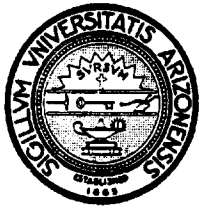

University of Arizona

COLLEGE OF AGRICULTURE

AGRICULTURAL EXPERIMENT STATION

FIFTY-FIRST ANNUAL REPORT FOR THE YEAR ENDING JUNE 30, 1940

PUBLISHED BY
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TUCSON, ARIZONA

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* In co-operation with United States Department of Agriculture, Bureau of Plant Industry.
† On leave.
‡ In co-operation with United States Department of Agriculture, Bureau of Agricultural Engineering.

February 25, 1941

President Alfred Atkinson
University of Arizona

Dear Sir:

I have the pleasure of presenting herewith the Fifty-First Annual Report of the Arizona Agricultural Experiment Station for the fiscal year ending June 30, 1940. 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-FIRST ANNUAL REPORT

INTRODUCTION

The Arizona Agricultural Experiment Station was established in 1889 for the purpose of serving the rural people of this State. It was made possible by joint action of the Federal and State governments. It is the organized agricultural research agency of the State and is one of the major divisions of the University of Arizona. The work of the main Station located at Tucson is supplemented by that of five outlying experimental farms in important agricultural areas. These farms are under the direction of department heads at the main Station. Many of the experimental results to be discussed in this report were secured at these substations. A glance at the pages which follow will show that much progress has been made during the past year in the application of the sciences to the solution of Arizona's agricultural problems. These results are made available to the farmers and ranchers by means of Experiment Station publications, through the efforts of the Agricultural Extension Service, and by the teachers of vocational agriculture in the high schools. Another important function of the Agricultural Experiment Station staff is direct service, such as personal conferences and farm visits; letters about individual problems (over 15,000 per year); chemical analyses of feeds, fertilizers, soils, and other agricultural products; seed analyses; insect pest control; plant and animal disease diagnoses with recommendations; radio and other talks; judging at county and state fairs; and advisory or active membership on public service committees. Besides the above, active cooperation with a number of the research bureaus and divisions of the United States Department of Agriculture is now made necessary, due to the many action programs being conducted in Arizona by federal agencies. A research background for most of these is proving beneficial.

The calendar year 1940 was a profitable one for the agricultural interests of the State. The cash income from the sale of farm and ranch products totaled approximately $58,000,000,[1] an increase of $4,000,000 over the previous year and a figure higher than for any single year since 1929 when $60,100,000 was received. Seventy-five per cent of Arizona's agricultural income comes from the sale of four commodities: cattle and

[1] For comparison it is interesting to note that the total metal output for the State during 1940 was approximately $81,500,000, of which $57,000,000 was copper.

calves ($16,000,000), cotton ($13,800,000), truck crops ($10,000,000), and dairy products ($3,500,000). Some twenty other commodities make up the other 25 per cent, including hay, sheep and wool, poultry products, wheat, feed grains, citrus fruits, flax, mohair, sugar-beet seed, dry beans, hogs, and potatoes, named in the order of importance. Only twice in the history of the State has the annual agricultural cash income exceeded that for 1940.

RESULTS OF THE YEAR'S RESEARCH

Edited by R. S. Hawkins, Vice-Director

AGRICULTURAL CHEMISTRY AND SOILS

The work of this department during the past year has dealt with research in the physical, chemical, and microbiological soil problems, irrigating and domestic waters, analytical (chemical) service to farmers (approximately 4,000 samples), enforcement of the Feed and Fertilizer Control laws, and keeping the weather records.

Soil Microbiology

Azotobacter

The study of azotobacter distribution and their activity in Arizona soils was completed during the year and published as Technical Bulletin No. 83. This publication presents a survey which showed these organisms to be more abundant in cultivated than in range soils. Since most of the cultivated soils are alkaline, a study was made of correlations between distribution and activity and salinity and alkalinity. Multiple regression statistics showed that sodium and calcium ions in the soil solution are dominating factors, while chloride and sulphate are associated only by virtue of their close correlation with sodium and calcium.

Microbiological, physical, and chemical characteristics of some soils from Mt. Graham and vicinity[2]

From thirteen locations, selected to represent the various vegetative and soil groups, extending from the top of Mt. Graham to the desert grass and shrub lands of the San Simon Valley at Tangue, soil samples have been selected for microbiologi-

[2] This project is being conducted in co-operation with the Soil Conservation Service.

cal, chemical, and physical study. The selected locations were in forested areas, mountain park areas, oak woodlands, desert grassland, and desert shrub lands. This investigation is now being prepared for publication. Apparently the great majority of factors studied vary significantly with elevation, and a number of associations between properties seem to be present, notably moisture equivalent and nitrification rate, per cent dispersion and cellulose-destroying bacteria, per cent nitrogen and nitrification rate, and pH and number of cellulose destroyers.

Investigations of soil changes which accompany water spreading[2]

This study is designed to determine what physical, chemical, and biological changes take place in soil areas which are subjected to diversion and spreading of floodwaters on land where vegetation is becoming re-established. The study sites are located in the Freeman Flat experimental area near Safford. Soil samples are taken twice yearly both in the regular manner according to horizon and in the undisturbed state. Since the area has been subjected to water spreading for less than 3 years, it is apparent that no definite conclusions can be drawn yet. One striking trend has been noted--namely, an increase in microbiological activity in the soil with increase in moisture penetration and vegetative growth. This includes increases in numbers of total bacteria, molds, and nitrifiers.

Influence of organic matter decomposition on the chemical and physical properties of some Arizona soils

With the great interest in crop rotation and green manuring in Arizona this project is one of major importance. Thus far the investigation has been confined to the laboratory. Sesbania, sour clover, hegari, and Markton oats have been used as manuring crops. They have been mixed with three soil types at the rate of 2 per cent organic matter and incubated at 30 degrees C. Experiments to date show that leguminous plant materials decomposed more rapidly initially than nonleguminous and in each case the decomposition was more rapid in Laveen and Pima soils than in Superstition sand. After approximately 21 days, however, a greater percentage of carbon in the nonlegumes had been lost than in the legumes. All organic materials brought about an aggregation of soil particles, but it was greater for the nonlegumes. The legumes gave the greatest decrease in pH of the soil. In fact there was no decrease in pH from nonlegumes. Nitrification was much more rapid in the soils to which legumes were added, the nonlegumes depressing the nitrate nitrogen content during the duration of the experiment.

Root nodule bacteria of some leguminous plants native to Arizona

Seeds of some 100 leguminous plants, native to Arizona, have been collected and to date forty-six have been planted in the greenhouse using soils collected from around the roots of the specific plant in the field as an inoculant. The materials have been collected from three field trips and from materials supplied by the Soil Conservation Service. Thus far ten cultures of Rhizobium have been obtained from nodules occurring on some of these plants. The others have either not nodulated or have not been examined as yet. It is planned that these cultures of Rhizobium be studied physiologically and that cross-inoculation tests with both native and cultivated legumes be conducted. Other studies are also being planned.

The micropopulation of the soil is intimately associated with soil fertility and the productive capacity of the soil. It breaks down organic matter into humus, fixes nitrogen from the air, transforms complex forms of nitrogen into simpler forms that the plant can assimilate, and has many other valuable functions. This research in microbiology is of value to the agriculture of the State in that it will lead to a more intelligent utilization and control of the microbiological operations in alkali soils.

Physical Research

Oxidation-reduction potentials of semiarid soils

The redox (reducing-oxidizing) potential is a measure of the extent to which a soil has been oxidized or reduced and represents a summation of the effects of all compounds that can undergo oxidation in soils. For this reason it is useful in organic matter decomposition studies. In fact, it is a more reliable measure of the degree of oxidation than a determination of the change in organic matter content by analysis. For this reason it is being used in the studies on soil structure with special reference to soil puddling and organic matter decomposition in Arizona soils.

While the rate of organic matter decomposition can be easily followed by way of redox potentials, the complexity of the organic matter added in the form of plant residues or animal manures makes the interpretation of the results difficult. For this reason attention has been directed during the past year to experiments with relatively simple compounds. These were starch, cellulose, and gum arabic; the nitrogen compounds, urea, cystine, and casein; and two organic acids—namely, suc-

cinic and benzoic. These compounds were mixed with samples of soil in the proportion of 0.5 per cent by weight and incubated at a uniform moisture content of 60 per cent of the water-holding capacity of the soil. The redox potential measurements were made on a 1:5 suspension of soil in double distilled water.

