation water in comparison with an equivalent amount of $P_2O_5$ applied with the grain drill in the form of treble superphosphate. Indications are that the use of phosphoric acid applied in the irrigation water will become increasingly popular as a means of fertilizing alfalfa.

**Culture and improvement of legumes**

A test of six different legume crops was conducted on the Gila Project Farm. These were harvested in May. Yields of Hubam clover were much higher than those of any other legume included in the test. The other legumes ranked as follows on dry-weight basis with the yield of Hubam clover expressed as 100: Papago peas 61, Calearata vetch 52, Monantha vetch 47, Hairy Peruvian alfalfa 45, and African alfalfa 38.

## ANIMAL HUSBANDRY

### CATTLE FATTENING RATIONS

The cattle fattening tests conducted at the Salt River Valley experimental farm each year were devoted almost exclusively this year to a comparison of hegari silage and Manko silage when fed with varying amounts of alfalfa hay, barley, grain, and cottonseed meal. Previous studies made at this Station, supported by local feeding practices, have established hegari silage as a valuable

beef-producing feed. Its feeding value has been conclusively determined as being one third to one half that of alfalfa hay. This fact coupled with its high yield on Arizona farm lands and the succulent value it adds to a ration, making for a maximum consumption of feed, accounts for its widespread use in this area.

In recent years a new grain sorghum known as Manko has been grown on the experimental farm. It is similar to Fargo and is doubtless a kaffir-milo hybrid. This new crop, because it is an exceedingly heavy grain and silage producer, warranted consideration as a cattle fattening feed in comparison with hegari silage.

**Hegari silage vs. Manko silage**

In two of the three different comparisons of these feeds, the steers fed hegari silage made greater and more economical gains in live weight. The results are in line with those of the preceding test and prove conclusively a slight but definite superiority of hegari silage over the Manko. An average of the results of this and the two preceding tests of these feeds when full fed, free choice, with alfalfa hay shows that hegari silage is productive of a 10 per cent greater and more economical gain in fattening cattle. Furthermore, the advantage of making for cheaper gains was maintained by the hegari silage in this test when these two feeds were full fed with a restricted allowance of alfalfa hay. Consuming practically identical amounts of feed, the hegari silage steers in this comparison gained 2.21 pounds per head daily at a feed cost per cwt. of $10.67, while the Manko steers gained 2.06 pounds per day at a feed cost of $11.50.

No significant difference in the rate and cost of gains occurred when the two silage feeds were fed in restricted amounts and the alfalfa hay was full fed.

**Rolled barley vs. ground barley**

A significant difference in favor of rolled over ground barley was found in this test. A ration of alfalfa hay, hegari silage, cottonseed meal, and rolled barley was compared with a similar ration having ground barley fed to two lots. The steers receiving ground barley gained an average of 2.05 pounds per day at a feed cost of $11.70. The steers fed rolled barley gained 2.5 pounds at a feed cost of $9.96 per hundredweight gain. Further tests will be made before conclusive results can be reported regarding the relative values of rolled and ground barley for fattening cattle.

**Limiting the allowance of concentrates**

During the earlier years of the cattle fattening industry in this state, concentrate feeds, particularly grain, were fed very sparingly. Cottonseed meal was fed in rather liberal quantities and

constituted almost entirely the only supplement to alfalfa hay, silage, cottonseed hulls, and other roughages. The later development of a good market outlet for well-finished cattle in California led to the use of grain feeds for fattening cattle in Arizona. A satisfactory market finish is attained by feeding a limited grain allowance at the rate of about three fourths of a pound per 100 pounds live weight.

In order to determine if a more economical gain could be obtained by further restricting the amount of grain, two lots of steers were grain fed at the rate of ½ pound of barley per 100 pounds live weight. The steers in one lot received an average daily allowance of 4.22 pounds rolled barley and .98 pound cottonseed meal. In the other lot the barley was deferred until the last half of the feeding period, making an average of 3.95 pounds for the entire period and 1.91 pounds of cottonseed meal. Both lots of steers were full fed, free choice, alfalfa hay and hegari silage. A comparison of the rate and cost of gains made by these two groups indicates that there is no choice between these methods of restricting the amount of grain. The results further show that restricting the barley to ½ pound per 100 pounds live weight was significantly less profitable than the more liberal allowance of three fourths of a pound of barley per hundredweight.

**Varying the relative amounts of alfalfa hay and silage**

The full feeding of silage and alfalfa hay according to the choice and appetite of the cattle for these feeds is productive of slightly greater daily gains. In this and previous tests limiting the amount of silage, which makes for an increase in the consumption of hay, has resulted in slower and more costly gains. Similar results were obtained from increasing the amount of silage and reducing the allowance of hay. Since the effect on the rate of gain is not great, feeders may find good reason to vary the relative amounts of silage and alfalfa hay. Hegari silage has a value of one third to one half of alfalfa hay when fed with grain and cottonseed meal, which favors its liberal use in this combination. The relative market price of these two roughages will determine the proportionate amounts productive of the most economical gains.

**Dressing per cent**

Contrary to popular opinion among cattle feeders and fat-cattle buyers, very satisfactory yields were made on rations including a high proportion of silage. The carcass yield was above 60 per cent in all but one of the ten lots of steers fed silage. There was no significant difference in the dressing percentage of the four lots of steers full fed silage and hay, free choice, and the two lots of steers fed a limited allowance of silage.

### PROGENY TEST OF HEREFORD SIRES

The second crop of steer calves sired by each of the three bulls used in this test were fed to a satisfactory market finish according to the experimental plan described in the preceding annual report. The three groups of calves numbered 9, 10, and 11 head, respectively, and after they were weaned they were kept in individual fattening pens. They were started on feed early in November when they weighed an average of 450 pounds and were fed a ration of alfalfa hay, hegari silage, rolled barley, and cottonseed meal for a period of 150 to 210 days. The feeding efficiency of each animal was calculated at the close of the feeding period on the total digestible nutrients required for each pound of gain in weight. Compared on this basis, no significant difference was found among the three groups of calves in the current test. The uniformity of their performance is shown herewith:

| | T.D.N. per lb. gain (lbs.) | Av. daily gain (lbs.) | Carcass grade |
|---|---|---|---|
| Group 1 | 4.34 | 2.42 | 8 choice, 1 good |
| Group 2 | 4.57 | 2.23 | 9 choice, 1 good |
| Group 3 | 4.61 | 2.31 | 10 choice, 1 prime |

These records reveal the exceptionally high level of feed efficiency attained by all three groups of the experimental calves.

## ANIMAL PATHOLOGY

### INFECTIOUS KERATITIS

Cultural studies have continued to show that infectious keratitis is not transmitted by direct contact. Additional field cases are constantly being studied. The allergy studies failed to show that the primary injury is due to dust from various corrals or to the selected single or composite pollen samples prevalent during an outbreak. Studies are in progress to divide the disease into different types, although the gross lesions are similar.

### PARASITE CONTROL

Warble control was again undertaken by using the mixture of 10 pounds of derris root (5 per cent rotenone), 100 pounds of 325-mesh sulphur, and 1,000 gallons of water. A power spray (150 pounds pressure) was used to apply this material to the backs of the animals. About 3,000 head were treated in December and January. Results have been very favorable with an estimated reduction of about 75 per cent in heel flies.

Ranchers are using with good results the power spray idea to treat cattle for lice.

Conservation of livestock has been the major problem of this department:

(1) The removal of "cancer eyes" was demonstrated to a large number of ranchers. (2) The intravenous injection of sodium iodide for the treatment of actinomycosis was demonstrated. (3) Proper methods of sanitation and parasite control were demonstrated at several large hog ranches. (4) The sterility problem in dairy herds was investigated. Numerous tests for trechonomas foetus were conducted. (5) Poison-plant losses were investigated.

### THE DIAGNOSTIC LABORATORY

| | | |
|---|---|---|
| Poultry disease diagnosis | 646 | case reports |
| Cattle disease diagnosis | 124 | case reports |
| Horse disease diagnosis | 9 | case reports |
| Swine disease diagnosis | 9 | case reports |
| Turkey pullorum tube tests | 1,730 | |
| Miscellaneous animals | 8 | |
| TOTAL | 2,506 | |

## BOTANY AND RANGE ECOLOGY

### BURROWEED INVESTIGATIONS

The severe drought period in 1942 and 1943 resulted in a relatively high mortality of burroweed (*Haplopappus tenuisectus*) on southern Arizona range lands. Counts made on conservatively grazed areas of the Santa Rita Experimental Range showed that 12 to 25 per cent of the burroweed plants had died, and general observations throughout the southern part of the state showed similar or higher death losses and a noticeable lack of vigor on the part of this important range weed.

Studies of the food reserves of burroweed made during the 1943 season indicate that the drought had weakened the plants by causing a severe depletion of the carbohydrate reserves in the perennial parts of the plants. As shown in Table 14, readily usable carbohydrate reserves (sugars plus starch) were at low levels in the roots and crowns of burroweed plants in June, 1943, near the end of the drought period. Further depletion of these stored foods occurred when rains caused renewed growth of the plants in late July and August. The lowest carbohydrate level was reached about August 10.

In order that the food-reserve studies may be useful in improving the effectiveness of practical control measures, a co-operative project has been established with the Southwestern Forest and Range Experiment Station under which plots located on burroweed-infested areas on the Santa Rita Experimental Range will

be mowed and burned at monthly intervals. At the same time samples will be taken for carbohydrate analyses. Field data will be secured on control of burroweed and on the recovery of forage plants.

TABLE 14.—"READILY AVAILABLE"* CARBOHYDRATE RESERVES IN BURROWEED ROOTS AND CROWNS (JUNE TO SEPTEMER, 1943).

| | June 29 | July 27 | Aug. 10 | Aug. 24 | Sept. 21 |
|---|---|---|---|---|---|
| Roots ..... | 4.65 | 3.72 | 2.72 | 3.18 | 4.12 |
| Crowns ..... | 3.92 | 2.93 | 1.71 | 2.69 | 3.26 |

*Total sugars plus starch, expressed as per cent of dry matter.

## RANGE RESOURCES OF ARIZONA

Work has been continued on the project to synthesize all available information on the range resources of the State of Arizona. Through the co-operation of all state and federal agencies concerned with range lands in the state, a series of maps showing in detail the range vegetation types and principal forage species has been completed for the counties in which the range livestock industry is important. Descriptions of the range types, their important forage plants, the present and potential carrying capacity of each type, and general recommendations concerning range management practices applicable in each type will be presented in the form of detailed county reports. Maps for the entire series of bulletins are almost complete, and the first bulletin covering Cochise County will appear in the near future.

## EFFECT OF DROUGHT ON DESERT GRASSLAND RANGE

Yearly observations, made continuously since 1931, on the density and abundance of range vegetation at the Santa Rita Experimental Range were of considerable value in demonstrating the benefits of conservative stocking in severe drought periods such as that experienced on southern Arizona ranges in 1942 and 1943. On a conservatively grazed mesquite-grassland range in which the principal perennial grasses were Arizona cottongrass, black grama, poverty grass, and Rothrock grama, a reduction in basal-area density of 41 per cent occurred between 1941 and 1943. Nearly half of this reduction in density is attributable to the depletion of Rothrock grama, a short-lived perennial which attains high densities during favorable years. The more important forage species, Arizona cotton grass and black grama, showed individual reductions in density of 1 and 32 per cent, respectively. Observations on similar ranges which had been moderately or heavily grazed in the past showed greater reductions in perennial grass density and volume of forage produced during the 1943 growing season on these ranges than on adjacent conservatively grazed areas.

## SUGAR BEET SEED PRODUCTION

In the eight-year period from 1936 to 1943, sugar beet seed growers in the Salt River Valley have produced approximately 43,500,000 pounds of seed from 30,000 harvested acres. This represents an average acre yield of 1,450 pounds, but the yields have varied widely in the different years of the period. The highest average yield of 1,917 pounds per acre was obtained in 1939, while the lowest yield for the period, 689 pounds, was obtained the following year.

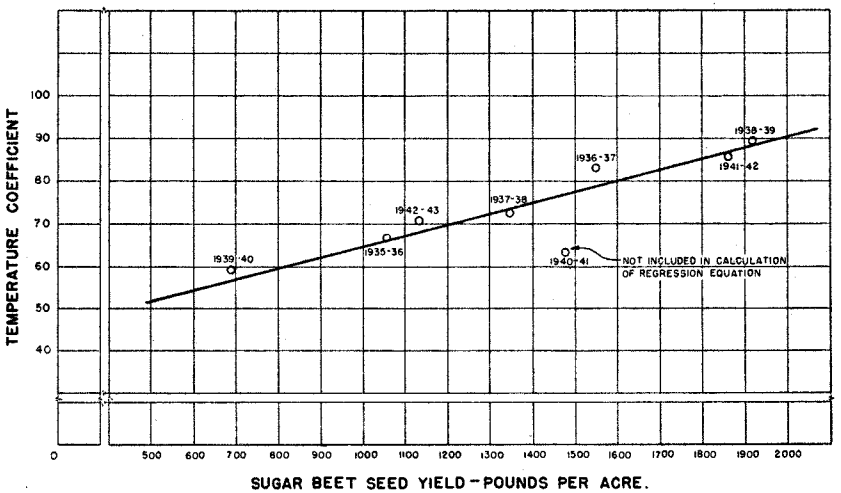


Figure 1.—Relation of temperature to sugar beet seed yields. Temperature coefficient is thermograph chart area in square inches below 60° F. minus area above 80° F. for the growing season October 1 to May 31.

As shown in Figure 1, these variations are very closely correlated with the net amount of low temperatures under which the plants grow from October 1 to May 31. The relationship is so close that it can be used with considerable accuracy to forecast yields. This study shows that under existing conditions of careful control of cultural practices and disease control,[4] sugar beet seed yields in the Salt River Valley may be expected to fluctuate in response to winter temperatures.

## ECONOMIC VALUE OF NATIVE PLANTS

### Simmondsia

The possibility that jojobe (*Simmondsia chinensis*) seed may become a commercial crop in Arizona has led to increased study of problems relating to its production. Jojobe is dioecious (having

[4]Supervised by Western Seed Production Corporation, Inc., Phoenix, Arizona.

male and female flowers on different plants), and the plants do not flower until three to five years after they are planted. In the present study an attempt is being made to obtain an early determination of the sex of seedling plants so that a proper adjustment of male and female plants can be obtained. Investigations of seed germination, seedling development, floral development, and seed setting are also in progress.

**Rubber content of southwestern plants**

A co-operative project with the Department of Agricultural Chemistry and Soils for the determination of the rubber content of native plants was begun in 1942 and continued in 1943. Results of this investigation are given under Agricultural Chemistry and Soils (see p. 11).

## DESTRUCTION OF RANGE FORAGE BY RODENTS AND RABBITS

**Kangaroo rats**

Continuation of studies on the food habits of the Merriam kangaroo rat has confirmed the earlier finding that a large part of the food of this animal consists of seeds. This diet is made up, for the most part, of seeds of annual weeds and perennial three-awns, plants which are not highly palatable to livestock.

In addition to the character of the diet, the economic importance of the kangaroo rat depends upon the animal population per acre. Population studies are being carried on by means of live-trap and snap-trap quadrats. The live-trap quadrats furnish data on home range or cruising radius, since the animals are taken alive, marked, and released. The snap-trap studies kill the animals and furnish data on pouch contents as well as on animal numbers.

**Jack rabbits**

Base ration tests and growth measurements have been continued with young Arizona jack rabbits to supplement the forage consumption data published by J. F. Arnold in *Technical Bulletin 98*. The results show that food consumption levels off at about three months of age, which fact indicates that the animals reach maturity at that time.

## DETERMINATION OF THE CORRECT SCIENTIFIC NAMES OF COMMON PLANTS

In 1939 the University established a project designed to clear up the confusion of scientific names applied to southwestern plants. From 1941 until 1943 study was concentrated upon the trees and shrubs native to the southwestern deserts, and an

illustrated manual for their classification was prepared. This work includes all the trees and shrubs except some of the smaller and less significant bushes occurring in the deserts and the desert grassland. It is intended for use by both layman and scientist, and it includes both popular characterizations and detailed technical descriptions and keys. There are 116 plates, including colored and black-and-white photographs, line drawings, and distributional maps.

A revision of the classification and the names of certain confused groups of cacti was completed for publication, and a guide for research by amateurs and technical workers in systematic botany was prepared and published in order to facilitate work outside the University in straightening out the classification and the naming of plant groups.

### PLANT COLLECTION AND IDENTIFICATION

Additions to the University of Arizona Herbarium included about 5,000 specimens, which were mounted and filed with the collections. Many of these were collected by members of the staff; others were received from individuals interested in their identification. Plants to be identified were contributed by such institutions and agencies as the following: schools, peace officers, the State Game and Fish Department, departments of the Agricultural Experiment Station, Agricultural Extension Service, Fish and Wildlife Service, National Park Service, Division of Grazing, Indian Service, Soil Conservation Service, Forest Service, and the Bureau of Plant Industry. Development of a complete card index of the taxonomic literature in the Herbarium and the University Library was continued.