Carbohydrates decomposed readily in the normal (unpuddled) soil where there was an abundance of oxygen, and the soil samples containing them showed practically no change in Eh value (and only a small change in pH value) even after 18 days' incubation. However, when samples containing these carbohydrate materials were puddled, the potential dropped promptly by about 300 millivolts. In the case of cellulose the final equilibrium potential was about 380 millivolts.

All the nitrogen compounds showed a sharp decrease in potential during the first 2 days, and thereafter the potential of the unpuddled soils gradually rose to that of the check. In the case of the succinic and benzoic acid samples, the potentials of the unpuddled soils were again slightly higher than those which had been puddled, but in either case the equilibrium value of the potential was above that of the check soil. This appears to be simply a pH effect.

Sterilization of the soil samples containing these groups of compounds resulted in redox values which were the same as the check samples. These results show that the decomposition of organic matter does not take place to an appreciable extent in the absence of soil microorganisms.

When nitrogen is bubbled through the 1:5 suspension, the potential decreases due to oxygen removal. When oxygen or air is used, the potential remains constant or increases slightly.

In redox studies the storage of soil samples under nitrogen until such time as the potential can be measured will lead to erroneous results. It is also essential that the soil be kept in continuous suspension during the period of a potential measurement. Another important detail is the use of platinum foil electrodes of fairly large dimensions rather than platinum wire spirals, and they should be cleaned by heating to redness rather than with a chromic-sulphuric acid mixture.

A report on this investigation has been published during the year in the Journal of the American Society of Agronomy (Vol. 31, p. 903).

A healthy root system must have access to oxygen. Fundamental research in oxidation and reduction in soils is of value in helping to clarify the complex operations of this nature going on in soils.

Moisture relations in puddled soils

In semiarid regions moisture is of course the major growth-limiting factor. Soil properties which influence moisture movement and moisture availability are therefore of vital concern. Nonavailable water is sometimes referred to as "bound" water. In previous studies on the extent to which water is bound, it was found that this was related to the nature of the base with which the base exchange complex is saturated. When saturated with calcium and magnesium considerably more water was bound than when potassium and sodium were the dominant ions. This observation is in agreement with the known hydration of these ions which for Na is 8 mols of water per gram ion, 4 mols for K, 21 mols for Mg, and 22 mols for Ca.

In order to throw further light upon this phenomenon a study of the behavior of simple solutions of these ions upon freezing of soil moisture was carried out. The following salts were chosen for this experiment: LiCl, NaCl, KCl, NH_4Cl, $CaCl_2$, $MgCl_2$, $BaCl_2$, Na_2SO_4, and $MgSO_4$. Nonelectrolytes, such as sugar and glycerine, and colloidal solutions of agar and gelatine were also studied. Salt concentrations varied from 0.01 to 0.25 molal, sugar and glycerine solutions from 0.25 to 1.0 molal, and agar and gelatine solutions from 0.1 to 2.0 per cent. They represent the range within which reliable results can be secured. The dilatometer technique used in this work has been published in the Journal of Physical Chemistry.

In each case the amount of water that failed to freeze in the salt solutions increased with the salt concentration but not linearly. In the case of the nonelectrolytes the amount of water failing to freeze was a linear function of the molal concentration. The colloidal gels, agar and gelatine, showed no binding of water by the dilatometric method within the range of concentrations to which the method applies. The structure of the gel lattice is too weak to prevent the water from passing into the crystalline form.

In the clays the conditions are fundamentally different. The lamellar structure and the expanding character of the clay mineral lattice make it possible for the water to be bound. The amount bound depends upon the amount of water in the clay when it is puddled. Work on the extent to which different clays bind water and the rate at which the soil loses its moisture after puddling is being conducted.

During the hot summer months in Arizona crops will sometimes show wilting in the presence of ample water in the soil. One reason for this is that they are unable to withdraw the water because it is bound too strongly to the soil. Research in bound water is of value in clarifying this problem.

Lysimeter Studies

This experiment is a study of the nitrogen balance in the soil under different crop rotation programs and without nitrogen fertilization. The second 5-year rotation in this experiment will be completed in 1941 at which time all the data will be prepared for publication. All crops are being analyzed in order that a complete record of all the nitrogen entering the experiment may be had.

Can a farmer maintain a reasonable productivity by crop rotation alone? This experiment should be of value in answering this important question.

Fluorine Investigations

Preparation of bone filter

The efficiency of bone as an absorbent for the fluorides in drinking water has become an important phase of the fluorine investigation. In the original method the bone was heated 8 to 12 hours in 2N NaOH, washed with water, neutralized with HCl, and then calcined. By reducing the alkalinity to 1N, boiling for 1 hour, and substituting acetic acid for hydrochloric, a bone of greater absorptive capacity has been obtained.

Removal of stain from teeth

Many individuals who drank water containing high concentrations of fluorides during the time of tooth development have, in addition to mottled enamel, a brown stain on their teeth. The stain is presumed to penetrate the softer portions of the mottled tooth surface after the teeth have erupted. A search has been made for a safe method of removing the stain. In co-operation with a Tucson dentist the stain was removed from the teeth of five individuals with superoxol, hypochlorite, and very dilute acids. The technique was similar to that developed by Ames, of Virginia, some members of the Texas dental profession, and possibly others. Superoxol was slightly more effective than hypochlorite, and it is of interest that the pH of the former was 1.7 while that of the latter was 9.5. A series of 1-hour treatments extending from 5 to 20 hours was sufficient to bleach the most stubborn cases.

In view of the fact that acids are added to superoxol to stabilize it, a mixture of these acids was made—namely, sulphuric, oxalic, hydrofluoric, hydrochloric, and phosphoric. The bleaching action of this mixture was comparable with the hypochlorite. Ammonium persulphate, iodine, and sodium thio-

sulphate, potassium permanganate, and sodium oxalate were also tried, but none were satisfactory.

A study of the nature of this stain is being made.

Fluorine content of milk

In co-operation with the Dairy and Nutrition departments, cows were given drinking water containing as high as 500 parts per million of fluorine. Milk samples analyzed periodically showed little if any fluorine. Evidence indicates a lack of transference of fluorine from drinking water to milk. This was confirmed by analyzing milk samples from herds at Gila Bend and the Salt River Valley where the cows were drinking water containing as much as 11 parts per million of fluorine.

Fluorine in plants

Another phase of the problem being investigated is the absorption of fluorides by plants from soils bearing fluoride minerals or being irrigated with high fluorine water. Sodium fluoride was applied to Pinal soil and calcium fluoride to Gila soil, both calcareous types. The crops grown on these soils were wheat, hegari, sorghum, alfalfa, sweet potatoes, tomatoes, carrots, and beets. While the absorption of fluoride by treated plants was not high, it was consistently higher than in the plants grown on soil to which no fluoride was added. This is in agreement with work at the Wisconsin Experiment Station showing very little absorption of fluoride by plants fertilized with phosphates high in fluoride. The fate of sodium fluoride when applied to the soil is under investigation.

Fluorides in ground water

A survey of the ground waters of Arizona showed that water from deep wells is consistently lower in fluoride than that from shallow wells and usually below the toxic concentration. The laboratory has co-operated in some well drilling where a domestic supply low in fluoride content was desired. One illustration is presented in which a well yielding 9 parts per million of fluorine was reduced to 1.5 parts per million by deepening the well from 185 to 256 feet. Continued drilling below this level yielded a water below 0.9 part per million which is considered the line of safety.

This fluorine research has already proved its value many times over. A way has been shown for treating high fluoride waters to remove the fluorine or for drilling to lower levels where safe waters for domestic use can be obtained.

Boron

During the past few years there has been frequent mention of boron as related to Arizona crops, notably citrus, but thus far no systematic investigation of the subject has been made. Such an investigation was started during the past year. While boron is present in many Arizona waters and its presence has been shown by chemical analyses in plant tissue, there is no definite evidence of widespread injury. Because of the calcareous nature of Arizona soils there is much need for a comprehensive study, especially in view of the fact that calcareous soils quite often show deficiencies of essential amounts of boron for plant growth.

Boron is an essential plant food element with only a short range of tolerance between essential concentration and toxic concentration in the soil solution. This project is of value in answering the demand for information on the limitations of this range with respect to Arizona crops and soils.

Soil Moisture Relationships with Special Reference to the Development of Equipment for Determining Soil Moisture in the Field[a]

A capacitance bridge or soil moisture meter has been developed utilizing a triode crystal-controlled oscillator and a pentode vacuum voltmeter. An unknown condenser is connected in parallel with a precision condenser in the circuit, and the latter can be tuned to resonance to find the capacity of the former. The type of condenser which is proving most adaptable, simple, and inexpensive to construct, consists of two copper plates insulated with lead glass and separated by a porous ceramic plate condenser. As moisture enters the porous plate it increases the capacity of the condenser. Since the capacitance range is calibrated against known amounts of moisture, it is possible to determine moisture in the soil by merely reading the capacitance on the dial. Thus far measurements have been on an experimental scale, but these experiments have gone far enough to warrant field installations. The applicability of the instrument for field use must be proved before it can be recommended for any extended practical use.