## DAIRY HUSBANDRY

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

During the past two years a comparison has been made of the bacterial content of milk produced with daily dismantling and cleaning of the milking machine versus weekly dismantling.

In the first-mentioned method the machine is dismantled after the morning milking, washed, and the rubber hose and teat cup liners placed in chlorine solution in a crock until the evening milking. Immediately after the evening milking the machine is rinsed with cold water; then follows a hot water rinse—180° F.—of at least 2 gallons. The teat cups and hose are then placed on a solution rack and filled with 0.5 per cent lye solution.

In the weekly dismantling method, immediately after each milking the machine is rinsed with cold water followed by hot water, and the teat cups and hose are placed on a solution rack

and filled with 0.5 per cent lye solution. Once a week the machine is dismantled and washed thoroughly. The rubber hose and teat cup liners are held in chlorine solution until the next milking.

Table 15 gives the average bacterial count of the milk for the two methods for different periods of the year. The average count for the weekly dismantling method was 6,200 as compared with 18,024 for the daily method. No satisfactory explanation can be found for the higher bacterial counts of the daily dismantling method, other than the growth of bacteria in air pockets in the rubber hose when immersed in chlorine solution between the morning and evening milkings. It is interesting to note that the bacterial counts for both methods were lower during the summer and early fall than during the three winter months. Owing to the poor quality of rubber now in use it was not possible to make any worth-while study of the effect of the two methods on the life of the teat cup inflations.

TABLE 15.—AVERAGE BACTERIAL COUNTS BY PERIODS FOR THE TWO METHODS.

| Period | Weekly dismantling | Daily dismantling |
|---|---|---|
| Dec., Jan., Feb. | 8,170 | 24,600 |
| Mar., Apr., May | 7,961 | 16,600 |
| June, July, Aug. | 5,264 | 9,060 |
| Sept., Oct., Nov. | 4,100 | 13,600 |
| Average of all counts for the two years | 6,200 | 18,024 |

## THE SERUM-SOLIDS CONTENT OF MILK

This project has been completed and the data are being prepared for publication. One thousand and thirty-five samples of milk have been analyzed. Seven hundred and forty-nine samples were from individual cows and two hundred eighty-six were mixed samples from eleven herds.

Table 16 gives the average composition of milk from the herds. Monthly samples were obtained for two years from six herds and for one year from five herds.

The average serum-solids ranged from 8.42 per cent for one of the Holstein herds to 9.48 per cent for one of the Jersey herds. The herds of mixed breeding ranged between these limits. The total solids ranged from 11.85 per cent to 14.48 per cent. The average lactose content of 4.71 per cent would be considered low since this constituent is usually given as about 5 per cent. The highest lactose average of any herd is 4.86 per cent for a Guernsey herd. The average density of 1.0333 indicates that Arizona milk is higher in serum solids than that of the country as a whole, since the density of average milk is usually given as 1.032.

The effect of weather, feed, breed, condition, etc., will be discussed in detail in the manuscript for publication.

TABLE 16.—AVERAGE COMPOSITION IN PER CENT AND DENSITY OF MILK FROM ELEVEN ARIZONA HERDS.

| No. herd | Fat | Total solids | Serum solids | Lactose | Protein | Cl. | Acid | Density | Breed |
|---|---|---|---|---|---|---|---|---|---|
| M H | 3.48 | 12.03 | 8.55 | 4.67 | 2.85 | .098 | 0.17 | 1.0322 | Holstein |
| 17 | 3.43 | 11.85 | 8.42 | 4.74 | 2.83 | .097 | 0.17 | 1.0324 | Holstein |
| 245 | 3.83 | 12.64 | 8.81 | 4.69 | 3.24 | .090 | 0.22 | 1.0330 | ½ H. ½ G.&J. |
| 166 | 3.54 | 12.02 | 8.48 | 4.69 | 2.92 | .100 | 0.19 | 1.0325 | Holstein |
| 188 | 3.97 | 12.74 | 8.77 | 4.65 | 3.24 | .090 | 0.22 | 1.0332 | ½ H. ½ G. |
| 77 | 3.70 | 12.29 | 8.59 | 4.56 | 3.16 | .088 | 0.20 | 1.0331 | ¾ H. ¼ J. |
| 255 | 3.63 | 12.47 | 8.84 | 4.67 | 3.20 | .091 | 0.19 | 1.0336 | ⅔ H. ⅓ J. |
| 3 | 3.81 | 12.53 | 8.72 | 4.78 | 3.09 | .100 | 0.17 | 1.0330 | 4/5 H. |
| M G | 4.32 | 13.55 | 9.23 | 4.86 | 3.27 | .085 | 0.17 | 1.0342 | Guernsey |
| 4 | 5.00 | 14.48 | 9.48 | 4.77 | 3.57 | .069 | 0.18 | 1.0351 | Jersey |
| 18 | 4.86 | 14.18 | 9.32 | 4.74 | 3.51 | .070 | 0.18 | 1.0345 | Guernsey |
| Av. | 3.96 | 12.79 | 8.83 | 4.71 | 3.17 | .088 | 0.18 | 1.0333 | |

## PASTURE STUDIES

### Nutritive value of annual pasture crops

It is possible to have practically a year-round pasture program in the irrigated valleys of southern Arizona through the use of alfalfa and annual crops such as barley, oats, and Sudan. More recently, as a result of the acute labor shortage, interest has been aroused in the place of permanent pastures in the state. Good pasture is the dairy farmer's cheapest and best feed. Information on the nutritive value of Arizona pasture crops is essential to the formulation of a well-balanced feeding program.

TABLE 17.—ANALYSIS OF BARLEY, OAT, AND WHEAT PASTURE (AIR-DRY BASIS).

| Grazing | Height (inches) | Moisture | Protein |
|---|---|---|---|
| | Barley | | |
| 1st | 12-14 | 81.8 | 20.3 |
| 1st | 10-12 | 85.1 | 14.74 |
| 2nd | 12 | 77.2 | 18.20 |
| 2nd | 10-12 | 79.8 | 25.5 |
| 3rd | 11-13 | 78.2 | 19.19 |
| | Oats | | |
| 1st | 6-7 | 80.0 | 19.39 |
| 1st | 7-8 | 79.4 | 19.85 |
| 1st | 6-7 | 78.07 | 21.11 |
| 1st | 8-9 | 79.61 | 17.84 |
| 1st | 8-9 | 80.16 | 18.74 |
| 2nd | 5-6 | 75.86 | 17.34 |
| 2nd | 5-6 | 82.3 | 30.4 |
| 2nd | 5-6 | 83.0 | 30.75 |
| 2nd | 7-8 | 75.7 | 19.0 |
| 2nd | 6-7 | 74.6 | 15.19 |
| | Wheat | | |
| 1st | 12-14 | 79.79 | 17.75 |
| 2nd | 12-14 | 80.9 | 16.25 |

During the year clippings were made of successive grazings of fields of barley, oat, and wheat pasture at the Campbell Avenue University Farm. These consisted of square-meter samples taken just prior to grazing in each field and were analyzed through cooperation of the Department of Agricultural Chemistry and Soils.

Wheat is seldom used for pasture in Arizona. A border was grown in a comparison with oats and barley in the same field. Since it grew more rapidly than the other crops, it was clipped and grazed at a more advanced stage of growth.

The data in the table show that oats and barley, the commonly sown annuals in Arizona, are good sources of protein through at least three grazings. On the green basis, the protein content of the listed cuttings ranges from 2.5 to 5.4 per cent. It is apparent that on good pasture the dairy cow in southern Arizona is receiving well above the protein requirements for maintenance and milk production. The wartime shortage of high protein concentrates need have no concern for the dairyman with a well-managed pasture program in operation.

**Palatability tests**

No difference was observed in the way in which the dairy herd grazed California Red and Texas Red oats planted in adjoining borders. At the first grazing the California Red had about a 15 per cent advantage in growth, which was not evident in later grazings.

No significant difference was noted in the palatability of Common and Tift Sudan. The latter is a new variety developed at the Georgia Coastal Plain Experiment Station. It made less growth up to the time of first grazing, as the common Sudan had an advantage of about 14 per cent in height and about 11.5 per cent in dry weight at first grazing. This difference was not observed at later grazings.

## METHODS OF DRYING OFF COWS

For over two years all cows in the University herd, with one or two exceptions, have been dried off by the "stop-milking" method. This consists in reducing the grain for the last few days before milking is to be discontinued, then placing the cow in dry lot, with all feed removed except a part ration of hay. Water is provided at all times. The cow is kept under observation until all swelling has left the udder.

It should be stated that this herd is relatively free of mastitis, as judged by gross symptoms such as flaky or clotty milk. Five of the cows showed counts ranging up to 60,000 bacteria per c.c. in their milk.

This past year all cows, with one exception, were dried off by this method with entirely satisfactory results. Maximum daily production recorded at the start of the drying-off period was 22

pounds for Holsteins, 20 pounds for Jerseys, and 23 pounds in the case of one Guernsey. It is felt definitely that more dairymen could take advantage of this labor-saving procedure with all cows known to have comparatively healthy udders.

## ENTOMOLOGY AND ECONOMIC ZOOLOGY

### RANGE RODENT INVESTIGATIONS

Life-history studies and stomach collecting for food data on both the Arizona cottontail and the Arizona round-tailed ground squirrel were continued. The latter is the small, plain, grayish squirrel, abroad by day, commonly miscalled a "gopher." It spends some months of the year in aestivation-hibernation and has a short spring breeding season, producing only a single litter of young each year.

Some extension of the rodent studies has resulted in securing specimens of rodents not, until recently, known to occur in the state. Still another, a very small species, occurs in the grass country of Cochise County, but we have not yet succeeded in taking specimens.

### SCALE INSECTS

Scale insects of both wild and cultivated plants continue to arrive for identification, and field collecting, especially of the obscure and little known but highly important scales of forest conifers, is being continued as opportunity permits. A small prostrate *Euphorbia* (*albomarginata*?) was found to be the host of a species of coccid, *Margarodes* sp., associated with the kangaroo rat, *Dipodomys spectabilis*. Another scale associated with rodents was found on galleta grass, *Hilaria jamesii*.

The war has stimulated interest in the lac-producing insects (scales); and in addition to collecting these, a list of the lac insects of the Western Hemisphere and a check of the literature since 1913 are being made. Thus, information on American lac insects will be on hand if and when it is required in the war effort. (Shellac is derived from the secretions of lac insects.)

### GUAYULE INSECT PESTS

At this time also, insects affecting guayule (Mexican rubber plant, *Parthenium argentatum*) and closely related plants may be important. Accordingly, scale insects affecting false guayule, *Parthenium incanum*, are being collected and identified.

The carrot beetle, *Ligyrus gibbosus* (a brown June beetle), was found in the summer of 1942 to be injurious to guayule. These beetles or their larvae attacked and girdled the roots, and this resulted in the death of a high proportion of the plants, beginning

in June and continuing throughout the summer. Damage by this insect was somewhat less in 1943, but whether because of fewer beetles or greater resistance of the older plants is not known.

## OTHER PESTS

Beans, soybeans, zinnias, and *Sophora japonica* were damaged at Willcox and Douglas, as well as at Tucson, in 1942, by a leaf beetle closely resembling *Chalepus scapularis.*

Assassin bugs, *Triatoma uhleri, T. protracta,* and *T. longipes,* always attacking sleeping persons to some extent in early summer, were particularly annoying in May and June, 1943; and especially so at Montezuma Castle and Tuzigoot National Monument, as well as around Tucson. Since the first two of these pests breed only in the nests of the wood rat (pack rat) and are not commonly found far distant from their breeding places, it follows that only dwellers in rural areas are molested. A rather simple preventive measure is to keep wood rats cleared out of the immediate vicinity (radius of 200 yards) of the dwelling house. This may be readily accomplished by the use of ordinary (snap) rat traps.

Also causing great discomfort to humans by its blood-sucking activities in 1943 was the Mexican chicken bug, *Haematosiphon inodora,* especially at Canyon de Chelly and Tonto National monuments. These pests are most active in April, May, and June.

The brown dog tick, *Riphicephalus sanguineus,* was rather plentiful during the last summer of 1942. This tick, not native, is becoming more prevalent as dogs increase in abundance, and several houses have become infested, to the discomfort of the human inhabitants. Fortunately, this tick seldom attacks man.

## PECAN APHIDS

Continuation of life-history observations on the black-margined aphid, *Monellia costalis,* indicates that under favorable winter conditions aphids may be present and feeding on trees in the Tucson area from early May until late December. This species occurs on pecan trees in the Safford, Tucson, Phoenix, and Yuma areas.

In September, 1942, specimens of the black pecan aphid, *Melanocallis caryaefoliae,* were collected from pecan trees at Thatcher, Safford, and Solomonsville. This is the first report of the presence of this pecan pest in Arizona. It is well established in the areas mentioned; and since elsewhere it is considered as the most important defoliating insect of pecan, its presence there may indicate the approach of an important problem of control.

### COLLECTIONS

Besides the special collections made in connection with scale insect and aphid problems, the general insect collection continues to expand. The grasshopper collection has recently been put in fine systematic order.

Vertebrate collections, especially of birds and mammals, are continually augmented by gifts, through classwork, and in connection with field work on Station projects.

## HORTICULTURE

### CITRUS INVESTIGATIONS

**The Salt River Valley Citrus Research Farm**

On April 23, 1943, the citrus growers of the Salt River Valley gave the University a 40-acre citrus grove located southwest of Tempe. This grove fills a long-recognized need and provides a valuable addition to citrus research facilities. Most important perhaps is that it will provide an opportunity to put the results of researches into effect where they can be conveniently visited by the large majority of the state's citrus people. This should have material influence toward increasing yields, improving fruit quality, reducing operating costs, and other desirable ends for the citrus industry of the Salt River Valley.

Most trees in the orchard are in bearing. Grapefruit, navels, and Valencias range from eight to twelve years. Miscellaneous varieties of oranges are somewhat younger. The orchard is well divided as to varieties, with some 1,500 grapefruit trees and 500 each of navels, Valencias, and sweets. The trees are uniform and reasonably well adapted for plot studies.

During the first summer, the irrigation system has been changed so that the water is now run crosswise of the slope. Each row of trees is in a separate border and these are terraced with a 2- or 3-inch difference between the rows.

Several plots have now been laid out. These are designed for such investigations as the effects of varying irrigation practices on yield and quality of fruit and the relationship of seasonal nitrogen supply to yield and quality. Another plot is arranged for the study of nitrogen control effects and general usableness of various permanent covers in citrus orchards. Still another has been planned to study the effects of various methods of orchard handling upon soil organic matter and the seasonal release of nitrogen from it. This latter is in co-operation with the Soils-Chemistry Department. While the above apply chiefly to grapefruit, they also extend to oranges. Special studies with navel oranges also involve pruning and a possible relation of tree form to movement of nitrogen into the top of the tree.

**The nitrogen control program for grapefruit orchards**

It has now been nearly six years since the studies on the effects of seasonal nitrogen supply were initiated. The results have clearly and consistently revealed that the orchard management program should be built around practices to make nitrogen available at a time when the tree needs it and unavailable when it is not needed or may be damaging. Methods to control nitrogen have been adapted by many growers, and the term "nitrogen control program" is commonly used. Nitrogen must be controlled.

Each year new information seems to emphasize the value of such a program and the need for more complete knowledge of factors relating to nitrogen availability in the soil and its metabolism in the tree. It is remarkable how many factors having to do with the market value of the fruit are improved by decreasing the nitrogen content of the tree through the summer and fall. Earlier coloration and improved rind texture were among the first effects noted. Then it became evident that acid was generally reduced and sugars increased, giving a higher ratio. The possibility of holding the fruit on the tree later into the spring was indicated. Data from the fertilizer study have shown that nitrogen supply has had a pronounced influence upon the uptake of calcium, phosphorus, and potassium. This year there has been a most interesting and valuable addition to this list. It has been found that the concentration of vitamin C in the juice is increased when nitrogen is reduced.

**An inverse relation of nitrogen to the vitamin C concentration in citrus juice**

Beginning in the fall of 1942, grapefruit samples were collected at approximately weekly intervals from the Yuma plots and sent to Tucson, where the juice was analyzed for vitamin C by the Human Nutrition Department. The fruit was from plots which had been treated to give a low, medium, and high nitrogen nutrition through the period of fruit maturity. While no analyses for nitrogen were made, the appearance of the trees and fruit bore evidence that the treatments had produced the desired effects upon the nitrogen content of the tree.

During the spring of 1943 a similar study was made of fruit from plots on the Bartlett-Heard ranch in the Salt River Valley. The data corroborated those from the Yuma plots.

A much more detailed study involving both navel oranges and grapefruit was inaugurated in September, 1943, again with samples from the Yuma plots. Analyses are being made in the horticultural laboratory and include not only ascorbic acid but nitrogen in various tissues, sugar, citric acid, pigments, and various mineral elements. The data obtained to date (November 1, 1943) have clearly shown what those of last year indicated: that there is an

inverse relation between nitrogen content and vitamin C. Figure 2 shows this for grapefruit juice.

The data have been remarkably consistant and statistically significant. It is now possible to report with assurance that nitrogen has a regulating effect upon the concentration of vitamin C in citrus juice. The grower who uses practices which reduce the nitrogen content of the tree during the summer is very likely increasing the vitamin C concentration in the fruit.

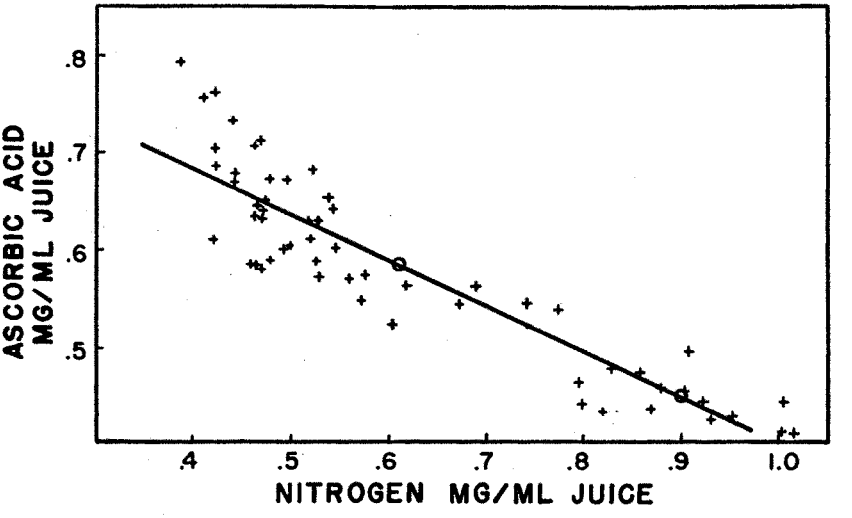


Figure 2.—Nitrogen influences the vitamin C content of grapefruit. Note that the ascorbic acid content of the juice is least where nitrogen is highest.

**Permanent covers in citrus orchards**

It is now five years since some of the permanent covers were first planted in the experimental plots. Since then there has been no cultivation. Handling has consisted simply of applying commercial nitrogen each winter, irrigating when necessary, and cutting and removing the cover each fall. Yields have been well maintained, and the pack out has consistently shown a superior quality of fruit. They have provided an excellent means for obtaining the necessary "nitrogen control."

**Factors influencing the acid content of grapefruit juice**

The percentage acid in grapefruit juice has always been a factor in saleability of fresh fruit. Of recent years juice canneries in the Salt River Valley have found that at certain seasons some of the juice may have more than 2.05 per cent citric acid, which is the minimum tolerance for U.S. Grade A juice.

As already indicated, where orchard treatments have brought about a reduction in percentage nitrogen in the tree as the fruit matured, the juice of the fruit has tended to have a lower percentage acid. Information gained this year suggests that temperatures may have an important effect upon acid content over and above that of nitrogen nutrition.

On April 4, fruit from the Bartlett-Heard ranch was carefully selected and divided into three lots. Acid was immediately determined on each fruit of one of the lots. The other two lots were stored sixteen and twenty hours, respectively, at 110° to 120° F., with a relative humidity approaching saturation. At the end of sixteen hours the fruit contained only 90.4 per cent of the original acid, and at the end of twenty hours only 80.4 remained. The Brix value did not change significantly during this period.

Apparently, the increased temperature speeds up respiratory activity, which takes place at the expense of the acid. The recognition of the influence of temperature provides an interpretation of some commonly known situations. As an example, fruit grown at Yuma, where temperatures are higher, has a consistently lower percentage of acid than that of the Salt River Valley.

A further example is that as fruit matures through September and October there is a gradual reduction in percentage acid. This appears to be related to ripening processes. As cooler weather comes on, the reduction in acid ceases and by December begins to increase. This increase is less pronounced at Yuma than it is in the Salt River Valley, where the acid remains high until the warmer temperature of early spring.

It appears that Salt River Valley canners would be helped by (1) a program to educate growers to the need of using practices which depress nitrogen supplies during the period of fruit maturity, (2) as much as possible avoid canning during the coldest weather, and (3) if practicable, heat-treat high-acid fruit before processing it.

**The influence of nitrogen upon the uptake of phosphorus, calcium, and potassium in grapefruit**

The grapefruit fertilization study has been completed after seven years of comparisons. Nitrogen is the only element that has improved yields.

Many analyses of plant tissue have been made throughout the course of the study. These indicated another important influence of nitrogen having to do with the uptake of calcium and phosphorus. During the last year of the study an extensive sampling of the plots was made. The analyses of the samples have now been completed, including a determination of potassium by the Department of Agricultural Chemistry.

Leaves in all plots fertilized with commercial nitrogen tend to have the same content of phosphorus, calcium, and potassium,

regardless of whether or not these elements were applied. Similarly, trees in all plots not fertilized with nitrogen tend to be alike in phosphorus, calcium, and potassium, whether or not fertilized with them. On the other hand, there are wide differences in phosphorus, calcium, potassium, and nitrogen among plots fertilized with nitrogen and those not fertilized with it. The plots fertilized with nitrogen have a higher nitrogen and calcium content. In fact, the amount of calcium was about doubled by the nitrogen application. There was about a fifth more on a percentage basis.

The phosphorus and potassium content of the leaves was inverse to that of the nitrogen and calcium. Where no nitrogen was applied the percentage phosphorus was two or three times as high as it was in the nitrogen-fertilized plots, and the actual amount per leaf was about doubled. Differences in potassium were similar but not so great.

In the fruit, phosphorus content was more influenced than that of any other element. As for the leaves, it was lowest where nitrogen had been applied.

The question might well be asked, "What is the significance of these differences in mineral composition?" At the present time we know of none. Differences in the content of phosphorus, calcium, or potassium within the range of the present studies have had no effect upon the yield or quality of fruit or other economic condition. That nitrogen should influence uptake of these elements to such an extent is interesting and further emphasizes the importance of the role of nitrogen in citrus orchard management. It gives additional evidence that citrus growers need not spend money for these fertilizing elements or for special materials to make them available. However, more should be known of the effect of the nitrogen nutrition of the tree on mineral elements in the edible portion of the fruit. Such information would be important from the human nutrition viewpoint.

## VEGETABLE CROP INVESTIGATIONS

### The Salt River Valley Vegetable Research Farm

A year ago it was reported that the old Tempe Date Garden was being adapted for use in vegetable investigations. This conversion has continued through the past year. About 14 acres are now cleared of palms. Some of this is in use now, and the balance is being improved by growing green manure crops and by other treatments. The greenhouse unit has been completed. The greenhouse is of two compartments, with provision for the automatic heating of one. Thus, through the winter months it will be possible to grow plants at differential temperatures. It is appropriate that such facilities be available, since temperatures play such an important role in the operation of the fresh-vegetable industry of Arizona.

With these changes accomplished it was decided to give the date garden the more appropriate name of "Salt River Valley Vegetable Research Farm." This corresponds to that for the new citrus farm. Laboratory facilities for all horticultural investigations of the Salt River Valley will continue to be maintained, but otherwise the old date garden will be devoted to vegetable research.

**Lettuce fertilization**

Again the importance of soil organic matter either as barnyard or green manure has been revealed. Plots receiving corral manure in 1940 and green manure in 1942 produced more marketable heads than those receiving either one alone. The highest yields of lettuce occurred when either treble superphosphate or 11-48 ammonium phosphate was band-placed at the time of planting in plots which had already received both corral and green manure.

Commercial and experimental mixed fertilizers of 10-20-0 and 10-30-0 analysis containing either blood meal or other organic material produced somewhat more lettuce than treble superphosphate or 11-48 ammonium phosphate when used in the absence of other manures on this soil low in organic matter.

Studies on the effects of band-placed and broadcast sulphur were made in 1942-43 on the Valley Vegetable Farm where the soil is low in $CO_2$-soluble phosphate and nitrate-nitrogen. Yields were not improved by the sulphur.

**Cantaloupe breeding and selection**

The cantaloupe breeding program begun in 1938 resulted this year in the release of a new variety known as Arizona 13. When

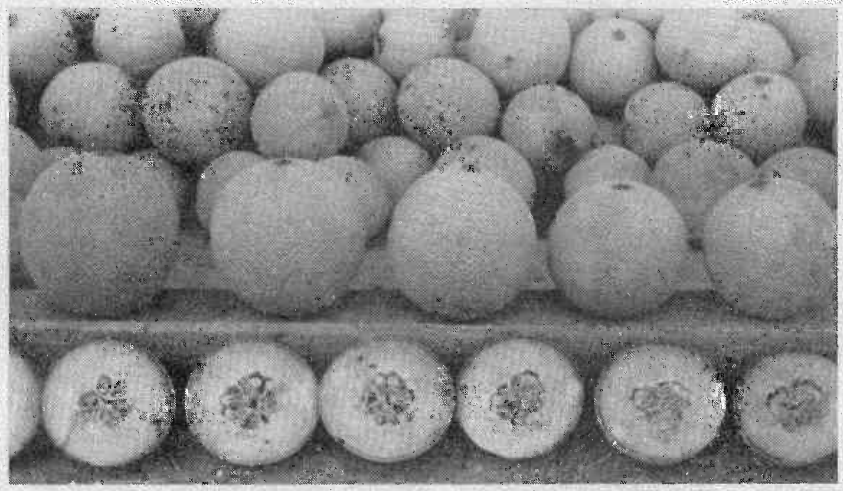

Plate V.—Field run specimens of the Arizona 13 cantaloupe. Note uniformity, lack of rib and stripe, thick flesh, small cavity, and firm matrix.

released it was an eighth generation selection within a line obtained by inbreeding from the progeny of a cross between the Imperial 45 and the AZ, a commercial selection out of the Superfecto. The original cross and subsequent selection were aimed at combining the fine edible characteristics of the Superfecto with the firm-fleshed character of the Imperial 45. The Arizona 13 appears to combine these characters well and to possess other desirable features.

Some 400 pounds of Arizona 13 seed were produced under isolation. A supply was given to all interested seed companies for foundation purposes; the remainder was given to growers in the state. For variety stabilization purposes, it is planned to maintain foundation stocks as long as the variety is in demand. A 7-acre increase plot of Arizona 13 is being grown by Yuma shippers in the late summer of 1943.

**Lettuce breeding and selection**

Strains of 615 and 152 inbred and selected in Arizona are now known as Arizona 615 and 152. During the past season the foundation stock of both varieties was increased in the Yuma Valley by the Central Arizona Grower-Shipper Association under the supervision of the Experiment Station.

In the Salt River Valley, test plantings of these strains have been made by growers. Both strains continue to indicate special merit for Arizona. The Arizona 152 has been particularly well received because of its uniformity, vigor, resistance to bolting, high protective wrap, and complete lapping of head leaves.

Selection and inbreeding in hybrid lines has continued. Two strains now in the sixth generation from a cross of 615 and 152 were grown in a commercial test. Strain 3-4-43 appears well adapted. It is more vigorous than 152, which it resembles, is fairly resistant to bolting and tip burn, and seems to hold up longer than comparable varieties. Strain 0-29-43 is later, larger, and more resistant to bolting than strain 3-4-43. Arizona strain 24-43 from the U.S. Department of Agriculture hybrid 41068 is now in the seventh generation. It is greener than Imperial 44 but otherwise resembles it and gives promise as an early variety.

**Tomato production**

The extremes of temperature experienced in southern Arizona give difficulty in tomato growing. There is a relatively short time between temperatures which are too low in the winter and those which are too high in the summer, or vice versa in the case of fall planting.

As is well known, high temperatures tend to encourage extreme vegetative growth, reduce blossoming, and increase blossom drop. High nighttime temperatures are thought to be especially damag-

ing through stimulating respiration and consequent loss of carbohydrates during the night when replacement by photosynthesis does not occur. Experiments at the Valley Vegetable Farm in 1943 indicate that this difficulty can be overcome to a considerable extent with the use of better adapted varieties and by carefully controlled fertilization and irrigation.

Seed of several varieties was planted March 1 under hotkaps. The Improved Pearson yielded 900 lugs per acre, 720 lugs of which were picked between July 1 and 28. The new Victor was the only other variety to approach Pearson in yield; it was about ten days earlier. Stone and Rutgers were moderately satisfactory, but Super Marglobe was extremely vegetative and set no fruit.

Studies at Tucson, where temperatures are slightly lower, also indicated the merit of the Pearson variety. The desirability of early plantings to produce blossoms before the high summer temperatures was clearly shown.

**Onion production**

Onion variety trials have revealed some of the characteristics and the outstanding merit of the Babosa, a recently developed straw-colored onion of the Grano type. It is by far the most promising new variety to be introduced into Arizona. Plantings made on September 20 on the Valley Vegetable Farm produced marketable bulbs ½ to 1 pound in weight by May 1; this indicated that it could be harvested somewhat in advance of peak shipments from other early areas. A yield of 18 tons per acre was obtained.

Onion production is somewhat hazardous in the lower elevations where they are grown as an over-winter crop. If they are planted too early there is danger of bolting in the spring, with consequent reduction of yield and quality of bulbs. Conversely, if they are planted too late the plant does not attain sufficient size before bulbing and low yields result. The Babosa is highly desirable for over-winter production because of its high resistance to bolting and its small, tight neck. Extensive commercial plantings are being made for 1944 shipment.

**Vegetable seed production**

Some 400 acres of vegetables were grown for seed in Arizona in 1942-43, and about 2,000 acres are under contract for 1943-44. This development is largely in answer to demands for seed to be sent abroad throught lend-lease and is based to a considerable extent upon exploratory research by the Horticulture Department.

Trials through the several years have indicated that Arizona has some advantages in seed growing—especially for certain hardy annuals and biennials. One of these advantages is that

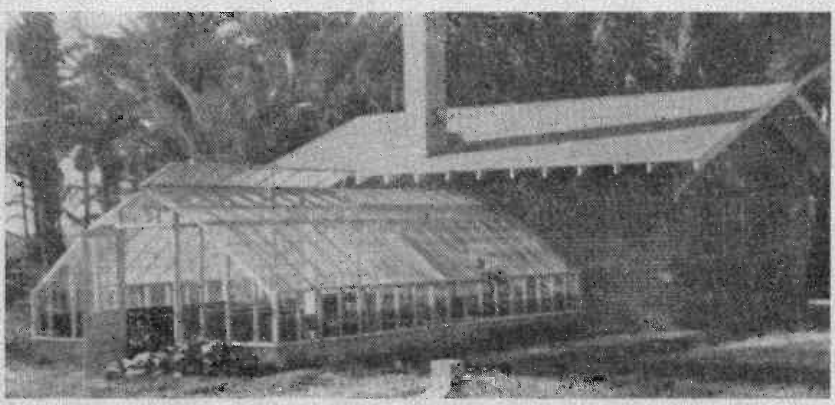

Plate VI.—New greenhouse unit on the Salt River Valley Vegetable Research Farm provides needed facilities for studying temperature effects on vegetable crops and will facilitate the vegetable breeding program.

seed can be harvested in less than twelve months, compared with two-crop years in many areas. Another is the freedom from rains at harvest time; and for most crops, depending upon elevation, there is ample chilling in the winter to induce seeding but not enough cold to make winter freezing a hazard. Freedom from disease is probably another advantage.

Certain problems in vegetable seed production have appeared. Insect pests constitute a major one of these. Also, the rapid increase of temperature in the early spring may cause a reversion to vegetative growth in certain types of vegetables. In some instances it causes light seed. The necessity of planting in areas where chilling requirements of the particular crop will be satisfied has been emphasized. Commercial seed production of cabbage has been unsuccessful in the Salt River Valley where some 1,100 hours of chilling occur each winter. It is not certain that it can succeed anywhere in the state, but limited trials have indicated possibilities at elevations where there are 1,400 hours or more of chilling.

Lettuce, endive, carrots, and some others appear to have possibilities in the lowest elevations, such as at Yuma. In elevations of the Salt River Valley, broccoli, table beets, carrots, and onions seed well, and they continue to do so into somewhat higher elevations. Cabbage would be limited to the latter.