The value of this project can be readily appreciated by all irrigation farmers, for water control is a most important problem.

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[a] Project conducted in Experiment Station Laboratory by personnel of Soil Conservation Service.

Lodging of Wheat

An interesting example of lodging of wheat was observed during the past year. It occurred on plants just approaching the heading-out stage following a light April shower and was confined to three limited areas. Two of these had received heavy applications of 16-20 ammonium phosphate and the other a heavy application of manure. Samples of soil and plants (lodged and not lodged) were taken for analysis at this time. At maturity heads were taken for further analysis. The data obtained are given in Tables 1 and 2.

The soil analyses show that a high nitrate is associated with the lodging. The plant analyses show a high nitrogen, phosphate, and potash in the lodged plants. This high nutrient absorption produced heavier, more vegetative plants as shown by the green weights, and the lodging was due to this heavier vegetative weight. This was proved by the fact that most of the plants again assumed an upright position a few days after the rain.

The analyses of the mature heads did not show definite evidence of a difference in per cent protein or phosphate. However, weight of heads and number of seed per head were definitely greater in the plants absorbing higher nutrients, and this is reflected in a greater amount of protein and phosphate per head.

Sulphur

During the past 10 years this department has given a great deal of attention to the effect of alkaline soil reactions on the absorption of plant food by crops being grown on alkali soils. It has been definitely shown that alkaline reactions seriously interfere with the availability and absorption of certain elements. In view of this the department has developed the use of "acidulated fertilizers"—namely, fertilizers containing a small amount of sulphur and built upon an organic base, a combination which on decomposition should aid plant food absorption. This is especially true if the fertilizer is applied as a band. Where fertilizer "simples" are used, sulphur and organic matter are placed in the band with the simple.

Field experiments in which sulphur was applied with the simples to lettuce have shown response in only one case. An examination of the bands indicated that often the sulphur may not decompose rapidly enough to be of benefit to the lettuce crop. It is apparent then that for short-growing crops sulphur should be composted with soil or manure before applying in bands with the fertilizer.

TABLE 1.—ANALYSES OF SOILS AND IMMATURE PLANTS.

Soil treatment	Plant condition	Soil		Plants			
		PO_4 (ppm)	NO_3 (ppm)	N (%)	P_2O_5 (%)	K (%)	Wt. green plant (gm.)
Manure	Lodged	16	40	1.89	1.20	3.62	9.5
Check	Not lodged	16	0	0.86	0.82	2.27	6.7
16-20	Lodged	18	5	2.24	1.31	2.98	8.3
Check	Not lodged	16	1	0.96	0.90	2.45	7.4
16-20	Lodged	16	120	2.05	1.20	3.52	9.6

TABLE 2.—ANALYSES OF MATURE HEADS.

Soil treatment	Plant condition	Wt. grain 20 heads	No. grain 20 heads	Per cent protein	Per cent P_2O_5	Gm. protein per head	Gm. P_2O_5 per head
Check	Not lodged	17.6	757	12.40	1.08	4.69	0.41
16-20	Lodged	22.4	828	12.25	1.01	5.06	0.42
Check	Not lodged	22.0	775	9.50	0.98	3.68	0.38
16-20	Lodged	23.5	966	14.50	1.05	7.16	0.51

In a greenhouse experiment where more rapid decomposition of sulphur is possible than in the field, an experiment was conducted in which ten crops were grown and fertilized by the band method as follows: 11-48 Ammo-Phos; 11-48 Ammo-Phos and sulphur; sulphur; and check, unfertilized. The plants were analyzed for phosphate, calcium, potassium, nitrogen, iron, manganese, and zinc, and the analyses showed increased absorption of these elements in most cases when sulphur was placed in the band with the fertilizer. The experiments are being continued in order to get more conclusive evidence of the effect of low pH on mineral absorption by crops.

The value of this project is in showing the way to more effective and efficient fertilization of the alkaline-calcareous soils of the State.

Lettuce Fertilization and the Plant Food Requirements of this Crop

During the past year an extensive series of experiments on lettuce fertilization was submitted for publication as a technical bulletin. In this investigation the field work was conducted by the Horticulture Department and the chemical work by the Chemistry and Soils Department. Most of the data submitted are of a chemical nature. It involves a study of the changes in nitrate nitrogen, available phosphate, and potassium in the soil during the growth of the crop and was conducted by analyzing soil samples from the lettuce beds at various stages of growth. Other phases of the work were: analysis of plant samples at different stages of growth; effect of fertilizers on yield, size of head, weight of head, and rate of maturity; and efficiency of different methods of fertilizer application as measured by the absorption of plant food by the crop and the amount of plant food removed from the soil by a lettuce crop. Briefly this investigation showed that the lettuce crop makes a continuous withdrawal of nitrogen, phosphate, and potassium from the soil throughout its period of growth. The amount of calcium and phosphate in the plant continues relatively constant throughout the growth of the plant, while the potassium and nitrogen fluctuate considerably. Lettuce removes potassium from the soil in greatest amount closely followed by nitrogen, while the amounts of calcium and phosphate removed are much less.

That phase of the work showing the efficiency of fertilizer application favored the band application. However, it was shown that even by this method only a relatively small amount of the phosphate added as fertilizer is used by the crop. On the other hand, practically all the nitrogen applied is used.

This suggests room for improvement in the economy of phosphate fertilization, and the value of sulphur and fertilizer acidulation is being studied with this in mind.

Heavy fertilization is required for economical production of most truck crops in Arizona. This investigation is of value because it showed the effect of different kinds of fertilizer and methods of application on lettuce production.

Soil Reaction

Studies on soil reaction, pH, continue as one of the major projects. During the past year co-operation between the eleven western states was continued in an effort to develop a uniform method of determining soil pH which would be applicable to all western soils.

This work has been centered at the Arizona Experiment Station, and a method developed in this laboratory has been accepted as most suitable for all soils. This method is simple in that the determination is made with the glass electrode at soil moisture content closely approximating field moisture content and therefore represents the pH with which the plant must contend. Previously soil pH had been determined at high soil-water ratios never met under field conditions, and due to the hydrolysis of the potentially alkaline compounds in the soil high pH values, never met under field conditions, were obtained. The method which is given here has been accepted as a tentative method by the Association of Official Agricultural Chemists and is being included in their new book of methods now in press.

Weigh 20 to 25 grams of soil into a 50 milliliter beaker and add boiled distilled water until the soil is soft enough to permit the ready penetration of the electrodes. (This moisture content is slightly above the moisture equivalent and well below the water-holding capacity of the soil. The mass may be stirred with a glass rod if desired to produce uniformity.) Gently tap the beaker and contents on the table top, press the glass electrode and its companion calomel electrode into the soil and make the pH reading. Make several readings on each sample by withdrawing the electrodes and pressing them again into the soil mass. The first reading is often in error because equilibrium is not always attained by the first contact between the electrodes and the soil mass.

The first year's investigation on this project was published in the Journal of the Association of Official Agricultural Chemists in May, 1940. The second year's work, which will complete this phase of the project, will be published in the same journal for 1941.

Alkali soils adversely affect crops because of their high pH or alkalinity. This project is of value for having shown the importance of accurate methods of measuring the pH value of soils.

Feeding Value of Waste Lettuce

During the lettuce packing season which extends through most of the winter there is a large waste of unmarketable heads and trimmings which are left in the field or discarded at the packing sheds. During a recent investigation of the composition of the lettuce plant, some feed analyses were made. These analyses are given in Table 3 in comparison with alfalfa. The data show that on the dry basis lettuce is on a par with alfalfa in protein content, higher in phosphate but lower in lime. It should make an excellent feed but would probably be best mixed with a more fibrous material because of its high moisture and low fiber content.

TABLE 3.—COMPARATIVE COMPOSITION OF LETTUCE AND ALFALFA.