**Co-operation with the U.S.D.A. in vegetable work**

Since 1938 the lettuce and cantaloupe breeding work has been covered by a memorandum of agreement with the Bureau of Plant Industry. This has provided for an exchange of crosses and selections to further the breeding program with these crops. In 1942-43 new strains developed by the Bureau in the east for

eastern growers were increased on the Yuma Valley Farm. This arrangement hastens the variety development program of the government breeders in the colder areas. This past year the vegetable seed production studies were made co-operative with the Bureau. At the same time and with the commercial growing of vegetable seeds in this state and their ultimate consumption in lend-lease channels, a member of the Department was deputized to inspect the various fields and to report on them to the lend-lease agency. Recently, the War Food Administration has asked the Horticulture Department to co-operate in testing some of the lend-lease seeds.

## DATE INVESTIGATIONS

### The 1943 season at the Yuma Valley Date Garden

Systematic fruiting of the palms was again accomplished by arrangements with a commercial grower. The first appearance of blossoms was, as previously, on the Khadrawi palms and occurred early in February. Pollination was accomplished during February and March on all varieties. Only a few bunches remained to be pollinated after April 1. This year a tuft of cotton carrying a liberal supply of pollen was tied into each bunch. There was no apparent lack of pollination as in the previous season.

A number of trees still carry some offshoots. There has been no fertilization of the grove, but the palms appear quite thrifty. No tree was allowed to carry more than eight bunches. A total of 1,500 bunches was pollinated, supported, and thinned. Spreader rings were inserted, and just before ripening cloth covers were put on to protect the fruit from birds and bees.

Ripening began the latter part of August and ended early in October. The order of ripening was: Khadrawi, Hayany, Sayer, 16-23, Iteema, Tadala, Kustawi, Halawi, Gush, Braim, Apdamdon, Laguna, Zahidi, Deglet Noor, Maktoom, and Hellila. There were no rains during the ripening period to cause any loss of fruit. Fruit of all soft varieties was of high quality, but Khadrawi, 16-23, and Maktoom were outstanding. There was some checking in the Hayany, Deglet Noor, and Hellila varieties, although it was not severe. Early in the season, Hayany fruit was damaged somewhat by "sour bugs." It is evident that this variety has need for constant care and quick handling through fumigation and curing. Blacknose in Deglet Noor was not severe, but considerable shriveling tended to make fruit of this variety inferior. Deglet Noor consistently bears heavy crops, and the fruit looks good until ripening begins; then it deteriorates.

Because of the high water table only four irrigations were given during the growing of the crop. The last was in late May. During January and March there was 0.61 inch of rain.

More than 15,000 pounds of marketable fresh fruit were harvested.

## PECAN INVESTIGATIONS

**The pecan situation in the Yuma Valley**

A few more small pecan orchards have been removed during the past year. The high prices for annual crops, together with accumulating evidence that pecans are not climatically suited in the Yuma Valley, has tended further to decrease interest in pecans.

As has been many times reported, one of the important climatic limitations for pecans at Yuma is the high summer and fall temperatures. These induce poor filling and other defects of kernels—probably through speeding up respiration, thereby destroying carbohydrates which would otherwise be available for oil synthesis. It has for many years been reported that a reduced nitrogen content favored filling and a higher oil content. It seems appropriate now to note that each year those plots which have been handled to give a reduced nitrogen and an increased carbohydrate content through the summer and fall have produced marketable nuts. Thus it is possible by careful handling to obtain well-filled nuts of most varieties in spite of the adverse climatic conditions. However, only a few varieties are sufficiently well adapted to give well-filled nuts under ordinary commercial handling.

Yields are more influenced by winter temperature and light conditions than by any other factor. Thus far, treatments with various chemicals to break dormancy have failed to give a completely usable response. The use of varieties requiring relatively little chilling in the winter is the only solution known at present.

A light crop was borne in 1943. This was believed to be related to dormancy conditions of the previous winter when there were only 613 hours of chilling and a higher than average percentage of sunshine. Delayed foliation in the spring was very much in evidence.

# HUMAN NUTRITION

## VITAMIN ASSAY STUDIES

Because of the wartime stimulated interest in and the need for information concerning nutritive value of foods, the Department of Human Nutrition has for the past year carried on research along the lines of vitamin assays as a part of the National Co-operative Research Project on the Conservation of the Nutritive Value of Foods.

**Factors affecting the vitamin C content of cantaloupe**

The findings of the preliminary study of vitamin C (ascorbic acid) value of cantaloupe as related to such factors as varietal

differences, stage of maturity, growth conditions such as difference in soil fertilization, and light intensity have been presented in Mimeographed Report 53, February, 1943.

The ascorbic acid content of cantaloupe was found to increase with ripening, ranging from the average of 29.0 mg./100 gm., edible portion in the green melons of the first harvest to 40.6 mg./100 gm., edible portion, in the fully ripened melons of the fourth harvest. Again, cantaloupe shaded from the sun during the growth period by covering with cloth were found to be of an inferior quality, smaller in size, and lower in vitamin C value than the sunned melons picked at the same time from the same field. Their ascorbic acid content averaged 37.2 mg./100 gm. and 46.0 mg./100 gm., edible portion, respectively.

Appreciable differences in the ascorbic acid content of the cantaloupe also resulted from different fertilizer applications. Analyses of melons of the same variety, all picked at full slip at the same time, showed an average ascorbic acid value of 48.0 mg./100 gm. of ripe edible portion for those picked from vines that had received nitrogen side dressing at the time the fruit set, 41.8 mg./100 gm. for those receiving phosphate side dressing, and 40.6 mg./100 gm. for those given combined nitrogen and phosphate fertilizer application.

Analysis of a few samples of five different varieties of cantaloupe, all picked at full slip, showed an ascorbic acid content of edible portion as follows: Burrel Gem 54.4, Superfecto 37.6, Jade Beauty 41.3, Pride of Wisconsin 67.1, and Arizona strain 45, 40.9 mg./100 gm.

The vitamin C value of honeydew melons handled in different ways was also determined. Those tested were much larger in size and lower in ascorbic acid content than the cantaloupes. Ripe honeydew melons were richer in ascorbic acid than green ones; they were also richer than those considered to have passed beyond the desirable ripe stage. Thus green honeydew melons were found to average 16.7 mg./100 gm., edible portion, as compared with 25.1 mg./100 gm. ripe melons and 18.8 mg./100 gm. of the overripe ones. No significant difference was found in the ascorbic acid content of ethylene-treated and of nontreated honeydew melons.

In conclusion it may be emphasized that cantaloupe can be considered an excellent fruit source of vitamin C.

**Factors affecting the vitamin A, B, and C content of Arizona-grown carrots**

Carrots are grown in Arizona at different seasons of the year and therefore under different soil temperatures. Harvesting usually begins in the early fall and continues until early summer. In co-operation with the Department of Horticulture a study has been made to determine the vitamin A (carotene), vitamin $B_1$ (thiamine), and vitamin C (ascorbic acid) of carrots as affected

by the environmental conditions under which they are grown. Fifty-foot plantings in east-west beds of two varieties of carrots, Chautenay and Imperator, have been made in Yuma and Tempe in October, November, December, February, and March. In order to determine the relationship of the nutritive value of these carrots with their size, age, and season of maturity, the carrots have been harvested each month after planting and analyzed for their vitamin content.

The carotene assay has been carried out by following the method of L. A. Moore as modified by Moore and Ely. The carotene was thus extracted in the Waring blendor, using an alcohol-petroleum ether (Skellysolve) foaming mixture. Interfering pigments were removed by passing through an absorption column of Baker's dicalciumphosphate mixed with Dyno to speed up passage. The concentration of carotene is measured in the Evelyn photoelectric colorimeter, comparing the readings with a calibration curve of pure beta-carotene. The thiamine content of carrots has been measured by following the thiochrome method of Hennessey and Cerecedo, as modified by Conner and Straub. The concentration of the extracted thiamine which is oxidized to thiochrome has been measured in the Phaltz-Bauer photoelectric fluorophotometer model A. Again, for the assay of the vitamin C value the method of S. A. Morell has been followed. It has consisted briefly of extraction of the ascorbic acid by blending the carrots in 3 per cent metaphosphoric acid solution in the Waring blendor. The bleaching effect of the ascorbic acid on 2-6 dichlorobenzenoe-indophenol was then measured in the Evelyn photoelectric colorimeter, with correction made for turbidity and interfering pigments. The moisture content of representative samples of all carrots selected for the vitamin assay has been determined by drying them in the vacuum oven at 70 degrees for six hours. All results are being expressed on both the fresh- and dry-weight basis and are being prepared for publication at an early date.

**Factors affecting vitamin C content in Arizona grapefruit and oranges**

A previous study of the Department of Horticulture has shown that grapefruit grown in Arizona on "low nitrogen trees" tend to be sweeter, to color earlier, to be thinner skinned, better shaped, and therefore of higher market value than those grown on "high nitrogen trees." As citrus fruits are recognized as an excellent source of vitamin C (ascorbic acid), a study of the relationship of this and other factors to the ascorbic acid content of citrus fruits was begun. Collection of samples of Marsh grapefruit and navel oranges from the University Farm near Yuma began in the fall (September 30) when coloration of the fruit was in process, and continued at weekly intervals until the fruit was ready for marketing. Thereafter, sampling was continued every two weeks until the middle of January. Thus changes were observed in the

ascorbic acid content of the fruits left on the trees as long as they remained marketable. A selection was made of citrus fruit from trees of both high and low nitrogen nutrition. Fruits selected from the north, south, east, west, and center of the trees were weighed and analyzed separately for their volume of juice, pH, total acidity, per cent of sugar (Brix), and ascorbic acid content. All the analyses of the ascorbic acid content were made by following the method of Morell, using the Evelyn photoelectric colorimeter for measuring the extent of bleaching of 2.6 dichlorobenzenoe-indophenol, in preference to the less satisfactory visual titration method.

A similar study of the grapefruit and oranges grown near Phoenix, the collection of which began in March and continued biweekly until the middle of June, has been under way. The data from both locations are being tabulated and prepared for publication at an early date.

**Losses in nutritive value of vegetables by home dehydration**

Drying of foods in the home is now widely recommended as a practical, simple, and inexpensive method of preserving foods produced on the farm or in victory gardens. In rural areas of Arizona it is commonly practiced by following the method recommended by the University of Arizona Extension Nutritionist in Extension Folder W-8, *Drying of Fruits and Vegetables.* The type of the small air-blast home drier, which is recommended, has been described in Extension Folder W-7, *Home Evaporator.*

Accordingly, following the recommended practice, the losses in certain essential nutrients which might result from the home drying of foods has been under investigation. Beets, beet greens, snap beans, broccoli flowers and stems, green cabbage, red cabbage, carrots, rutabagas, banana squash, spinach, Swiss chard, turnips, and yams have been included thus far in this study. Representative samples of each of the fresh, raw vegetables have been prepared for analysis for their ascorbic acid, carotene, thiamine, and moisture content. Immediately after they were brought to the laboratory the vegetables were prepared for blanching and drying, the details of the method and time factor varying with each vegetable, and the procedure recommended in Extension Folder W-8, or a slight modification of it was followed. Thus the beets, carrots, banana squash, turnips, rutabagas, and yams were washed, peeled, and sliced. Snap beans were cut in 1-inch lengths and the cabbage was shredded. The leaves of Swiss chard, beet greens, and spinach were washed and left whole. In the case of broccoli, the flowers and stems were separated to provide for greater uniformity of sampling for analysis.

All the vegetables were then blanched in steam until heat had penetrated the food and the leafy vegetables had wilted, at which time all the foods were nearly cooked. The time varied from two

minutes for cabbage to from ten to fifteen minutes for rutabagas and turnips. In the first series of experiments the temperature of the tunnel type of dehydrator was maintained at 140 degrees Fahrenheit, a combined heater and fan forcing the air through until the food was air dry. The dried material was sampled for analysis of its ascorbic acid, thiamine, carotene, and moisture content. The remaining dried foods were then placed in pint glass Kerr jars, the tops sealed with paraffin, and they were stored in the storeroom adjacent to the laboratory.

The methods used for the vitamin assay were those used for other vitamin assays in the laboratory. Results on both the fresh- and dry-weight basis of the raw and dehydrated vegetables and the percentage of loss which has occurred are being calculated and prepared for early publication.

**The vitamin A and C content of certain canned foods**

For intelligent planning, evaluation, and rationing of human dietaries, information concerning the nutritive value of all varieties of foods grown, prepared, or processed under different conditions is keenly needed. Therefore, as a part of the National Canners Research Project, certain commercial canned fruits, vegetables, and fish have been assayed for their vitamin A and C values by following the recommended chemical methods used in this laboratory. The canned foods of the same kind represented different sampling periods—that is, early, late, and midseason; collections from different districts, canned therefore in eastern, western, and midwestern states by different canneries in the same canning section; and material canned in different can sizes—No. 1 tall, numbers 2, 2½, and 10. Analyses were made on composited, semihomogeneous samples of combined solids and liquids from all cans in the same group, obtained by blending in the Waring blendor.

The ascorbic acid and carotene content have been determined for twenty-one composited samples of the combined solids and liquids of canned apricots, thirty of green asparagus, fourteen of white asparagus, seventy-five of green cut beans, twenty-six of lima beans, five of baked beans, twenty-seven of beets, twenty-three of carrots, forty-five of white corn, sixty-three of yellow corn, twenty-two of grapefruit sections, forty-two of grapefruit juice, fourteen of orange juice, sixteen of clingstone peaches, thirteen of freestone peaches, twenty-nine of pears, one hundred three of peas, seventeen of sliced pineapple, eighteen of pineapple juice, ten of prunes, thirty-four of spinach, sixty-three of tomatoes, and seventy-nine of tomato juice.

Eight composite samples of mackeral, five of salmon, fifteen of sardines, eight of shrimp, and five of tuna have been analyzed for vitamin A. The analytical data for each canned food are being summarized in tabular form showing range, average, and standard

deviation. The possible relationship of the observed range in vitamin values to such factors as difference in variety, in soil and climatic conditions during growth in different sections of the country, in maturity, and in method of processing, etc., will be briefly discussed and prepared for publication at an early date.

## PLANT BREEDING

### ALFALFA

Owing to a shortage of labor for making the necessary cuttings and for weeding, the alfalfa breeding project became partly inactive during the past year. Both selfed and open-pollinated seeds were planted from each of twelve different progenies in 1942. These twelve are the surviving progenies in the selfing program with Arizona common alfalfas. Selfed seed of U.S.D.A. No. 19316, a wilt-resistant sort, was also planted. Seed of A136 and A147, wilt-resistant sorts also from the U.S.D.A., were planted for the purpose of studying wilt resistance in inbred lines derived from them. Nine of these plantings had made sufficient growth to permit selfed seed to be taken in the summer of 1943. An attempt will be made to study the wilt resistance and growth characters of these progenies during the coming winter and spring.

### COTTON

**Upland cotton breeding**

Plant selections were made from the best progeny rows of Santan Acala grown in the breeding block at Queen Creek in 1942. These plants were carefully studied in the laboratory and the less desirable ones eliminated on the basis of yield, boll size, percentage of lint, lint index, seed index, and length and strength of lint. Those remaining were planted in progeny rows from which selections will be made in the fall of 1943. For the first time the mass seed from two families included in the breeding stock was planted in separate parts of the parent seed field. These plantings will be checked in regard to yield and length and strength of lint. If either planting is found superior, the seed will be kept separate for future distribution.

A parent seed field of 1517, a strain of Acala developed in New Mexico, was also grown in 1942. This variety, however, is not adapted to growth in the lower cotton-growing areas of Arizona owing in large part to the fact that the bolls do not open well and the lint does not fluff out. Plant selections were made and are now being grown in an attempt to overcome this difficulty.

All the work with Santan and 1517 is being done in co-operation with the U.S.D.A. Field Station at Sacaton.

Selections were made from progeny rows of Stoneville 4A grown at Yuma in 1942. These were not planted in 1943, how-

ever, but are being held in reserve together with a small amount of parent seed. At this time when very little cotton is being grown in the Yuma Valley, progeny rows of Stoneville 2B are being tried out in the hope that this variety will yield as well as 4A and at the same time give a better grade and a slightly longer staple. Plants will be selected from the best of these Stoneville 2B rows in 1943 for carrying on the work in 1944.

The $F_2$ plants from a large number of crosses made in 1941 are being grown in 1943 at the Mesa Experiment Farm. These include populations of approximately 800 plants from each of the following crosses: Santan x 1517, Santan x Stoneville 2B, and Santan x Wilds No. 13. Smaller $F_2$ populations of the crosses 1517 x Stoneville 2B, 1517 x Wilds No. 13, Stoneville 2B x Wilds No. 13, and D & PL 12 x Wilds No. 13, as well as backcrosses and selections from each of the parent varieties, are also being grown. During the summer of 1943 an attempt was made to secure selfed seed from as many of these plants as possible.

Results derived from a laboratory study of samples from four of the parent varieties are shown in Table 18. The length of lint was derived from the sorting data. Twenty-five per cent of the lint is longer than the figure given, and 75 per cent is shorter. The figure for strength represents the number of pounds required to break a milligram of fiber approximately ½ inch in length.

TABLE 18.—VARIETIES USED AS PARENTS IN CROSSES

| Variety | Bolls per lb. of seed cotton | Per cent lint | Lint index | Seed index | Length of lint (inches) | Strength of lint |
|---|---|---|---|---|---|---|
| Santan Acala..... | 62 | 37.4 | 7.7 | 12.8 | 1 | 7.11 |
| 1517 Acala (N.M.) ..... | 69 | 34.0 | 6.8 | 13.1 | 1 | 9.63 |
| Stoneville 2B..... | 67 | 33.6 | 6.6 | 12.9 | 1 1/32 | 7.92 |
| Wilds No. 13..... | 73 | 31.0 | 6.7 | 14.3 | 1 5/16 | 9.24 |
| Acala Selection* | .... | 30.9 | .... | ..... | 1⅛ | 8.91 |
| 2B Selection*..... | .... | 32.4 | .... | ..... | 1 3/32 | 8.81 |

*Used as parents in crosses made in 1943.

New Mexico 1517, which very frequently staples 1⅛ inches when grown in that state, was very little longer than Santan when grown on the Mesa Experiment Farm in 1943. The fiber was much stronger, however.

Figure 3 shows the percentage of lint in each length class for the varieties and selections in Table 18.

As grown on the Mesa Experiment Farm in 1943, each parent variety shows certain weaknesses or defects. The fiber of Santan is short and weak, although the plant stands up well and produces a good yield. The bolls are large and fluff out nicely. The fiber of 1517 is not much longer than that of Santan but is about 35 per cent stronger. The plant, however, has a tendency to fall, while the bolls do not open well and the locks are frequently hard. The

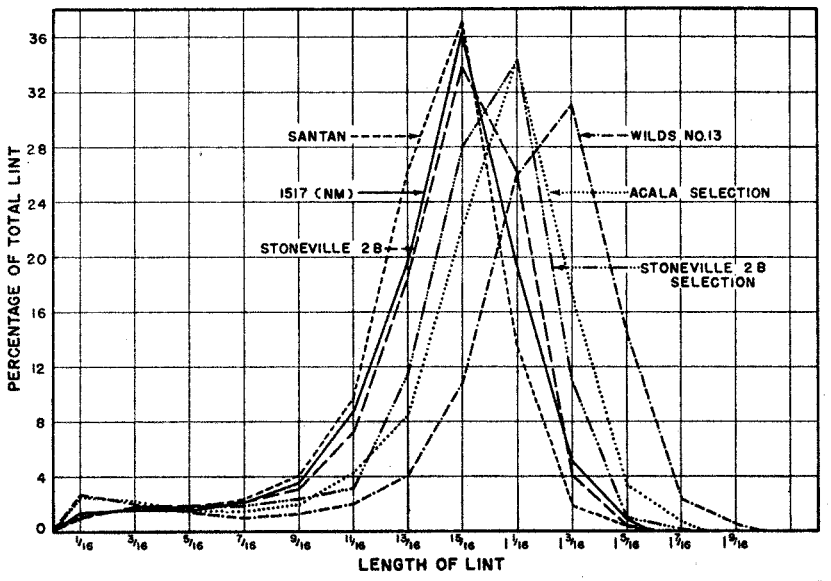


FIGURE 3. PERCENTAGE OF LINT OF VARIOUS LENGTHS OBTAINED FROM SAMPLES OF VARIETIES AND SELECTIONS USED AS PARENTS IN CROSSES—GROWN ON MESA EXPERIMENT FARM IN 1943

plant of Stoneville 2B is weak. The fiber is slightly longer than either Santan or 1517 but is much weaker than the latter. The bolls open well and are easily picked. The greatest objection to Wilds No. 13 is that it is hard to pick. The fiber is long and strong, but the percentage of lint is low.

The $F_2$ plants show many of the defects of their parents. Where Santan was used as one of the parents, the $F_2$ plants are standing up fairly well. This is particularly noticeable where Santan was used as the recurring parent in backcrosses. Where 1517 and Stoneville 2B were used as recurring parents, the $F_1$ plants of the backcrosses are practically all down.

**Fiber strength tests**

Tests have shown that the strength of fiber on the individual seed decreases as the length decreases. The curve in the lower half of Figure 4 shows the results obtained in testing the strength of fibers of different lengths sorted from twenty-five ten-seed samples. These samples were sorted into classes differing in length by one sixteenth of an inch, decreasing from left to right. All the fibers in each class were then tested and the mean strength of each length-class determined. Each point represents the mean of from twenty-five to more than one hundred tests. The largest number was of course obtained from the class containing the greatest amount of fiber indicated as the modal class in the figure.

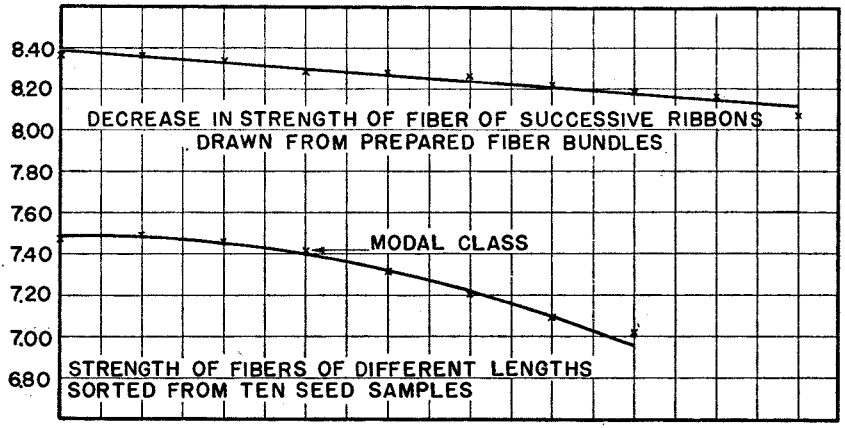


Figure 4.—Results obtained in testing the strength of fibers of different lengths. Length and strength are both shown decreasing from left to right.

Results obtained from testing successive ribbons drawn from prepared fiber bundles are shown in the upper half of Figure 4. Each point here represents the mean of forty tests. These results show the same tendency for strength to decrease with length, since the average length of the fibers in a ribbon decreases as successive ribbons are drawn from an individual bundle.

**Long-staple cotton breeding**

One hundred fifty-nine $F_3$ progenies of the second backcross of the Pima x Tanguis cotton cross were grown in 1942, with Pima the recurrent parent. The work with this cross during the past year has been mainly devoted to lint and seed-weight studies. Length, strength, and fineness tests were made on thirty-six of these $F_3$ progenies. Table 19 shows the results obtained with sixteen of them, along with their respective lint percentages, seed weights, and lint indexes. The object of this cross originally was to combine the length and fineness of fiber of the Pima parent with the high lint abundance of the Tanguis. Later, fiber strength became important and is now being studied in these progenies. Table 19 shows to what extent the objectives of the cross have been realized. Progeny No. 12, for instance, has lint qualities comparable to those of Pima, but it is somewhat lower in lint abundance than the Tanguis. Progeny No. 120 has the lint abundance of Tanguis, but its lint is shorter and coarser than that of Pima. It seems that a seed weight of approximately 13 grams per one hundred seeds is desirable in long-staple cottons. Thus far, the productive progenies of this cross with the highest percentage and fineness of lint have a seed weight below 13 grams per hundred seeds. This relationship between lint fineness and abundance and seed weight indicates that if the finest cottons are to be produced with

TABLE 19.—LENGTH, FINENESS, AND STRENGTH OF LINT, LINT PERCENTAGE, SEED WEIGHT, AND LINT INDEX OF SIXTEEN $F_3$ PROGENIES OF THE SECOND BACKCROSS OF PIMA X TANGUIS, PIMA BEING THE RECURRENT PARENT, AND OF THE TWO IMMEDIATE PARENTS. CROP OF 1942. FIBER TESTS WERE MADE BY THE UNIVERSITY OF TENNESSEE FIBER RESEARCH LABORATORY.

| Second backcross progenies. No. | Length (inches) | | Fineness Cm.²/mg. | Strength index | | Lint per cent | Weight per 100 seeds | Lint index |
|---|---|---|---|---|---|---|---|---|
| | Mean | Upper half mean | | | | | | |
| | 1.19 | 1.40 | 2.50 | 8.24 | 8.27 | ..... | ..... | ..... |
| 5 | 1.22 | 1.45 | 2.61 | 7.86 | 8.01 | 36.3 | 11.8 | 6.48 |
| | 1.29 | 1.50 | 2.74 | 8.32 | 8.26 | ..... | ..... | ..... |
| 12 | 1.20 | 1.49 | 2.77 | 8.09 | 8.16 | 35.7 | 11.7 | 6.19 |
| | 1.13 | 1.40 | 2.57 | 7.83 | 8.03 | ..... | ..... | ..... |
| 20 | 1.16 | 1.40 | 2.42 | 8.08 | 7.89 | 38.0 | 10.7 | 6.43 |
| | 1.18 | 1.49 | 2.73 | 7.75 | 8.00 | ..... | ..... | ..... |
| 71 | 1.24 | 1.50 | 2.65 | 8.12 | 7.95 | 35.4 | 13.4 | 7.26 |
| | 1.21 | 1.41 | 2.60 | 7.43 | 7.63 | ..... | ..... | ..... |
| 81 | 1.14 | 1.43 | 2.50 | 8.07 | 7.47 | 36.8 | 12.9 | 7.30 |
| | 1.13 | 1.46 | 2.70 | 8.02 | 7.79 | ..... | ..... | ..... |
| 82 | 1.19 | 1.46 | 2.52 | 7.69 | 7.89 | 36.4 | 12.9 | 7.30 |
| | 1.14 | 1.49 | 2.45 | 7.69 | 8.12 | ..... | ..... | ..... |
| 94 | 1.14 | 1.45 | 2.35 | 8.04 | 7.87 | 39.8 | 11.5 | 7.36 |
| | 1.26 | 1.45 | 2.46 | 8.47 | 8.53 | ..... | ..... | ..... |
| 120 | 1.16 | 1.40 | 2.52 | 8.46 | 8.52 | 37.2 | 12.9 | 7.63 |
| | 1.05 | 1.38 | 2.87 | 7.86 | 8.09 | ..... | ..... | ..... |
| 149 | 1.07 | 1.43 | 2.82 | 8.15 | 8.11 | 37.5 | 11.9 | 6.74 |
| | 1.22 | 1.46 | 2.66 | 7.87 | 7.79 | ..... | ..... | ..... |
| 163 | 1.20 | 1.46 | 2.81 | 8.09 | 7.90 | 36.5 | 12.6 | 7.03 |
| | 1.25 | 1.50 | 2.74 | 7.89 | 8.05 | ..... | ..... | ..... |
| 172 | 1.17 | 1.45 | 2.78 | 7.51 | 7.89 | 34.5 | 12.1 | 6.17 |
| | 1.32 | 1.55 | 2.62 | 7.85 | 7.90 | ..... | ..... | ..... |
| 176 | 1.31 | 1.56 | 2.52 | 8.39 | 8.01 | 40.0 | 11.7 | 7.68 |
| | 1.21 | 1.44 | 2.52 | 7.68 | 7.91 | ..... | ..... | ..... |
| 178 | 1.14 | 1.44 | 2.70 | 8.02 | 7.83 | 36.9 | 11.9 | 6.75 |
| | 1.16 | 1.45 | 2.35 | 7.77 | 8.06 | ..... | ..... | ..... |
| 184 | 1.24 | 1.45 | 2.38 | 7.50 | 7.55 | 35.1 | 11.9 | 6.43 |
| | 1.00 | 1.34 | 2.64 | 7.87 | 8.01 | ..... | ..... | ..... |
| 186 | 1.03 | 1.39 | 2.70 | 8.23 | 8.05 | 37.7 | 11.9 | 7.05 |
| | 1.10 | 1.44 | 2.53 | 8.30 | 8.00 | ..... | ..... | ..... |
| 201 | 1.18 | 1.49 | 2.52 | 7.97 | 8.48 | 33.7 | 14.2 | 7.21 |
| 1st backcrossed.. | 1.05 | 1.39 | 2.45 | 7.20 | 7.32 | ..... | ..... | ..... |
| 120. Parent..... | 1.03 | 1.34 | 2.47 | 6.77 | 6.98 | 40.8 | 11.3 | 7.78 |
| Recurrent ..... | 1.21 | 1.55 | 2.77 | 7.87 | 7.84 | ..... | ..... | ..... |
| Pima. Parent..... | 1.23 | 1.56 | 2.70 | 7.47 | 7.53 | 32.2 | 12.8 | 6.07 |

the necessary seed weight, a lint percentage somewhat lower than that of the coarser cottons must be expected. In the matter of fiber strength it is interesting to observe that progenies 12 and 120 of Table 19 are significantly stronger than either parent. Strong progenies occur in both the fine- and the coarser-fibered progenies.

Three hundred twenty $F_4$ progenies of this cross are being grown in 1943 in order to make further lint studies and to isolate the most productive progenies.

## WHEAT

Eleven selections from three double crosses (see page 88, Annual Report, 1940) were grown for seed increase for more adequate yield testing and for further studies on strength of straw. Two of these selections appear to be the equal of Baart in yield and superior to it in strength of straw. However, it was observed that strength of straw was not constant in these selections. Consequently, about two hundred head selections were made from each

of the four highest-yielding selections. These eight hundred head selections will be planted in head rows in order to isolate new selections with uniformly strong straw.

The first backcrossed generation of Timopheevi x common wheat was made, with Baart 38 as the recurrent parent. Ten first backcrossed families in four original crosses have been established. These ten families will be increased in order to provide seed for planting in the rust-infected areas of the state. The resistant plants isolated in this test will be crossed on Baart 38 to constitute the second backcross. With sufficient rust infection to reveal the resistant plants and progenies, it is believed that both the Hope and the Timopheevi factors can be fixed in a single strain in the third backcross.

## PLANT PATHOLOGY

Activities of the Department of Plant Pathology during the past year have been modified by the war emergency, considerable time having been taken up in connection with problems affecting vital crops. Thus, diseases of guayule, Russian dandelion, and other rubber-bearing plants, and diseases of war-garden vegetables as well as maladies of the usual crops, have received attention. Requests for assistance with diseases of garden vegetables have been particularly numerous.

### RUBBER-PLANT DISEASES

Guayule plants (Plate VII) heavily inoculated with the fungus *Sclerotium rolfsii* remained in a healthy condition during the second year, although plants of that species (*Parthenium argentatum*) which were dying from attack of the same fungus have been sent to this Department. The explanation appears to be certain environmental conditions. Our inoculated plants have good drainage; they showed symptoms of the beginning of disease in pots that were overirrigated, such as the death and browning of a few leaves, but the disease went no further. Likewise, plants of guayule that were heavily inoculated with the common nematode (*Heterodera marioni*) remain thrifty, having developed only a very few small knots, although they were subjected to much heavier inoculum than would occur in nature. Guayule growing[5] in Arizona has shown decided resistance to the Texas root rot fungus, *Phymatotrichum omnivorum*. Not only does this statement hold true for the acreage planted for data on percentage of rubber, but also that in plots utilized for experiments in pathology. Pieces of root-rot-infested cotton roots buried in contact with the taproots of fifty healthy guayule plants gave no visible symptoms of the disease. Guayule plants growing in heavily inoculated soil in the greenhouse have remained healthy.

[5]Streets, R. B. The susceptibility of guayule to Phymatotrichum root rot under irrigation, *Pl. Dis. Rept.* 27, Feb. 1, 1943.

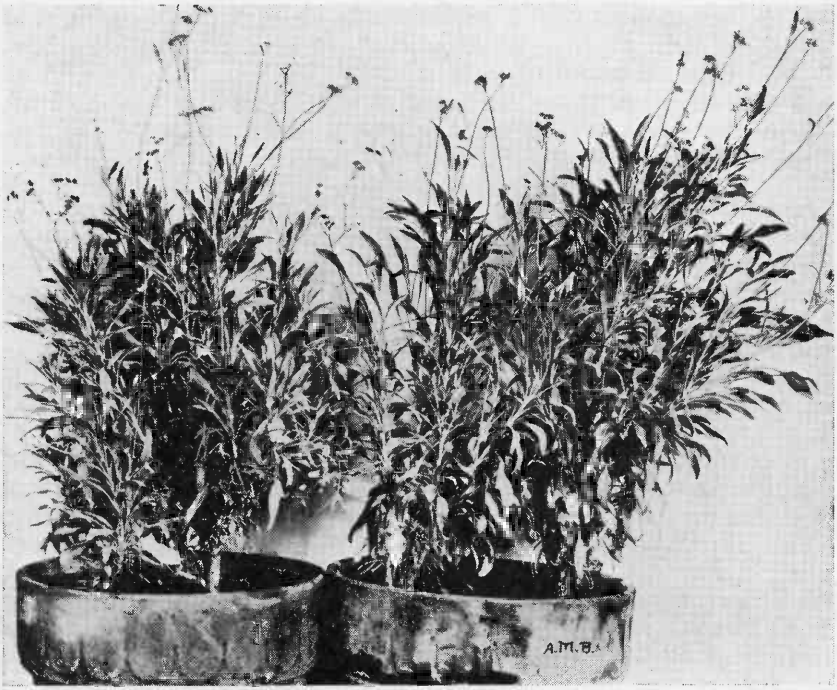

Plate VII.—Guayule plants heavily inoculated with *Sclerotium rolfsii* have remained in healthy condition during the second year.