	Protein	Fiber	Ash
Alfalfa No. 1 grade.....	16.2	29.5	8.4
Alfalfa No. 2 grade.....	15.0	29.5	8.4
Lettuce lowest.....	7.0	----	----
Lettuce highest.....	22.5	----	----
Lettuce average.....	15.0	10.8	19.0

Interpretation of Soil and Water Analyses

The Department of Agricultural Chemistry and Soils analyzes annually about 2,000 samples of soil and water. In order to assist the farmer and the layman to interpret these analyses and thus increase their value to them, two Extension circulars were published during the year. One was entitled "Interpretation of Soil Analyses" and the other "Interpretation of Water Analyses." The circular on water analysis gives a typical water sample and discusses each determination made in the analysis. The circular on soil analysis presents a scale from which the farmer may easily understand the pH determination in terms of alkalinity which is becoming of increasing importance in soil analysis; tolerance limits for white alkali or soluble salts; an interpretation of the plant food analysis for nitrate, phosphate, and potash; and a figure which can be employed in classifying a soil mechanically from a mechanical analysis. Both circulars are in the nature of handbooks and should be of constant use to farmers who submit samples of soil and water to the Experiment Station.

Feeds and Fertilizers

The Department of Agricultural Chemistry and Soils is charged with the enforcement of the feed and fertilizer control laws which were enacted by the State legislature in 1937. These are essentially correct labeling acts which require a statement of guarantee and registration of all feeds and fertilizers sold in the State. The duties of the control office involve the inspection and analysis of all feeds and fertilizers on sale in the State for comparison with the registered guarantees. During the year sixty-nine samples of fertilizer, 541 samples of mixed feed, forty-four samples of cottonseed meal, and seven samples of mineral feeds were analyzed. As represented by the sale of stamps and tags, 34,000 tons of mixed feeds, 35,000 tons of cottonseed meal, and 7,000 tons of fertilizer were sold in the State during 1939.

AGRICULTURAL ECONOMICS AND RURAL SOCIOLOGY

Farm Management

Custom work, Salt River Valley

The major source of power for cotton farming in Maricopa County shifted from horses to tractors in one decade. That less than 5 per cent of the power for cotton farming is now supplied by horses was brought out in a study being made by the department in 1939-40. In comparison, 57 per cent of the power and machinery costs were attributed to horses and horse-drawn machinery by a University study made in the same county in 1929. Horses are still used extensively, however, in harvesting hay.

Many of the heavy tillage operations are at present done by custom contractors. The study now being made indicates that about one half of the farmers in Maricopa County do practically none of their own plowing and that many others hire a part of their plowing done. Other tillage operations frequently performed by custom work are renovating, floating, disking, and bordering, while for some years baling, combining, and ensilage harvesting have been done largely by the custom operators.

This study also brings out some of the changes taking place in cultural practices. For example, most of the cotton is now planted by bedding and irrigating prior to planting, or by planting dry and irrigating up. A few years ago it was a common practice to use borders for irrigating prior to planting cotton.

Analysis of farm and home account records kept by Arizona Farm Security clients

The cost of family living averaged $633.62 in 1939 for seventy-one Farm Security clients, well distributed throughout the State, whose farm and home account records were summarized by this department. Of this amount 45 per cent went for purchased food. In addition, home-produced food was valued at an average of $212 per family. The next largest item of expenditure was clothing, which amounted to 12 per cent of the total living cost, while 8 per cent went for household operation. The farms averaged a net cash income per farm of $176.73. This amount included the value of farm products used in the home. In addition, these families had an average earning of $328.45 per family from labor off the farm.

The detailed summarization of these records was published in a mimeographed report entitled "A Comparative Summary of Farm and Home Account Records Kept by Arizona Farm Security Clients, 1939."

Farm leases under irrigation

During the current year some revisions were made in the flexible farm lease, with instructions, prepared during 1938-39. Data on the types of farm leases with special attention to share leases and the shares of the farm owner and tenant were gathered in Graham, Maricopa, and Pinal counties.

Supply-Price Relationships

The desert grapefruit industry

Desert grapefruit comprised 22,000 acres in 1940, made up as follows: Maricopa County, Arizona, 13,000 acres; Yuma County, Arizona, 1,100 acres; Imperial County, California, 5,500 acres; Coachella Valley, California, 2,500 acres. The producers of this grapefruit numbered more than 1,600, of whom 950 were in Maricopa County and about eighty in Yuma County. For the most part, owners of grapefruit groves in Maricopa and Yuma counties have no other agricultural interests than citrus production which is principally grapefruit. In the California areas, citrus growing constitutes only a part of the farm operation.

Desert grapefruit production approximated 113,000 tons in 1939-40. This fruit tends to move in the main toward the population centers of California and the northwestern states. Returns "on the tree" by subareas varied from $22 to $45 per

acre of mature fruit trees for the year 1939-40. The cost of production for the same year varied from $49 to $102 per acre. The cost of production per acre exceeded returns per acre in each of the subareas, even though no allowance was made for interest on the investment. Need for readjustment of the industry was indicated also by the percentage of the crop unharvested and the amount of tree abandonment or removal. Findings of the study were presented at the Arizona grapefruit prorate hearing at Phoenix, January 22, 1940, and again at a federal prorate hearing for the desert area, at Yuma, Arizona, October 15, 1940.

Marketing American-Egyptian cotton

A study made at the request of the American-Egyptian cotton growers consists of a rather complete analysis of the markets which utilize American-Egyptian cotton and an analysis of the competition which producers of American-Egyptian cotton have in the eastern seaboard mill areas. The report was published by the Arizona Agricultural Experiment Station as Bulletin No. 167, dated January, 1940, entitled "American-Egyptian Cotton: Utilization, Supplies, and Prices."

Arizona agricultural situation

The Arizona producers' adjustments to fit the national adjustment program and at the same time to provide themselves with a continued source of income have taken several forms. Short-staple cotton acreage was reduced 140,000 acres from the peak year of 1937 to 1939. American-Egyptian cotton, unrestricted by the adjustment program, was increased by 22,000 acres, and alfalfa in those 2 years was increased by more than 40,000 acres. The remaining 80,000 acres were idle in 1939. Much of the idle acreage of 80,000 is likely to go into alfalfa, grain, and other crops as soon as irrigation water becomes more plentiful. Arizona producers have attempted to meet the challenge of acreage reduction by effecting reduction in costs of production, especially by resorting to the use of larger machines and to custom work; by the acquisition of additional land, through purchase or rental, to increase the size of the farm; and by the substitution of conservation and price adjustment payments for earned income. An economic analysis of Arizona's agricultural situation was published by the Agricultural Extension Service, January 17, 1940, under the title "Arizona Agricultural Situation, 1940."

Population Trends and Migration

Arizona's agricultural population

While Arizona's man power requirements were supplied by the resident population excepting during peak months when migrant families added their numbers to the supply, the occupational and other cultural backgrounds of the population offered some handicaps to agriculture under irrigation. Many found it difficult to gear their plans to the fast-moving pace necessary to successful farming under irrigation; some were deficient in workmanship, and others anxious only for quick returns have threatened the future of Arizona's agriculture by overexpansion. Those social factors that tie in with place of origin, age, tenure, farming experience, etc. are of vital importance to the future of Arizona's agriculture, because they have had so much to do with the performance of the workers in the agricultural population. The purpose of this study was to show the relation of the population in agricultural families to the requirements of Arizona's agriculture and to emphasize the basic importance of the population as a factor in production. It is scheduled to be published by the Arizona Agricultural Experiment Station as Technical Bulletin No. 88.

Migration into Arizona, 1930 to 1940

A study of the volume and character of recent migrations into Arizona has been made through the co-operation of the Arizona Agricultural Experiment Station, the Arizona Department of Education and the Division of Farm Population and Rural Welfare, Bureau of Agricultural Economics, U.S. Department of Agriculture. The results of this study, for which data were obtained through the schools of Arizona, are being prepared for publication by Varden Fuller, of the Bureau of Agricultural Economics, and Dr. E. D. Tetreau, Rural Sociologist, Arizona Agricultural Experiment Station.

Social organization in Arizona's irrigated areas

A proportioned relation between family and commercial farms so as to maintain vigorous local government, education at accepted standards, and a minimum of local unemployment was the idea set forth in this study. A report of this study was published in Rural Sociology, June, 1940.

Social aspects of the farm labor problem

Manuscript was prepared for publication from a paper read at the annual meeting of the Rural Sociological Society, at Detroit, December, 1938. It was accepted by the Journal of Sociology and Social Research, Los Angeles. This article compares Arizona's farm labor with farm labor in other regions of the United States with respect to the proportion of wage earners in contrast with family workers, with respect to changes in seasonal labor, with respect to incoming migrants, and progress in farm mechanization.

Location of heirs and of property rights in farm estates

While rural-urban migration results in the transfer of wealth from farms to cities and from cities to farms on account of inheritance, by far the most significant movement of wealth is cityward. It is significant, however, that the movement of heirs is largely localized and that the consequent movement of wealth is also localized. Significantly, the movement of wealth is more highly polarized about the location of estates than the movement of heirs. The results of this study concerning the location of heirs and of property rights in farm and city estates were prepared for publication and accepted by the Journal of Land and Public Utility Economics.