Kok-saghyz, or Russian dandelion (*Taraxacum kok-saghyz*), in experimental plantings has been attacked by the fungi *Rhizoctonia solani* and *Fusarium solani* and by nematodes. The worst injury came from Rhizoctonia that caused the well-known sunken, brown-to-black lesions on the root. The nematodes occurred mainly in the bases of dead leaves in the crown and in stubs of decayed lateral roots. There were no knots characteristic of the effects of the common nematode.

## DISEASES OF FIELD CROPS

### Bacterial wilt of alfalfa

From a large number of alfalfa introductions planted during the spring of 1941, two (nos. 19316 and 84409) were selected as being outstanding for resistance to the wilt bacterium *Corynebacterium insidiosum* and for desirable growth characteristics. Individual plants from these two introductions were selfed during the growing season of 1943. One promising Hairy Peruvian plant was likewise selfed.

A second plot containing several of the most promising introductions planted in 1941 was started in the spring of 1943 for increasing the available material from which individual resistant plants can be selected.

**Rust of cotton**

Sulphur-dusting trials for the control of cotton rust (caused by *Puccinia schedonnardi* according to Arthur[6]; by *P. boutelouae* according to Presley[7]) were carried out in two 6-acre fields. One field was located near Sahuarita, the other near Continental, both in a bad rust district. One 1-acre plot in each field received four dustings, one received three, two plots at Sahuarita and one at Continental received one, and remaining plots were controls.

Application of dust began at the time of the first summer shower; the second application followed in two weeks, the third after an interval of three weeks, and the fourth a month later. The dust used was Sunland Brand, 325-mesh; it was applied with one Root Hand Gun, Model C3, and one Savage Duster. The varieties of cotton were Acala and Sahuarita and SxP at Continental.

The first pustule of rust was found on July 30 in a planting outside the plots; the disease became bad in August—rather late for the district. There was significantly more rust in fields of SxP than in Acala fields.

Comparison of the extent of rust in the various plots was made by counting the pustules on all the leaves of every plant in unit pieces of row, the unit being selected at random and uniform in length for all plots. Counts of pustules were made on 20,759 leaves in the experimental plots and 3,238 leaves in commercial fields. For the field of Acala cotton at Sahuarita, nondusted plots showed an average of 3.45 rust pustules per leaf. In the same field the dusted plots averaged 4.05 pustules per leaf; the lowest average was 3.04 pustules for the acre that received a single dusting and the highest was in the acre that was dusted four times. The SxP cotton at Continental had an average of 13.2 rust pustules per leaf for the nondusted plots, with the highest count 13.87 and the lowest 12.14; in the same field, the dusted plots showed an average of 10.37 pustules, with the highest 11.13 and the lowest 9.05. For further comparison, rust pustules were counted in the same manner in two commercial fields in the same district, one nondusted planting, the other powerdusted with the same brand of dust used in the experimental plots. The latter received but one dusting. An average count of 26.1 was obtained for the nondusted field as against an average of 7.41 rust pustules for the dusted field.

A summary of the results indicates lack of control of cotton rust at Sahuarita and only slight control at Continental, although the commercial fields studied indicate marked results from a single

[6]Arthur, J. C. *Manual of the rusts in United States and Canada*, pp. 143-144.
[7]Presley, J. T. Aecidium gossypii, the aecial stage of Puccinia boutelouae. *Phytopathology* 32:97-98, Jan., 1942.

application of sulphur. The explanation of the contradictory results appears to be clearly indicated by examination of the distribution of sulphur particles applied with the hand machines used in the plots. Although the machines, when set for a minimum rate of application, delivered 35 to 50 pounds of dust per acre, much more than was really needed, the distribution of the dust on the cotton leaves was so irregular that unprotected leaf surface was extensive (see Plate VIII).

**Sclerotial rot and wilt of cotton**

Sulphur applied to soil heavily infested with *Sclerotium rolfsii* at dosages of 500, 1,000, and 2,000 pounds per acre reduced visible infection from 5.6 to 68.8 per cent and from 9.7 to 72.9 per cent over infections in the two control plots, respectively. An application of 500 pounds appeared to be as effective as larger applications.

**Ring rot of potato**

Field and laboratory studies have disclosed a somewhat widespread occurrence of bacterial ring rot (*Corynebacterium sepedonicum*) of potatoes in Arizona. One district lost the opportunity to market its entire potato crop for seed because the rot was present.

Bacterial ring rot in stored tubers occasionally has been associated with vegetable soft rot (*Erwinia carotovora*). Attack by the two pathogenes results in greater loss than infections by either parasite alone. To date, vegetable dealers have been mainly concerned. More careful sorting and handling of potatoes to be stored, together with efficient disinfection of storage rooms, probably would reduce losses.

**Root knot of soybean**

Field observations of the new nonshattering soybean, Armredo, have indicated that it is highly resistant to infestation by the root knot nematode, *Heterodera marioni*. Limited greenhouse tests support observations in the field.

## DISEASES OF HORTICULTURAL CROPS

**Dry root rot of citrus**

Young trees on sour orange and rough lemon rootstocks were grown in (a) fertilized and (b) unfertilized soil, in continuation of experiments on dry root rot mentioned in previous reports of the Station. Two thirds of the trees in each of four plots were inoculated with cultures of Fusarium recovered from dying trees by placing pure cultures of the fungus in contact with the taproot of each tree 4 inches below the surface. The soil was kept moist. None of the trees has died or become infected.

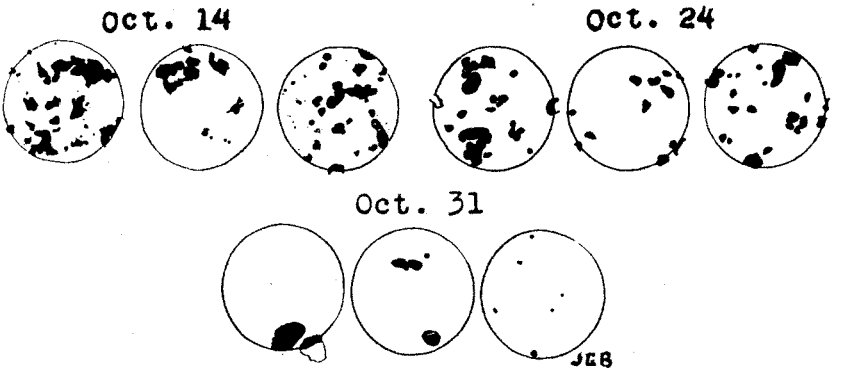


Plate VIII.—Distribution of sulphur granules on upper surface of same areas of cotton leaves at dusting, ten days, and seventeen days later, respectively. Leaves selected for examination occupied comparable positions on the plant. Sulphur dust was Sunland brand, 325-mesh, applied with a hand duster. Note distance between particles. Sulphur volatilizes rapidly at the high temperatures which prevail during a large part of the cotton-growing season in Arizona.

**Watery brown rot of lettuce**

Because laboratory experiments[8] indicated that its 3,5 dinitro-o-cresol ingredient is very toxic to *Sclerotinia sclerotiorum,* Sinox has been used in the attempt to inhibit the attack of the fungus on head lettuce and thus to prevent watery brown rot. From one to four applications of various concentrations were sprayed on the soil around lettuce plants from the time of thinning until the leaves of the plants covered an area approximately 6 or 8 inches across. Limited evidence indicates that a concentration sufficiently strong to inhibit the fungus is somewhat injurious to the lettuce. The correct concentration and time and method of application for successful use of Sinox, if that is possible, have not been determined.

**Texas root rot of pecan**

Losses from root rot in pecan orchards continue to be much smaller in both treated and untreated groves where no susceptible crop is grown between the trees. A marked reduction in the amount of rot was observed in an untreated grove in the fourth and fifth years following the removal of the susceptible alfalfa cover crop.

The influence of the cover crop on the prevalence of root rot is well illustrated by results recorded this year. Three blocks of ninety-one pecan trees each, planted in an alfalfa field in 1936, had

[8]Hoyman, William G. The effect of various organic and inorganic compounds on the growth of *Sclerotinia sclerotiorum. Phytopathology* 32:10, Jan., 1942 (Abstract).

been severely damaged by the rot after four years. On November 5, 1942, three years after differential cover cropping, Block 1 (barley in winter; Sudan grass in summer) showed one slightly infected tree; Block 2 (alfalfa) had thirteen infected trees; and Block 3 (sour clover in winter; cowpeas in summer) showed no infected trees.

Three remaining plantings of five large pecan groves treated for root rot since 1937 showed that the disease is still under satisfactory control in the three best plots of eighty trees each, although it is continuing to spread in the two other plots where no control was attempted after the first two years. None of seventy-five trees planted in infected soil treated with sulphur, manure, ammonium sulphate, or ammonium phosphate, alone or in combination, was killed or infected in 1942. Untreated trees intercropped with alfalfa were dying or becoming infected.

**Curly top of tomato**

Probably connected with the effect of drought, both indirectly on weed food plants of the beet leafhopper *Eutettix tenellus,* carrier of the virus, and directly on developmental stages of that vector, curly top of tomatoes has been much less in evidence during the spring and early summer of 1943.

## PREVIOUSLY UNREPORTED PLANT DISEASES

Spotted wilt (*Lycopersicon Virus* 3) of tomatoes, root knot (*Heterodera marioni*) on *Myoporum luteum,* and a bacterial leaf spot of Washington palm are believed to be hitherto unreported for the state.

## GENERAL PLANT-DISEASE NOTES

Diseases unusually active or prevalent were Texas root rot (*Phymatotrichum omnivorum*), root knot (*Heterodera marioni*), bacterial pustule (*Xanthomonas phaseoli* var. *sojense*), and leaf spot (*Alternaria* sp.) on soybeans. Less damaging than in previous years were bean rust (*Uromyces phaseoli typica*), cotton rust (*Puccinia schedonnardi* or *P. boutelouae*), angular leaf spot of

TABLE 20.—AVERAGE FEED CONSUMPTION OF WHITE LEGHORN PULLETS.

| Annual egg yield | Total pounds feed consumed | Pounds of feed per dozen eggs |
|---|---|---|
| 80 | 71 | 10.6 |
| 120 | 75 | 7.5 |
| 160 | 78 | 5.9 |
| 200 | 82 | 4.9 |

cotton (*Xanthomonas malvacera*), and curly top (*Beta Virus 1*) of tomatoes and numerous other vegetables.

## POULTRY HUSBANDRY

### BREEDING INHERITANCE STUDIES

**Developing a high egg-producing strain**

A high egg-producing individual produces eggs more economically than a low producer. This is due mainly to lower feed consumption per dozen eggs in the case of the higher producing individual, as indicated in Table 20. Therefore, any procedure which will increase the egg production of an individual reduces the overhead and increases the profits.

Table 21 sets forth the results of nine years of selection for high egg production.

TABLE 21.—RESULTS OF NINE YEARS OF SELECTION FOR HIGH EGG PRODUCTION.

| Year of mating | Av. egg production | | Range in progeny production | Per cent progeny laying over 200 eggs |
|---|---|---|---|---|
| | Parents | Progeny | | |
| 1933-34 | 261 | 187 | 124-265 | 41 |
| 1934-35 | 258 | 172 | 85-260 | 30 |
| 1935-36 | 246 | 173 | 140-265 | 18 |
| 1936-37 | 239 | 211 | 137-264 | 78 |
| 1937-38 | 244 | 186 | 118-265 | 44 |
| 1938-39 | 262 | 200 | 122-248 | 58 |
| 1939-40 | 238 | 223 | 198-260 | 91 |
| 1940-41 | 274 | 220 | 117-305 | 74 |
| 1941-42 | 277 | 202 | 94-292 | 61 |

During the latter years of this project stress has been laid on the selection of increased egg-producing families; whereas previously, high individual producers were selected with no attention paid to family background. This accounts for the higher average production in the matings, in the progeny, and in the increased production of the high bird in the progeny. The low limit of production in the progeny is not significant, for the low producers are greatly in the minority; in any given population of poultry there are always a few inferior birds.

**Developing a low egg-producing strain**

An attempt to develop a low egg-producing strain has been carried on for several years for the purpose of checking values of male birds for their ability to transmit egg production and to use as a basis for other measurements. Table 22 sets forth the trend this work has taken. For the years 1933-34 through 1936-37, males

from high-producing females were mated to low-producing females. From 1937-38 to the present, six years, males from low-producing females were mated to low-producing females.

TABLE 22.—NINE YEARS OF SELECTION FOR LOW EGG PRODUCTION.

| Year | Av. egg production | | | | Range in progeny production | Type of mating |
|---|---|---|---|---|---|---|
| | Female parents | Male parent's dam | Parent stock (mating) | Progeny | | |
| 1933-34 | 122 | 264 | 193 | 135 | 89-128 | Foundation |
| 1934-35 | * | * | * | * | * | Foundation |
| 1935-36 | 115 | 248 | 181 | 95 | 45-148 | Foundation |
| 1936-37 | 140 | 253 | 196 | 191 | 176-206 | Foundation |
| 1937-38 | 116 | 178 | 147 | 139 | 88-181 | Foundation |
| 1938-39 | 90 | 101 | 95 | 147 | 53-235 | Foundation |
| 1939-40 | 147 | 73 | 111 | 170 | 33-249 | Progeny mated |
| 1940-41 | 135 | 87 | 111 | 228 | 147-282 | Foundation |
| 1940-41 | 228 | 72 | 150 | 200 | 165-229 | Progeny mated |
| 1941-42 | 104 | 132 | 118 | 211 | 167-274 | Foundation |

*No progeny

When males from high-producing dams were mated to low-producing females, the production in the progeny was increased but little in two years and decreased in the third. In subsequent years when males from low-producing females were mated with low-producing females there was a decided increase in the egg production of the progeny over that of the parent females. This was especially true in the years 1940-41 and 1941-42. In 1940-41 the parent females averaged 135 eggs, the male was from an 87-egg dam, and the average egg production in the progeny was 228 with an egg range of 147-282 eggs. In 1941-42 the average egg production of the parent females was 104, the male was from a 132-egg dam, the average egg production of the progeny 211 eggs, with a range of egg production in the progeny of 167-274. Why this heavy egg production developed from low-producing stock for two consecutive years is a mystery. It indicates that there is much to be learned regarding the transmission of egg production.

**Prolonging economic productivity**

The profitable life of a hen is considered to be two producing years. On this basis the usual practice is to replace 50 per cent of the flock each year. As the raising of these replacements is one of the costly items of overhead charged to the cost of egg production, any circumstance which will lengthen the productive life of a fowl beyond the present accepted two years would definitely reduce the overhead in egg production and thereby add to the profits.

A few years ago it was noticed that one individual, hen No. 1079, had laid 253 eggs the first year, 249 eggs the second year, and 251

TABLE 23.—RESULTS OF FOUR YEARS SELECTION FOR PROLONGING ECONOMIC PRODUCTIVITY.

| Year | Dams | | | | | | | | | | Progeny | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Egg production | | | | | No. in mating | | | | | Eggs 1st yr. | Number | Per cent lay to av. of foundation |
| | 1st yr. | 2nd yr. | 3rd yr. | 4th yr. | 5th yr. | 1st yr. | 2nd yr. | 3rd yr. | 4th yr. | 5th yr. | | | |
| 1938-39 | 263 | 174 | ..... | ..... | ..... | 8 | 8 | .. | .. | .. | 213 | 53 | 81 |
| 1939-40 | 245 | 207 | ..... | ..... | ..... | .. | .. | .. | .. | .. | 233 | 47 | 95 |
| 1940-41 | 233 | 208 | 166 | 173 | ..... | 8 | 8 | 4 | 1 | .. | 235 | 55 | 108 |
| 1940-41 | 217 | ..... | ..... | ..... | ..... | 8 | .. | .. | .. | .. | 194 | 36 | 89 |
| 1941-42 | 230 | 210 | 174 | 143 | 149 | 7 | 7 | 7 | 3 | 1 | 188 | 32 | 81.7 |
| 1941-42 | 253 | 184 | ..... | ..... | ..... | 28 | 1 | .. | .. | .. | 209 | 102 | 82.6 |
| 1941-42 | 263 | 216 | ..... | ..... | ..... | 5 | 5 | .. | .. | .. | 227 | 29 | 86.3 |

eggs the third. It was obvious that if a strain could be established which would continue this sort of production, it would be of untold value. Before this bird could be used as a foundation breeder it died. It had, however, indicated possibilities, so a project was started in 1938-39 in which the foundation females had averaged 263 eggs their first year and 174 eggs their second year. There were eight females in this original foundation, as indicated in Table 23. The selection of the foundations after the first year was on a family basis. Families were chosen in which both the first- and second-year egg records exceeded two hundred.

Lack of time has prevented a definite check on the progeny as to whether there is a tendency for increased egg production in the second and subsquent years. A casual observation indicates a definite tendency in this direction.

**Establishing a strain for large eggs**

Inasmuch as eggs are marketed according to size as established through grades, the larger the eggs produced the greater the profit. A project was started in 1937-38 to attempt to increase the size of the eggs through selection. That there has been some success in this method of increasing egg size is indicated in Table 24.

TABLE 24.—RESULTS OF FIVE YEARS OF SELECTION FOR LARGE EGGS.

| Year mating | Av. egg wt. mating (oz.) | Av. egg wt. progeny | Range in egg wt. progeny | Kind of mating |
|---|---|---|---|---|
| 1937-38 | 28.02 | 23.36 | 21.0-25.4 | Selected foundation |
| 1938-39 | 26.69 | 24.17 | 22.4-25.4 | Selected foundation |
| 1939-40 | 24.85 | 24.80 | 23.5-26.0 | Progeny mated |
| 1940-41 | 26.96 | 25.7 | 22.8-30.0 | Selected foundation |
| 1941-42 | 27.90 | 27.4 | 24.0-30.0 | Foundation & families |

That there has been a constant increase in egg size is indicated in the column headed "Average egg weight of progeny," in which the average size of a dozen eggs was 23.36 ounces in 1937-38 and 27.4 ounces in 1941-42. The range in egg size in 1937-38 was from 21.0 to 25.4 ounces per dozen eggs compared with 24.0 to 30.0 ounces in 1941-42. The weight of the eggs of the progeny from the 1937-38 mating was 17 per cent less per dozen than the parent stock, while the eggs from the progeny of the 1941-42 mating weighed only 2 per cent less.

**Establishing a strain for small eggs**

This is known as a negative experiment. If the lack of size in eggs, as well as the increase in size, can be controlled at will, the whole question of egg size shall have been solved. Table 25 shows the trend in this work.

TABLE 25.—RESULTS OF FIVE YEARS OF SELECTION FOR SMALL EGGS.

| Year mating | Av. egg wt. mating | Av. egg wt. progeny | Range in egg wt. progeny | Kind mating |
|---|---|---|---|---|
| 1937-38 | 21.19 | 22.40 | 20.52-24.96 | Selected foundation |
| 1938-39 | 21.52 | 21.70 | 19.37-24.11 | Selected foundation |
| 1939-40 | 20.83 | 22.80 | 20.00-24.50 | Progeny mated B+S |
| 1939-40 | 21.97 | 21.90 | 21.00-23.00 | Progeny mated ½ B+S |
| 1940-41 | 23.60 | None | None | Progeny mated B+S |
| 1940-41 | 22.20 | 21.60 | 20.40-23.50 | Progeny mated ½ B+S |
| 1940-41 | 22.83 | 22.90 | 22.60-23.30 | Selected foundation |
| 1941-42 | 21.27 | 22.80 | 20.90-24.60 | Selected families |

The tendency has been for the eggs to be larger from the progeny than from the parent stock, or at least of equal size. When selected families were mated as they were in 1941-42, the same held true; the eggs from the progeny were 7 per cent larger than those from the parent stock. As each year has passed, it has been harder to select foundations with small eggs as indicated by the average egg size in the mating and in the range of egg size in the progeny.

## POULTRY FEEDING

The poultry industry is now feeling the effects of the suddenly accelerated war program in many ways. Controls and restrictions ordinarily not involved until there is actual warfare are now in effect. This will materially influence the availability of many ingredients that go into the poultry ration.

In view of this situation a group of emergency rations was formulated and fed to equalized pens of White Leghorn pullets as follows:

Pen 1. The regular University of Arizona laying ration (check pen).

Pen 2. The dried milk was removed from the above ration and the dehydrated alfalfa meal increased from 25 to 50 pounds.

Pen 3. A commercial concentrate was substituted for the dried milk in the check ration.

Pen 4. Rice bran and soybean meal replaced all wheat products and dried milk. The dehydrated alfalfa meal was increased from 25 to 50 pounds.

Pen 5. Fish meal and dried milk were deleted. Meat scraps were increased 10 per cent and dehydrated alfalfa meal from 25 to 50 pounds.

Mimeographed Report 49, issued January, 1943, covers a 295-day test period. This report shows that:

1. There was practically no difference in the cost of the various rations.
2. Production was highest in Pen 2, followed by pens 3, 5, 1, and 4 in the order named.
3. Palatability was not a factor in feed consumption.
4. Feed cost per dozen eggs was lowest in Pen 5, followed in order by pens 1, 2, 3, and 4.
5. Increase in body weight was greatest in Pen 2 and lowest in Pen 1. Other pens were intermediate.

A second test in substantial agreement was terminated April 24, 1943, so as to comply with the government order restricting the amount of animal protein in the ration. Tests using the allowable amounts are now in progress.

## PULLORUM AND RANGE PARALYSIS RESISTANCE

Blood testing and livability data are being compiled on certain families and breeds. Some families show resistance to these diseases, even when reared with birds from infected parents.

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

Environment is known to have an effect on cycle, number, and size of eggs. Two groups of Rhode Island Red pullets are being employed in an attempt to determine how temperature, light, and ventilation affect these factors. One lot was confined in individual hen batteries in a room in which these conditions were relatively constant; the other group was similarly confined in a room in which no attempt was made to control them. Production and rate of lay per bird were slightly higher in the noncontrolled lot. However, production was more evenly distributed over the twenty-four-hour period in the group under controlled conditions.

# APPENDIX

## ANALYTICAL SERVICE

A considerable part of the work of the Department of Agricultural Chemistry and Soils is devoted to the chemical analyses of samples submitted by citizens of the state, other departments of the Experiment Station, and a number of government agencies located in the state. A tabulation of the analyses made during the past year is given in Table 26.

TABLE 26.—COMPILATION OF ANALYSES MADE IN THE DEPARTMENT OF AGRICULTURAL CHEMISTRY AND SOILS.

| | Tucson laboratory | Phoenix laboratory |
|---|---|---|
| Soils | 1,089 | 518 |
| Waters | 292 | 703 |
| Plant materials | 111 | ..... |
| Feeds | 3 | 15 |
| Fertilizers | 9 | 21 |
| Minerals | 10 | ..... |
| Milk | 159 | ..... |
| Poison cases (animals) | 13 | ..... |
| Miscellaneous | 10 | 35 |
| Totals | 1,696 | 1,292 |

## ARIZONA EGG LAYING TEST

The results of the twenty-first Arizona Egg Laying Test, which ended September 22, 1943, were on the same high plane as in the previous tests. The W. A. Seidel White Leghorn pen from San Antonio, Texas, was the highest in production, with 3,338 eggs and 3,481 points to its credit based upon the original thirteen birds entered. One bird in this entry died early in the test and another has been incapacitated since last spring. The eleven birds which finished the fifty-one-week period with a normal lay averaged 277 eggs a bird.

The highest producing individual was in the Seidel entry. This White Leghorn produced 312 eggs with a point value of 330 during the 357-day period.

Walter Cochran's pen of Rhode Island Reds from Phoenix, in fourth place, was the leading pen among the Arizona entries. Other state entries and placings were Belsey Leghorn Breeding Ranch, fifth; Tucson Hatchery, White Leghorns, Tucson, eighth and ninth; W. G. Ashby, New Hampshires, Phoenix, twelfth; Frances H. George, White Leghorns, Tucson, thirteenth; San Mateo Poultry Ranch, White Leghorns, Phoenix, eighteenth; C.

TABLE 27.—COMPARISON OF THE TWENTY-FIRST ARIZONA EGG LAYING TEST WITH ALL PREVIOUS TESTS.

| Year | Number of eggs per bird | | | | Per cent individual over 200 eggs | Per cent mortality | Name of winner | Breed |
|---|---|---|---|---|---|---|---|---|
| | Entire test* | Highest indiv.† | Highest pen‡ | Highest pen§ | | | | |
| 1922-23 | 196.6 | 264 | 247 | ..... | 39 | 14 | W. Griffith | W.L. |
| 1923-24 | 204.9 | 274 | 252 | ..... | 42 | 14 | W. Griffith | W.L. |
| 1924-25 | 191.4 | 291 | 246 | ..... | 36 | 18 | Del Rio Farm | W.L. |
| 1925-26 | 205.8 | 307 | 250 | ..... | 54 | 17 | Lee Apel | W.L. |
| 1926-27 | 213.4 | 319 | 270 | 245 | 58 | 15 | A. C. Wrenn | W.L. |
| 1927-28 | 212.8 | 299 | 247 | 203 | 64 | 15 | A. C. Wrenn | W.L. |
| 1928-29 | 211.3 | 274 | 247 | 237 | 62 | 12 | Lee Apel | W.L. |
| 1929-30 | 202.0 | 298 | 252 | 223 | 43 | 14 | Del Rio Farm | W.L. |
| 1930-31 | 195.2 | 283 | 258 | 242 | 45 | 11 | George England | W.L. |
| 1931-32 | 188.6 | 278 | 235 | 214 | 32 | 17.6 | Gold Spot Hatchery | W.L. |
| 1932-33 | 186.1 | 290 | 234 | 199 | 20 | 27 | George England | W.L. |
| 1933-34 | 219.9 | 307 | 258 | 233 | 58 | 18.4 | Max Johnson | W.L. |
| 1934-35 | 210.9 | 299 | 248 | 217 | 51 | 28.1 | P. S. Dickey | W.L. |
| 1935-36 | 214.1 | 295 | 242 | 216 | 55 | 21.5 | Gold Spot Hatchery | W.L. |
| 1936-37 | 218.3 | 318 | 256 | 244 | 55 | 18.8 | Leslie Guthrie | W.L. |
| 1937-38 | 216.4 | 325 | 276 | 262 | 56 | 21.9 | P. S. Dickey | W.L. |
| 1938-39 | 216.2 | 302 | 244 | 234 | 58 | 16.5 | J. A. Hanson | W.L. |
| 1939-40 | 211.0 | 311 | 276 | 237 | 51 | 25.4 | W. A. Seidel | W.L. |
| 1940-41 | 223.3 | 328 | 270 | 250 | 62 | 19.5 | A. L. Frees | N.H. |
| 1941-42 | 230.5 | 325 | 278 | 254 | 68 | 15.9 | Gold Spot Hatchery | W.L. |
| 1942-43 | 221.0 | 321 | 280 | 257 | 60 | 19.4 | W. A. Seidel | W.L. |

*Figured on hen-day basis.

†Actual record.

‡In 1922-23 and 1923-24 six birds were entered with five high birds figured in final results. In 1924-25 and 1925-26 twelve birds were entered with ten high birds counting in final results. In 1926-27, through 1936-37, thirteen birds were entered with the ten high figured in final tabulation. In 1937-38 and subsequent years thirteen birds were entered and all averages were based on a thirteen-bird entry, but for a basis of comparison with previous years the average of the ten high birds for 1937-38 and subsequent years is here recorded.

§Record based on thirteen birds originally entered, whether or not thirteen birds finished the year.

E. George, White Leghorns, Tucson, twenty-first; Del Rio Farm, New Hampshires, Mesa, twenty-second, twenty-fifth, twenty-sixth, twenty-ninth, thirty-second, and thirty-sixth; and the Gold Spot Hatchery and Wm. M. Sprietsma, Jr., White Leghorns, Phoenix, twenty-third and thirty-seventh.

The egg-weight average of 24.4 ounces per dozen, although above the market standard for large eggs, was 0.5 of an ounce per dozen less than that of last year's test.

This year's mortality of 19.4 per cent exceeds that of last year's test by 3.5 per cent. The increase was caused by the unusual humidity of the summer months.

The amount of feed consumed per dozen eggs produced decreases as egg production increased. The feed consumption per dozen eggs produced by the various breeds included in the test and the average number of eggs produced were: White Leghorns, 4.6 pounds feed, 227 eggs; Rhode Island Reds, 4.9 pounds feed, 229 eggs; White Rocks, 5.3 pounds feed, 206 eggs; New Hampshires, 5.4 pounds feed, 202 eggs; and Wyandottes, 5.5 pounds feed, 178 eggs.

Eight, or 1.5 per cent, of the 520 pullets starting the test laid 300 eggs or more during the 357-day period; 140, or 27 per cent, laid between 250 and 300 eggs; and 311, or 60 per cent, exceeded 200 eggs.

Evaluations are determined by three factors: the number of eggs laid, the weight of the eggs, and the mortality. The point system is an evaluation of the number of eggs laid and the weight of these eggs. An egg which weighs at the rate of 24 ounces per dozen, the minimum weight for large eggs, is given a point value of 1.00. For each ounce over or under 24 ounces per dozen the point value is increased or decreased 0.05 (that is, an egg weighing at the rate of 23 ounces per dozen is given a point value of 0.95, and one weighing 26 ounces per dozen, a point rating of 1.10). It was due to the point system that the high pullet which laid 312 eggs, with a point value of 330, ranked ahead of the second-place bird, which laid 321 eggs but with a point value of 328, due to smaller eggs. Pens with high mortality are penalized since production data are calculated on the basis of the original thirteen birds entered, irrespective of the actual number alive at any time during the test. This heavy penalty is applied to encourage the breeding of strains of poultry with greater livability.

## SOIL SURVEY (CO-OPERATIVE WITH U.S.D.A.)

The war has hindered the progress of soil survey work in Arizona because many surveyors have joined the armed forces or have transferred to emergency work, such as the Guayule Emergency Project and other wartime agencies. In spite of these handicaps a soil survey of the Fredonia Soil Conservation District was initiated in the spring of 1943. The survey comprises 11,639

acres of land. Part of the land in the area has a high water table which it will require a special survey to delineate.

No survey work has been done in the Yavapai County area this year, but two trips have been made to the area. The first was for the purpose of establishing land use capability ratings for the soils in the Bridgeport, Camp Verde, and Chino Valley districts. Later an inspection trip was made in which all the soil series in these three districts were visited and samples gathered for chemical and physical study. It was found that the soils, except those derived from sandstone, were very heavy in texture. Alkali is generally not a problem, but the soils are frequently deficient in nitrates and phosphates.

The district soil survey inspector visited Arizona in April. The purpose of the joint inspection was to correlate the series already mapped in the Tucson, Casa Grande, and Salt River Valley areas with one another wherever possible. In other cases soil series which were too inclusive were divided into two or more series. For example, the Chandler series was established to care for the extremely heavy soils in the vicinity of Chandler. These soils had previously been included in the Mohave series. The Laveen series was likewise divided in order to take the extremely calcareous soils out of the Laveen series. The Tubac series, which had been confused with the Mohave series in the Tucson area, was redefined.

The soils in the guayule project, in the Queen Creek district, and in the White Tanks area were all inspected.

## SUMMARY OF STATION PUBLICATIONS

### TECHNICAL BULLETINS

No. 94.—*Studies on Plant Food Availability in Alkaline-Calcareous Soils: Seedling Tests and Soil Analysis,* by W. T. McGeorge. 41 pages. This bulletin presents a study of the Neubauer method for determining the plant food availability in soils, the comparative extracting power of rye seedlings and the seedlings of six other crops, data showing the empirical nature of the test, variation in Neubauer values with variation in weight of soil and number of plants, and comparison of seedling tests and the chemical analyses of soils.

No. 95.—*Rainfall and Runoff of the Upper Santa Cruz Valley Drainage Basin,* by H. C. Schwalen. 52 pages. The physiographic features of the drainage basin are briefly discussed with particular reference to the relation of rainfall to elevation above sea level, which varies from about 2,000 to over 9,000 feet with mean annual rainfall of 11 inches to over 37 inches, respectively. A rainfall map of the drainage basin is included. Results of frequency studies of both rainfall and runoff on the basis of all past records are given. The annual runoff on the Santa Cruz part of the basin

varies from less than 0.2 per cent to a maximum of 1.4 per cent of the annual rainfall. From the Rillito portion of the drainage basin the annual runoff varies from a minimum of 0.2 per cent to approximately 3.3 per cent of the annual rainfall. Runoff from short storms of high intensity on small drainage areas may, however, approach 50 per cent of the total rainfall.

No. 96.—*The Microbiological Oxidation of Ammonia in Desert Soils. I. Threshold pH Value for Nitratification,* by A. B. Caster, W. P. Martin, and T. F. Buehrer. 32 pages. This publication is concerned with the bacterial oxidation of ammonia in alkaline-calcareous soils and especially the use of liquid ammonia as a nitrogenous fertilizer which is extensively practiced in this state. Special attention is given to the threshold value, pH 7.7, above which there is considerable accumulation of $NO_2$ nitrogen even in well-aerated soils, further oxidation to $NO_3$ being retarded until the pH is reduced below pH 7.7.