Land Use

Land use practices in Pinal County, Arizona

An attempt was made to determine the factors associated with high cotton yields in Pinal County. Very little relationship was found between the productive value of the soil as indicated by cotton ratings prepared by the Bureau of Plant Industry in a recent soil survey and cotton yields, by soil types, in 1938 and 1939. Almost without exception, the range in yields on each soil type studied was very wide. High yields appeared to be associated with farming practice, especially with the practice of using alfalfa in rotation rather than with the productivity of the soil in so far as such productivity has been measured by soil survey ratings.

Cost of pump irrigation, Pinal County

The cost of irrigation water by pumping varied from $3.65 to $4.64 per acre-foot, with an average increase in lift of from 65 to 162 feet, according to a study made in Pinal County

by the University for the 1939 crop year. Other important factors causing variations in pumping costs were the efficiency of the pumping plant and the extent to which the plant was used to capacity. To maintain high pumping plant efficiency necessitates frequent testing of plant performance and the replacement of worn parts. Diversification of crops offers the best means for utilizing a pumping plant to capacity and saving on overhead costs. Ten farms growing only cotton had an average pumping cost per acre of $18.44, while the average cost for ten farms with a variety of crops and similar lift was $14.49 per acre, which was a saving of $3.95 an acre.

The findings of this study were released in a mimeographed report entitled "The Cost of Pumping for Irrigation in Pinal County, 1939" issued by the Agricultural Extension Service.

Size pattern of land ownership and operating units

An analysis was under way during the year with the purpose of showing the relationship of size of ownership and size of operating units to land planning and land policy. The work was carried on entirely in Pinal County. Co-operating with the Department of Agricultural Economics and Rural Sociology in this study was the Bureau of Agricultural Economics, U.S. Department of Agriculture.

AGRICULTURAL ENGINEERING

Ground Water Studies

The Cortaro-Marana district

The importance of flood flows in the Santa Cruz and Rillito rivers as a source of recharge to the ground waters of this district is well illustrated by the comparative positions of the water table at the beginning of the 1940 pumping season with that of 1939. As pointed out in the previous annual report a draft of 16,400 acre-feet in 1938 resulted in an average residual lowering of the water table of approximately 1.6 feet. In March, 1940, with a pumping draft of 16,900 acre-feet the previous season the water table showed an average rise of 0.3 foot above its position in March, 1939. Thus, the net effect upon the water table of approximately the same pumping draft shows a difference of 1.9 feet between the 2 years. Combined flood flows of the Santa Cruz and Rillito for the 12 months previous to the 1939 water-level measurements were only 10,600 acre-feet, less than one half the average annual flow for the past 19 years. The flood flows for the 12 months previous to the 1940 spring water-level measurements aggregated 31,700 acre-feet or almost one and one half times

the average annual discharge of the two streams. In both cases runoff occurred almost entirely as summer floods with high peaks and of short duration, and the amount of ground water recharge expected would be much less than from an equal amount of winter runoff.

The Eloy district

Intensive studies of the ground water supply of the Eloy district were begun in 1936 and have been continued since that time. Preliminary estimates of the annual replenishment, the quantity of water which can be used each year permanently, were published in 1938.* The quantity of water pumped was determined by indirect means, and therefore the computations were approximate in character but were close enough for the purposes of the study.

It was shown that the quantity pumped in 1937 was about three times the replenishment, the remaining two thirds being taken from storage.

The years 1936-38 were years of low rainfall and runoff in the Santa Cruz drainage area. The direct recharge to the ground water from rainfall on the district itself and from floods during those years was considered as negligible. The summer floods of 1939 were unusually large, offering opportunity to study recharge of such floods to the ground water supply. The floodwaters were spread over wide areas of the Eloy district, and some water penetrated a few feet into the soil, but no recharge to the ground water could be found, except a limited quantity beneath a section of the former Greene Canal, which is now eroded into a broad, deep river channel.

An attempt was made with the records of the 1938 year to introduce a new factor, the annual increment to the annual recharge. It is now realized that the field data are too approximate to permit of such refinement. The conclusion that can be stated with certainty is that the annual replenishment available for permanent pumping is of the order of 20,000 acre-feet. No more wells should be drilled; there are too many already.

Observations were made to determine the interference of wells with each other. The group of wells around the unused Wagner No. 1 well, where the water-level recorder is installed, includes two wells at distances of 0.7 mile, three wells at distances of a mile, and two others at distances of about 1.1 miles. When one of the two nearest wells was started, the effect at the recorder was evident in about 45 minutes, and thereafter the resultant lowering of the water level was

* Arizona Agr. Exp. Sta. 48th Ann. Rept., pp. 15-17 and Agr. Eng. Mag., Sept., 1938, p. 395.

close to 0.5 inch per hour. When several of the irrigation wells were started at the same time, the effect at the recorder was noticeable in about 40 minutes. Doubtless the rate of transmission from the several wells to the Wagner well is variable depending upon the aquifers.

Several records of lowering of the water table at the Wagner unused well as a result of pumping at many of the surrounding wells are shown in Figure 1. The two upper records in Figure 1 were made when the electric power allotment for pumping was 50 per cent of the time, this group of plants

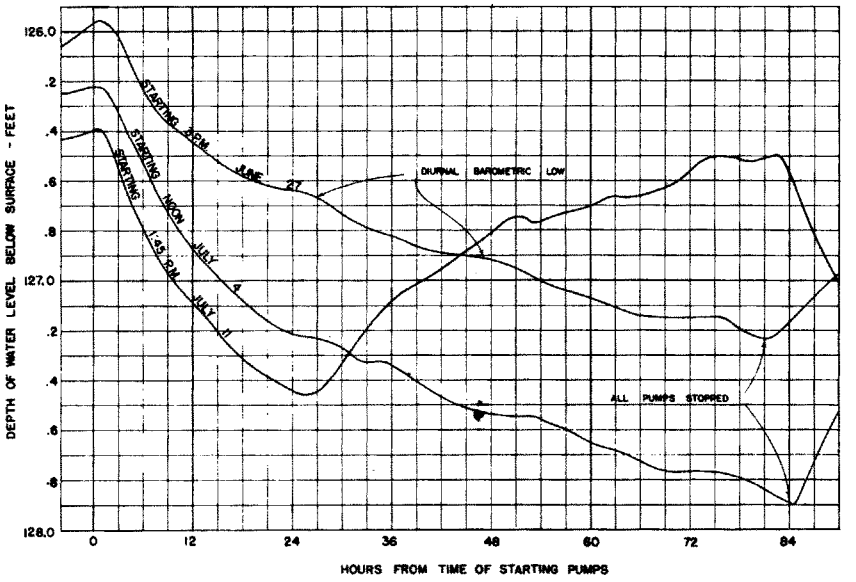

Figure 1.—Autographic water-level records at the Wagner No. 1 unused irrigation well, showing the lowering due to pumping at distant wells and recovery when the pumping at those wells ceased. About 45 minutes were required for the effect of starting a pump 0.7 mile away to reach the Wagner well. The lines of descent show the superimposed curves due to the diurnal fluctuations in barometric pressure.

being allowed to take power for 3.5 days per week, starting at a definite time. Hence all wells were started together.

The rates of lowering after the first few hours, as shown in Figure 1, were a little less than an inch per hour for 6 or 8 hours, after which the rates of lowering followed more closely the logarithm of time. The use of electric power which began at 2 o'clock July 11 was allowed to continue for 26 hours, at which time all pumping ceased, and the recovery curve thereafter is shown in the graph; all plants were started again at midnight July 14 after 56 hours' shutdown. After

this change-over the power allotment was one third of the time. The point established is that wells a mile apart do interfere with each other.

The record of lowering in the well at the site formerly occupied by the Griggs Service Station on the main highway offers opportunity to study the effect of draft on the water supply in a great basin. All of the pumped wells were to the west of the Griggs well, the nearest one being 2.5 miles away. The conditions were quite constant during the 3 years 1937-39, during which the residual lowering was nearly 10 feet. The lowering increased as the 1.23 power of the time and not as the logarithm of the time.

A bulletin giving the results of the studies made to the end of 1939 has been prepared and published.[5]

Upper Santa Cruz Valley

A special study was made of the physiography of a part of Santa Cruz County, the part lying between the lower course of Sonoita Creek and the international boundary. The eastern part of the area consists of pediments and valleys flanking the west side of the Patagonia Mountains. To the west is the dissected fan or delta of the so-called Sonoita Creek, which is a river after heavy rain.

After a long period of aggradation, the valley between the Patagonia Mountains and outliers of the Santa Rita Mountains was choked with alluvial deposits. The main drainage course occupied mid-valley and followed the present course of Guebabi Valley at one time. Later the stream which drained the south slopes and foothills of the Santa Rita Mountains captured the Sonoita, and it is now entrenched 600 feet below the level of the highest valley surface. The former course has been beheaded by the erosion of Flux Canyon. Erosion, in three main stages, has created an intricate system of valleys and ridges in which numerous stream captures are discernible.

The underdrainage is normal and stock wells are obtainable in Pleistocene deposits. Several dam sites in Sonoita Valley are worthy of detailed study, especially one in the NW.1/4 of Section 33, T. 22 S., R.14 E.

Recharge to the ground waters of the upper Santa Cruz Valley is in large measure dependent upon the surface flow of the Santa Cruz River through the area. Flood flows in August, 1939, resulted in a maximum rise of the water level in the automatic water level recorder well near Tubac, at a distance of about 700 feet from the stream channel, of 0.40 foot per

[5] Ariz. Agr. Exp. Sta. Tech. Bull. 87.

day. The taking of water levels in wells which was initiated in June, 1939, was at an opportune time, as water levels had reached the lowest point in many years. This may be attributed in part to the small runoff in the Santa Cruz River for the 3 previous years but it is probably due mainly to the fact that the runoff for the summer of 1938 and winter of 1938-39 was the lowest for which runoff records are available. Summer floods of 1939 were above average, and as a result the water levels in June, 1940, were slightly above those in June, 1939, notwithstanding almost negligible runoff or stream flow during the winter of 1939-40. The upper Santa Cruz pumping area was probably the only one in the State which entered the 1940 pumping season with a higher water table than in 1939.

Little Chino Valley

Continuation of the studies in the Little Chino Valley artesian district indicates an additional average residual loss in artesian pressure of 0.6 foot in the spring of 1940 as a result of the previous season's draft upon the artesian supplies. This lowering was practically the same as that noted in the spring of 1939 following the 1938 irrigation season, although the irrigation draft was approximately equivalent to that required for an additional 150 acres of crop land. Seasonal lowering of artesian pressures in the fall of 1940 averaged about 2.5 feet, most of which it is expected will be recovered by the spring of 1941. With increased development of the district during 1940 and the greater use of pumping equipment on flowing wells, interference between wells has become more marked. Artesian pressures are reduced, and the discharge from flowing wells decreased during the pumping season.

Seepage losses from irrigation have resulted in the partial waterlogging of a small area with tight subsoil below some of the larger irrigated fields and have also been reflected in the rise in water levels in near-by shallow surface wells. This should serve as a warning to farmers in the district that the use of excessive amounts of irrigation water and the waste of water from flowing wells may introduce locally serious drainage problems.

So far as known at present the only natural outlet of waters from the artesian basin is at Del Rio Springs. The outflow varies from a minimum of about 3.0 second-feet in midsummer to a maximum of 4.25 second-feet in winter. It is believed that the difference between summer and winter flow may be accounted for by increased evaporation and transpiration losses in summer from the cienega and shallow water table lands immediately above the weir installation.

Forecasting the Water Supply

Since 1932 there has been general deficiency in rainfall in Arizona, and since 1937 water shortage has been acute in the valleys of the Gila River and its tributaries. In such periods of shortage it is advantageous to have at planting time the closest possible forecasts of water supply for the ensuing months. The forecasts are needed to determine how much land should be in crop and how much should be left idle. If an excess is planted and receives only one or two irrigations, just that much water is wasted. Forecasts can be made only by those who have ready information on all the contributing factors.

Studies are under way to determine how accurately the runoff of April, May, and June can be forecast from records of rain and snow and snow pack and temperature of the 4 preceding months. The forecasts are needed most on April 1. At that time the winter rains are over; spring rains capable of producing runoff in quantity are so rare that that factor can be neglected.

A tabulation of the water requirements by months was made for the San Carlos irrigation project, and the forecast of water supply was computed in March, 1940, leading to the conclusion that 53 per cent of the project area should be in crop. The method of computation and the conclusion were publicized by radio on April 3.

If forecasts can be made late in September they will be helpful in determining the fall planting. During years of abundant water supply forecasts are not needed.

A paper on forecasting the water supply was prepared and read before the Southwestern Section of the American Association for the Advancement of Science in April. It has since been published.[6]

Special studies were made of the summer storms to determine correlations between the pressure distribution, the cumulus-cloud movement, and the occurrence of rain. Observations covering many years have indicated that conditions favoring precipitation in southern and eastern Arizona are accompanied or preceded by westward-moving air masses. The cumulus clouds formed over the mountains during midday by the convectional circulation and adiabatic cooling are carried along with the general high air movement. Publicity has been given to the following general rule. During the summer rainy season, if the cumulus clouds at noon are moving west or southwest, rain may

[6] The Pan-American Geologist, 74:94-98, Sept., 1940.

be expected; if the clouds are moving northwest, there is a fair chance of rain.

Wells and Pumping Equipment

Drouth conditions combined with a shortage of electric power gave impetus to the drilling of many new wells in the spring of 1940 and made necessary the change-over from electric to engine drive of many pumping plants. The drilling of new wells further increased the draft upon many already over-pumped areas. Many farmers did not realize until almost too late the acuteness of the power shortage. As a result there was a sudden rush to secure internal combustion engines to replace electric motors on irrigation pumping plants at the last moment. Only a few of the heavy duty, slow speed Diesels were available and in many cases the lighter, high speed automotive type of engine was hurriedly installed. Gasoline, gas, fuel oil, Diesel and semi-Diesel engines were secured for this purpose. Some of these installations were made without making sufficient allowance for the severity of the conditions under which they would have to operate. These included in many cases continuous duty at practically full load, extremely high air temperatures, very low humidities, and belted or right-angle gear drives, the efficiency of which may have been overestimated. Experience gained from the past season's operations indicates that at least in some cases engine companies should make greater allowances for the continuous duty requirements for pumping plants under Arizona conditions.

Measurement of Water

Various forms of the Pitot tube have been used in Arizona by pump sales engineers in recent years. This method is open to serious objection. The only method of measuring the flow of water that is adaptable to the farm is the weir. A weir can be built and used by a farmer with assurance and certainty.

For permanency, this department recommends a concrete structure with a weir crest of noncorrosive metal. Usually such structure serves a triple purpose. It is discharge box, weir, and division box. In such cases the extra cost of the weir feature is not great.

The department has designed a semipermanent weir of low cost, employing redwood for the principal parts. Blueprints of this design can be had by addressing the Agricultural Experiment Station.

Measurements of the Evaporation Rate

A project involving measurements of the evaporation rate was initiated in 1916. The purpose was to aid in determining the proper duty of water in the various irrigated areas of Arizona by comparing the climatic factors with those of Salt River Valley, where extensive duty of water investigations have been pursued and published.[7] Three Class A evaporation stations at Yuma, Mesa, and Willcox were established by this department, each one in an alfalfa field. The observers were paid by the Agricultural Experiment Station.

The results of the first year's observations were analyzed and published promptly.[8] Close relationship was shown between the evaporation rate and both temperature and wind movement. The highest rate was at Willcox, the lowest at Mesa. The influence of wind outweighed that of temperature, but in August, when the wind movement at Willcox was at a minimum, the evaporation at Yuma surpassed that at Willcox. However, the evaporation at Yuma in August was increased by the raising of a seed crop.

The Mesa Station has remained close to its original location, but after 1 year the alfalfa was plowed under. Cotton was planted in 1918, resulting in increased evaporation the first 7 months and lower rates in August and September. The Yuma Station was moved January 1, 1928, to the Yuma Date Orchard, at the corner of Third Street and Avenue B, and in July, 1931, to the Yuma Valley Experiment Farm, 8 miles farther south. The Willcox Station was moved in 1923 to the J. J. Adling Farm and in April, 1927, to the R. R. Harbour Farm, but always was in an alfalfa field. The records most directly comparable are those of the year 1917, although at Yuma a seed crop in that year increased the normal rate.

The Willcox and Yuma stations have been terminated, and therefore it is desirable to publish the complete records. They are given in Table 4.

It is apparent that there is much variation in evaporation at a definite location between successive years, and also that the evaporation losses at locations only a few miles apart vary definitely. In the Willcox area evaporation on the Adling Farm was the greatest, at Yuma the evaporation was greatest on the Valley Experiment Station. At the Mesa Experiment Station the low evaporation rate in 1917 is equalled by the low rate in 1925-27 when the evaporation pan was in a new location near a well-watered vineyard.