No. 97.—*Physiological Studies of Yield, Quality, and Maturity of Marsh Grapefruit in Arizona,* by William E. Martin. 48 pages. This bulletin reports four years of studies on basic physiological factors associated with yield and market quality of grapefruit. These phases of fruiting were found to be markedly influenced by seasonal nitrogen supplies. Highest yields were associated with a high nitrogen and carbohydrate content preceding and through the blossoming and fruit-setting period. Most desirable market qualities of fruit were associated with a declining nitrogen content through the summer and fall. Cultural treatments to bring about the most desired situations are indicated.

No. 98.—*Forage Consumption and Preferences of Experimentally Fed Arizona and Antelope Jack Rabbits,* by J. F. Arnold. 35 pages, illustrated. This three-year study of forage consumption and preferences of two species of jack rabbit reports that the animals prefer plants in the order of weeds, grasses, and browse. Weeds and grass make up the major and about equal parts of the diet. The equal proportion of weeds and grass in the diet offers an explanation as to why jack rabbits are more abundant on overgrazed than on normal ranges. The author suggests that once overgrazing is under way rabbits may be a partial cause of deterioration, and in the final stages of forage depletion they may be the major factor preventing natural revegetation. On the basis of available data, jack rabbits' grazing pressure can be visualized in terms of cows as follows: When competition is considered to be direct, $62\pm7$ Arizona jack rabbits consume the same amount of forage as a 1,000-pound range cow, while $48\pm2$ antelope rabbits consume the same equivalent. When the two classes of animals are considered to compete only for perennial grasses, the equivalents become $260\pm20$ for the Arizona rabbits and $164\pm7$ for the antelope jacks.

No. 99.—*Vertical Zonation of Great Soil Groups on Mt. Graham, Arizona, as Correlated with Climate, Vegetation, and Profile*

*Characteristics,* by W. P. Martin and Joel E. Fletcher. 57 pages. A fundamental study of the physical, chemical, and microbiological characteristics of soil groups extending from the desert floor to the summit of Mt. Graham in Graham County is presented. Consideration is given to plant cover, rainfall, altitude, temperature, and other factors as they influence the micropopulation and the physical and chemical properties.

No. 100.—*Studies in Soil Structure: V. Bound Water in Normal and Puddled Soils,* by T. F. Buehrer and M. S. Rose. 60 pages. When soils become puddled soil moisture becomes less available to growing plants, and in this form it is referred to as bound water. This bulletin presents a study of normal and bound water in soils and is the fifth in a series of bulletins dealing with the physical properties of Arizona soils. It describes a new type of dilatometer, a dilatometric method for determining bound water in soils, and presents the experimental application of the method to the study of bound water. These studies involve the effect of organic matter, alternate wetting and drying of soils, soluble salts, alternate freezing and thawing of soils, and the nature of the bases in the exchange complex on water binding.

No. 101.—*Acidulated Fertilizers for Arizona Soils,* by W. T. McGeorge. 33 pages. This bulletin is a further contribution to the subject of soil reaction and its relation to the nutrition of plants growing on alkaline-calcareous soils. It presents experimental evidence in support of the proposal that acid fertilizers be used on alkaline soils. The experiments, conducted both in the field and greenhouse, show a definite increase in absorption of the micronutrient elements by plants and indicate an increased absorption of the macronutrient elements. Acidulation of fertilizers is accomplished by mixing sulphur with the fertilizer or by using an organic base to which a small amount of liquid phosphoric or sulphuric acid has been added.

## GENERAL BULLETINS

No. 185.—*Swine Raising in Arizona,* by E. B. Stanley, C. L. Bell, and J. T. Rigden. 27 pages. Conditions favorable to and methods of hog production in the state are discussed. Results of feeding experiments showing the relative values of the important feeds are presented. Swine production costs, herd management problems, and details of hog-lot equipment are also included in this publication.

No. 186.—*Wanted, Man Power for Arizona Farms,* by Elzer D. Tetreau. 36 pages. Number of hired men required in 1942 on Arizona's irrigated farms, by months and by counties. Also recommendations on recruiting farm laborers within Arizona and suggestions for getting a large amount of effective work from the employees.

No. 187.—*Sharing Farm Machinery,* by Ned O. Thompson. 14 pages. Amount and age of Arizona farm machinery, custom rate for farm operations, and suggested rental rates for certain farm machines.

No. 188.—*Arizona Agriculture, 1943: Production, Income, and Costs,* by George W. Barr. 17 pages. Analysis of Arizona farm and ranch production in 1942, with a discussion of trends in production and price. Acreages, by crops and by counties, and cash income summaries from various sources. Included is a chart showing distribution of Arizona farm income.

No. 189.—*Eradication and Control of Nut Grass,* by C. H. Davis and R. S. Hawkins. 20 pages. Nut grass can be eradicated without excessive cost and still provide for the production of a cash crop each year. Drying the tubers by bringing them within a few inches of the surface through successively deeper plowings at intervals of two or three weeks during the hot months of the year, followed immediately by a sorghum smother crop, successfully controlled nut grass.

Irrigation nine days after planting sorghum on a nut-grass-infested area caused an accelerated growth of the sorghum and overcame the detrimental effect of the weed.

Chemicals have failed to give satisfactory control of nut grass.

## OTHER PUBLICATIONS

Benson, Lyman. Revisions of status of southwestern desert trees and shrubs—I. *Amer. Jour. Botany.* 30:230-240, 1943.

Brown, J. G. Diseases and your vegetable garden. Mimeographed Report 51, Ariz. Agr. Exp. Sta., November, 1942.

Brown, J. G. and Helen Nicholson. Enfermedades de las Plantas de Cultivo. Mimeographed Report 51 (Spanish Edition), Ariz. Agr. Exp. Sta., November, 1942.

Davis, R. N. Making cottage cheese on the farm. *Arizona Republic,* July 12, 1942.

Davis, R. N. Home canned milk. *Country Gentleman,* October, 1942.

Davis, R. N. Pasteurizing for rancidity of milk. *Arizona Farmer,* 22:12, April 10, 1943.

Davis, R. N. Making and storing farm butter. Ext. Folder W-12.

Embleton, H. and H. B. Hinds. Progress report on emergency poultry rations. Mimeographed Report 49, Ariz. Agr. Exp. Sta., January, 1943.

Finch, A. H. Better navel orange fruiting. Mimeographed Report 50, Ariz. Agr. Exp. Sta., January, 1943.

Griffiths, A. E. and A. H. Finch. Another season's results on the production of vegetable and herb seeds in Arizona. Mimeographed Report 48, Ariz. Agr. Exp. Sta., August, 1942.

Hilgeman, R. H. A note on the measurement of flesh tenderness in Arizona Marsh grapefruit. *Amer. Soc. for Hort. Sci.*, Vol. 42, 1943.

Martin, W. P. and M. J. Sullivan. Influence of the decomposition of organic materials on the aggregation of some Arizona soils. *Proc. Western Soc. Soil Sci.*, 1942.

Martin, W. P., T. F. Buehrer, and A. B. Caster. Threshold *p*H values for the nitrification of ammonia in desert soils. *Proc. Soil Sci. Soc. of Amer.* 7:223-228.

Riddell, W. H. Better calves and heifers. Ext. Folder W-13, March, 1943.

Riddell, W. H. Stepping up wartime milk production. Ext. Folder W-23, June, 1943.

Riddell, W. H. Saving labor on dairy farms. *Arizona Farmer*, November 21, 1942.

Smith, G. E. P. The production of guayule rubber under irrigation. *Agricultural Engineering* 23, 10, 312, and 324, 1942.

Smith, H. V. A practical method for removing fluorine from water. *Proc. 6th Pacific Sci. Cong.* 6:185-191.

Smith, H. V. and J. W. McInnes. Further studies on methods of removing brown stain from mottled teeth. *Jour. Amer. Dental Assn.* 29:571-576.

Smith, M. C., L. O. Burlinson and A. E. Griffiths. Cantaloupe—an excellent source of vitamin C. Mimeographed Report 53, Ariz. Agr. Exp. Sta., February, 1943.

Stanley, E. B. and Max E. Robinson. Pasture studies with calves on winter forage crops. Mimeographed Report 47, Ariz. Agr. Exp. Sta., July, 1942.

Stanley, E. B. and J. T. Rigden. The cattle ranching industry in Arizona. Mimeographed Report 54, Ariz. Agr. Exp. Sta., March, 1943.

Stanley, E. B. and C. L. Bell. Cattle fattening project. Mimeographed Report 56, Ariz. Agr. Exp. Sta., May, 1943.

Thompson, Ned O. Farm management problems associated with attainment of production goals. See mimeographed Proceedings of the Western Farm Economics Association for 1942.

Tetreau, Elzer D. Manpower requirements and the outlook for available labor, crop year 1943, Arizona's irrigated farms. Mimeographed Report 52, Ariz. Agr. Exp. Sta., 1943.

Tetreau, Elzer D. Population characteristics and trends in Arizona. Reprint from *Southwestern Soc. Sci. Quart.*, Vol. 23, No. 4, March, 1943.

Tetreau, Elzer D. The impact of war on some communities in the Southwest. Reprint from *Amer. Soc. Rev.*, Vol. 8, No. 3, June, 1943.

Fifth annual report of the Arizona Feed Control Office. 66 pages. This bulletin is a report of the inspection and analyses of mixed feeds, mineral feeds, and cottonseed meal sold in the state during 1942. The agricultural chemist in the Experiment

Station is held responsible for the enforcement of this law. The bulletin contains a tabulation of all the above feeds registered for sale in the state and the analyses of 396 samples collected from stocks found on sale.

Fifth annual report of the Arizona Fertilizer Control Office. 19 pages. This bulletin is a report of the inspection and analyses of commercial fertilizers sold in the state. The agricultural chemist in the Experiment Station is responsible for the enforcement of this law. It contains a tabulation of all the fertilizers registered for sale in the state and the analyses of fifty-two samples collected by the inspector. It also contains complete data and graphs showing the monthly sales of mixed fertilizers, superphosphates, and nitrogenous materials.

TABLE 28.—CLIMATOLOGICAL SUMMARY FOR THE UNIVERSITY WEATHER STATION, 1942.

| | Jan. | Feb. | March | April | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Highest temperature.... | 82 | 78 | 86 | 91 | 103 | 108 | 110 | 104 | 102 | 95 | 85 | 78 | 110 |
| Lowest temperature.... | 26 | 27 | 28 | 31 | 40 | 52 | 68 | 61 | 56 | 35 | 26 | 25 | 27 |
| Mean temperature..... | 52.2 | 50.8 | 55.5 | 63.7 | 72.5 | 81.2 | 88.7 | 84.4 | 79.6 | 67.1 | 59.6 | 51.2 | 67.2 |
| Mean temperature, 72 years..... | 49.1 | 52.2 | 57.7 | 64.4 | 73.2 | 82.6 | 86.4 | 84.2 | 79.7 | 68.7 | 57.7 | 50.7 | 67.2 |
| Total precipitation (inches) ..... | 0.52 | 1.65 | 0.40 | 1.37 | 0.00 | T. | 0.58 | 1.13 | 1.56 | 0.47 | T. | 0.37 | 8.05 |
| Mean precipitation 74-year average..... | 0.79 | 0.87 | 0.78 | 0.78 | 0.22 | 0.30 | 2.28 | 1.93 | 1.11 | 0.53 | 0.95 | 1.04 | 11.28 |
| No. days with 0.01 in. or more precipitation | 2 | 4 | 3 | 4 | 0 | 0 | 5 | 5 | 5 | 5 | 0 | 3 | 36 |
| No. clear days..... | 21 | 11 | 20 | 13 | 26 | 29 | 11 | 13 | 15 | 16 | 23 | 20 | 218 |
| No. partly cloudy days | 6 | 8 | 9 | 15 | 5 | 1 | 18 | 17 | 12 | 11 | 5 | 7 | 114 |
| No. cloudy days..... | 4 | 9 | 2 | 2 | 0 | 0 | 2 | 1 | 3 | 4 | 2 | 4 | 33 |
| Av. ground velocity of wind (m.p.h.)..... | 0.72 | 0.84 | 1.16 | 1.25 | 1.43 | 1.44 | 1.08 | 0.83 | 0.62 | 0.95 | 0.78 | 1.18 | 1.02 |
| Av. velocity of wind on roof of Agr. Bldg. | 5.7 | 4.9 | 5.6 | 5.9 | 5.1 | 5.6 | ..... | 5.5 | 5.2 | 5.1 | 4.8 | 4.8 | 5.3 |
| Evaporation (inches).. | 2.080 | 2.274 | 5.655 | 7.291 | 11.215 | 12.752 | 11.451 | 9.037 | 7.628 | 4.996 | 2.663 | 1.668 | 78.680 |
| Relative humidity 12 m..... | 42.6 | 36.0 | 33.1 | 30.8 | 21.4 | 22.2 | 33.6 | 41.9 | 34.5 | 30.3 | 24.0 | 34.4 | 32.0 |
| 4 p.m..... | 43.7 | 36.8 | 31.4 | 25.6 | 18.2 | 20.7 | 31.7 | 39.7 | 34.1 | 30.9 | 26.0 | 35.5 | 31.2 |
| Length of growing season (days)..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 211 |

TABLE 29.—FINANCIAL STATEMENT, 1942-43, 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 | | | | | | $65,161.88 | 65,161.88 |
| Main station | ..... | ..... | ..... | ..... | ..... | 26,766.70 | 26,766.70 |
| Substations | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Balance and receipts from Sales | ..... | ..... | ..... | ..... | $43,573.30 | ..... | 43,573.30 |
| Total receipts | $15,000.00 | $15,000.00 | $60.000.00 | $13,285.16 | $43,573.30 | $91,928.58 | $238,787.04 |
| **DISBURSEMENTS** | | | | | | | |
| Salaries | 13,523.14 | 9,723.21 | 38,361.86 | 8,431.34 | 909.00 | 64,127.89 | 135,076.44 |
| Labor | 547.27 | 1,826.53 | 7,658.35 | 979.95 | 8,067.91 | 14,091.12 | 33,171.13 |
| Stationery and office supplies | 215.15 | 43.78 | 164.80 | 70.82 | 428.22 | 337.58 | 1,260.35 |
| Scientific supplies | 23.29 | 738.07 | 4,071.44 | 278.47 | 158.60 | 769.22 | 6,039.09 |
| Feeding stuffs | 98.36 | ..... | 1,257.31 | 18.35 | 5,850.73 | 438.80 | 7,663.55 |
| Fertilizer and irrigation water | 4.00 | 187.76 | 833.87 | ..... | 472.59 | 1,897.22 | 3,395.44 |
| Sundry supplies | 289.75 | 279.77 | 485.91 | 169.17 | 939.34 | 1,355.04 | 3,518.98 |
| Communication service | 43.35 | 44.48 | 85.71 | 162.94 | 54.72 | 889.96 | 1,281.16 |
| Travel expense | 142.83 | 1,473.04 | 1,935.63 | 794.90 | ..... | 993.82 | 5,340.22 |
| Transportation of things | ..... | 16.34 | 40.14 | 8.24 | 326.36 | 91.54 | 482.62 |
| Publications | ..... | ..... | 1,226.87 | 740.72 | 184.27 | 2,600.62 | 4,752.48 |
| Heat, light, water, and power | ..... | ..... | 16.90 | 10.01 | 274.73 | 413.69 | 715.33 |
| Passenger carrying vehicles | ..... | ..... | ..... | 213.04 | 259.67 | ..... | 472.71 |
| Furniture and fixtures | 18.40 | 521.43 | 370.65 | 27.76 | 396.99 | 171.77 | 1,507.00 |
| Library | ..... | 20.00 | ..... | ..... | ..... | ..... | 20.00 |
| Scientific equipment | 27.50 | ..... | 2,574.58 | 77.95 | 130.20 | 83.75 | 2,893.98 |
| Tools, machinery, and appliances | 66.96 | 125.59 | 417.14 | 1,101.50 | 1,554.28 | 2,993.41 | 6,258.88 |
| Livestock | ..... | ..... | ..... | ..... | 10,563.46 | 165.00 | 10,728.46 |
| Buildings and land | ..... | ..... | 498.84 | 200.00 | 2,411.54 | 508.15 | 3,618.53 |
| Contingent expenses | ..... | ..... | ..... | ..... | 314.99 | ..... | 314.99 |
| Unexpended balance | ..... | ..... | ..... | ..... | 10,275.70 | ..... | 10,275.70 |
| Total disbursements | $15,000.00 | $15,000.00 | $60,000.00 | $13.285.16 | $43,573.30 | $91,928.58 | $238,787.04 |