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[7] Ariz. Agr. Exp. Sta. Bull. 120.

[8] Ariz. Agr. Exp. Sta., 28th Ann. Rept., p. 484, 1917.

TABLE 4.—RECORDS (IN INCHES) OF CLASS A EVAPORATION STATIONS AT MESA, YUMA, AND WILLCOX.

Year	Location	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1917	Mesa	1.792	2.882	4.059	6.525	7.482	8.478	9.569	9.134	6.918	4.285	3.357	2.579	67.060
	Yuma Valley	3.081	4.524	6.789	6.797	8.485	5.772	9.218	11.510	7.789	5.211	3.303	2.848	75.327
	Willcox	2.576	4.156	8.018	10.552	11.575	13.943	11.676	10,011	8.637	7.965	6.255	4.229	99.593
1918	Mesa	2.646	3.506	5.366	8.646	10.927	11.000	10.384	8.045	6.469	4.705	3.038	2.840	77.572
	Yuma Valley	3.468	4.486	5.302	9.291	10.148	13.841	11.879	9.986	7.986	5.380	4.198	3.032	88.997
	Willcox	3.570	5.269	7.154	11.086	12.007	9.799	10.239	8.853	8.423	6.832	4.930	2.795	90.957
1919	Mesa	3.305	3.180	6.298	8.379	10.940	11.372	9.317	7.816	6.953	4.681	3.518	2.857	78.616
	Yuma Valley	4.305	4.513	6.638	9.153	7.790	9.078	10.546	7.572	5.628	5.233	3.157	2.992	76.605
	Willcox	3.963	3.669	8.047	9.600	10.414	11.416	8.602	8.671	6.602	5.355	4.064	3.338	83.741
1920	Mesa	2.152	2.387	5.570	8.866	11.384	12.039	11.307	9.227	7.911	6.106	3.375	2.982	83.306
	Yuma Valley	2.735	2.980	5.233	6.785	7.307	8.123	9.551	9.253	7.495	5.432	2.749	2.660	70.303
	Willcox	2.840	3.755	6.429	8.920	10.915	10.756	11.400	9.452	7.854	5.676	3.450	3.555	85.002
1921	Mesa	3.069	5.220	7.952	9.809	11.619	12.822	12.081	8.599	6.739	5.210	3.402	2.833	89.355
	Yuma Valley	2.522	4.102	5.748	7.163	7.627	8.816	11.175	-----	6.582	3.638	2.427	-----	------
	Willcox	3.591	5.523	8.809	10.095	11.903	12.975	9.976	6.540	6.304	7.010	4.279	3.719	90.724
1922	Mesa	2.780	3.806	5.376	8.662	11.478	11.993	10.323	7.507	5.739	4.350	3.500	2.031	77.545
	Yuma Valley	2.714	3.321	5.381	7.635	8.378	9.129	10.311	8.969	8.327	5.637	3.180	1.971	74.953
	Willcox	3.153	4.592	5.002	-----	6.850	------	------	-----	-----	-----	-----	-----	------
1923	Mesa	3.499	4.143	6.929	8.609	11.563	12.169	9.779	7.560	6.150	4.580	2.773	2.333	80.087
	Yuma Valley	2.785	3.717	5.685	6.352	8.031	8.212	10.266	-----	-----	6.501	3.070	2.384	------
	Willcox	-----	3.794	7.270	10.423	13.837	12.488	10.213	7.198	7.595	7.308	3.769	2.587	------
1924	Mesa	3.360	4.841	5.902	7.608	11.849	12.333	10.331	8.099	6.403	6.325	3.702	2.531	83.284
	Yuma Valley	3.184	4.105	5.436	6.768	8.351	9.527	10.146	11.663	9.130	6.632	4.278	3.017	82.237
	Willcox	4.502	4.972	6.957	8.855	11.885	13.873	11.067	12.735	11.619	8.715	6.408	3.957	105.545

1925	Mesa	2.675	3.243	4.680	5.326	8.532	10.104	11.093	9.111	5.625	3.565	3.112	2.858	69.924
	Yuma Valley	2.939	3.233	5.431	6.388	7.651	7.879	9.951	12.284	9.606	5.113	4.238	3.161	77.874
	Willcox	5.564	6.634	9.330	11.280	11.786	12.514	11.936	8.748	7.790	4.942	4.171	3.114	97.809
1926	Mesa	2.551	3.539	5.272	5.399	7.410	9.240	11.153	7.798	4.959	3.482	3.766	2.382	66.951
	Yuma Valley	3.178	3.878	5.586	6.205	8.591	8.691	9.390	8.429	6.536	5.153	3.360	2.513	71.510
	Willcox	2.781	4.987	5.840	-----	-----	-----	-----	-----	-----	-----	-----	-----	-------
1927	Mesa	3.080	2.640	4.185	4.953	8.898	10.179	11.049	8.201	5.010	4.058	2.746	2.530	67.529
	Yuma Valley	2.663	3.799	6.276	7.959	10.428	10.651	9.608	8.675	7.114	4.757	2.677	2.693	77.300
	Willcox	-----	-----	-----	11.640	11.640	9.480	7.467	6.065	4.750	4.533	6.016	2.906	-------
1928	Mesa	3.133	3.663	6.661	8.374	11.483	12.204	12.218	9.992	8.328	4.971	3.615	3.242	87.884
	Yuma Valley	4.086	4.817	6.783	9.562	11.029	12.078	10.684	9.298	8.022	5.750	4.449	4.164	90.722
	Willcox	5.057	4.352	7.208	11.727	7.722	11.083	8.215	5.934	7.016	3.758	2.688	-----	-------
1929	Mesa	2.575	3.815	6.024	7.629	9.953	10.878	9.535	9.280	7.009	5.863	4.091	3.635	80.287
	Yuma Valley	3.959	5.027	7.762	8.878	10.940	10.431	10.518	9.306	6.927	5.507	4.194	-----	-------
	Willcox	-----	-----	6.365	9.791	11.103	------	------	7.380	6.829	4.195	-----	-----	-------
1930	Mesa	2.683	4.351	6.102	7.026	8.837	10.465	10.024	8.825	7.361	5.549	3.935	2.928	78.086
	Yuma Valley	-----	-----	-----	-----	-----	------	------	-----	-----	-----	-----	-----	-------
	Willcox	3.142	4.310	5.683	7.373	8.174	8.386	7.174	7.958	6.492	5.593	4.318	2.588	71.191
1931	Mesa	3.274	3.513	5.860	7.139	10.046	10.018	11.949	9.523	7.774	5.517	-----	2.520	-------
	Yuma Valley	-----	-----	-----	-----	------	------	------	10.513	9.068	6.717	4.472	3.509	-------
	Willcox	5.119	4.098	7.150	6.795	8.127	8.839	8.830	6.946	5.692	5.234	3.833	-----	-------
1932	Mesa	2.604	-----	5.538	6.560	9.082	9.980	10.380	9.288	7.727	5.118	4.096	-----	-------
	Yuma Valley	4.919	4.570	9.307	10.426	14.241	13.582	14.810	13.422	10.046	6.821	4.744	2.947	109.835
	Willcox	-----	4.485	6.820	8.861	10.828	12.193	8.401	7.843	7.881	5.869	5.992	3.526	-------
1933	Mesa	-----	3.766	5.811	6.831	8.585	10.138	11.143	10.014	8.434	5.824	3.846	2.273	-------
	Yuma Valley	3.353	4.902	7.994	9.417	11.124	12.293	14.619	12.491	10.213	7.382	5.106	3.546	102.440
	Willcox	-----	4.789	8.073	10.175	11.679	9.940	10.036	7.932	6.903	5.868	4.529	3.002	-------

TABLE 4.—RECORDS (IN INCHES) OF CLASS A EVAPORATION STATIONS AT MESA, YUMA, AND WILLCOX—Continued.

Year	Location	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1934	Mesa	3.519	3.780	6.603	7.747	10.295	10.716	11.524	9.458	7.305	5.667	3.035	2.495	82.144
	Yuma Valley	4.362	4.645	7.748	9.376	11.931	11.627	14.331	12.103	9.549	7.616	4.447	3.521	101.256
	Willcox	4.490	4.416	7.921	9.969	10.059	11.074	10.186	8.113	6.782	6.069	4.193	2.778	86.050
1935	Mesa	2.304	4.075	3.801	6.450	9.294	11.450	10.948	8.277	7.068	5.217	2.596	2.402	73.887
	Yuma Valley	3.158	4.898	7.125	9.247	12.461	14.237	12.546	9.296	7.881	7.308	4.121	3.175	95.453
	Willcox	3.112	5.150	6.138	9.737	8.613	9.464	9.686	7.421	6.574	6.318	3.309	3.568	79.090
1936	Mesa	2.483	2.892	5.882	8.347	11.209	12.322	12.081	9.968	9.078	6.629	4.945	2.409	88.245
	Yuma Valley	3.625	4.747	8.064	10.536	13.195	14.169	13.393	12.080	9.865	6.706	5.138	3.528	105.046
	Willcox	-----	-----	-----	------	------	------	------	------	-----	-----	-----	-----	-------
1937	Mesa	2.381	3.858	5.257	8.418	9.371	11.336	11.962	10.670	8.129	5.984	3.263	2.767	83.396
	Yuma Valley	3.399	5.522	7.781	11.042	12.679	14.209	14.933	12.497	10.246	7.273	4.689	4.164	108.434
	Willcox	-----	-----	-----	------	------	------	------	------	------	-----	-----	-----	-------
1938	Mesa	2.986	2.590	4.803	8.627	10.540	11.228	10.425	9.492	7.932	4.781	4.132	2.330	79.866
	Yuma Valley	4.705	4.224	7.375	11.317	12.491	13.164	13.246	11.657	9.675	6.863	5.673	3.466	103.856
	Willcox	-----	-----	-----	------	------	------	------	------	-----	-----	-----	-----	-------
1939	Mesa	2.867	3.459	6.413	8.801	11.435	11.842	12.381	10.355	7.275	6.416	3.899	2.466	87.609
	Yuma Valley	3.872	4.776	7.656	10.405	13.432	13.658	15.052	13.682	8.431	8.036	4.020	3.833	106.853
	Willcox	-----	-----	-----	------	------	------	------	------	-----	-----	-----	-----	-------

The average annual evaporation rate appears to be considerably higher at Yuma and at Willcox than at Mesa.

However, the wide divergencies in the record of each valley make the comparisons of little value. In the Yuma Valley there is considerable subirrigation, and at Willcox the irrigation season is shorter than at the two other locations; these factors tend to decrease the need for irrigation water. Relative evaporation rates are indicators of relative transpiration rates and duties of water, but it seems preferable to accept the duty of water as determined in the Salt River Valley as applicable to other sections of central and southern Arizona in legal proceedings and in the plans for any new projects.

A Class A evaporation station was established at Roosevelt about the same time as those already discussed. The records are not included because a study of them shows that the evaporation rate is affected greatly by the height of the Roosevelt Lake level and the consequent area of water surface. Thus high evaporation rates of 1929 can be accounted for only by the low lake level.

AGRONOMY

Cotton

Irrigation experiments

The cotton irrigation experiments were carried through the 1939 season on the Mesa Experiment Farm in co-operation with the Division of Cotton and Other Fiber Crops and Diseases. The results obtained again showed the superiority of early irrigation as compared with delayed irrigation following planting.

Early irrigation stimulated early fruiting as indicated by the percentage of the total crop harvested at the first picking. Seventy-three per cent of the total crop was harvested at the first picking on the Pima plots receiving early irrigations after planting, as compared with 49 per cent on Pima plots receiving delayed irrigations. These plots yielded a total of 468 and 390 pounds of lint per acre for the early and delayed irrigations, respectively.

Similar results were obtained with Acala cotton, although differences between the various irrigation treatments were not so pronounced as with the Pima variety.

Variety tests

Among the American-Egyptian varieties, the SxP and the Early Pima outyielded the Pima by 232 pounds of seed cotton per acre.

Seven strains of Acala with five replicated plots of each were grown in 1939 on the Mesa Farm. Santan Acala, a strain selected by the University in co-operation with the U.S. Field Station at Sacaton, outyielded all others. A New Mexico selection was the lowest yielding strain in the test, yielding 128 pounds less lint per acre than the Santan.

Hartsville, a variety with extra staple length grown commercially in Arizona a number of years ago, outyielded Acala by 71 pounds of lint per acre.

Heat resistance

Cotton is grown in Arizona at elevations ranging from a low of around 100 feet above sea level at Yuma to 3,600 feet at Duncan. Higher temperatures during the cotton growing season prevail at the lower elevations than at the higher elevations. Observations indicate that the quality of the Acala variety of cotton, at least, is poorer at the low elevations. This is likely a temperature effect. Studies are under way to determine the influence of excessive temperatures upon the growth and fruiting behavior of cotton plants. Definite differences in heat resistance have been shown by Acala plants held at high temperatures in temperature control chambers. Twelve plants which exhibited superior heat resisting qualities were selected in 1939 from a total of 184 plants. Fruiting studies have been made on these plants and additional selections are now being continued to determine the extent to which heat resistance is heritable.

Grain Sorghums

Varietal trials with grain sorghums were continued and expanded to include an earlier planting of late maturing varieties in which those included gave higher yields in all cases than the same varieties in the regular trial plots. The new variety, Manko, introduced by the department, is being recommended for planting on fertile lands with adequate water supplies because of its high yields of grain and silage. A yield of 24.25 tons per acre of silage was obtained on land just out of alfalfa. Grain yields of the leading varieties tested are given in Table 5.

Testing of pure line strains of hegari, Double Dwarf yellow

TABLE 5.—GRAIN YIELDS FROM IMPORTANT GRAIN SORGHUM VARIETIES, SALT RIVER VALLEY EXPERIMENT FARM, 1937-39, INCLUSIVE (LBS. PER ACRE).

	Manko	Fargo	Hegari	Ajax	Algeria	DDY Milo
1937	6,235[a]	5,699	5,742	6,525	6,246	5,697
1938	6,469[b]	5,536	5,982	5,187	5,410	4,489
1939	6,690[b]	6,998	6,397	5,898[b]	6,406	5,785
Average	6,465	6,078	6,040	5,870	6,021	5,324

[a]Damaged by birds.
[b]Early planting.

milo, Atlas, and Fargo has been continued. Seed of the five leading selections of hegari were bulked and planted in fields of foundation hegari for the purpose of securing seed increase which will be used as the foundation seed in 1941. This development should result in further improvement in the uniformity and yield of the leading sorghum of the State.

New Crops

Work with new crops indicated possibilities in seed production with Bahia grass. An average acre yield of 340 pounds of seed was obtained. The common difficulty in securing filling of seed was noted, but excellent germination of seed was obtained. The recleaned seed showed a germination of 73.5 per cent, and carefully selected seed germinated 91.5 per cent. It was necessary to treat the seed with sulphuric acid to secure germination.

Woolly fingered grass shows considerable promise but failed to set any seed. Good forage production is obtainable on the better soils in the Tucson area with two and possibly with only one irrigation per season. Plantings can be made by setting out plants, but no extensive use of this crop is practical unless seed supplies can be produced.

Fifty-two varieties and strains of castor beans were planted in the spring of 1940 to determine possibilities of this crop. One selection grown in 1939 showed fair yielding ability and desirable nonshattering qualities. Prices obtainable do not indicate much promise for this crop.

Seven varieties and selections of safflower grown in triplicated plots on the Salt River Valley Farm produced average yields ranging from 1,906 to 2,523 pounds per acre. This test and previous ones indicate that the crop can be grown in southern Arizona provided seed prices are satisfactory. The Russian variety appears to have the most promise and showed an oil content of 28.3 per cent.

Green Manure Crops

Green manure tests on the Salt River Valley Experiment Farm indicated that Vicia calcarata was rather outstanding in production of forage for plowing under early in February when planted October 1. Hubam clover and purple vetch were more satisfactory for plowing under in late March and early April.

Alfalfa at Yuma

Results with alfalfa on the New Yuma Mesa Farm at Yuma were very satisfactory in the early summer of 1940, and, as in the previous season, the response to applications of phosphate fertilizers was pronounced. Differences were most noticeable on the second cutting for which different applications of treble superphosphate gave the following yields:

	Acre yield (lbs.)
No fertilizer at any time	286
No fertilizer in 1940	1,512
100 lbs. treble superphosphate (1940)	2,351
200 lbs. treble superphosphate (1940)	2,934
300 lbs. treble superphosphate (1940)	3,326

All land, with the exception of that on which no fertilizer has ever been applied, had received 100 pounds of treble superphosphate at the time the alfalfa was planted in December, 1938, and 50 pounds of ammonium phosphate in the irrigation water in February, 1939.

Arivat Barley

Arivat continued to be the highest-yielding variety of barley on the field plots at the Salt River Valley Experiment Station at Mesa. The average yield of Arivat during the past 4 years was 11 per cent higher than Vaughn.

Flax

A rather extensive date-of-seeding and fertilizer test was conducted with Punjab flax at Mesa. There were six dates of seeding, starting on October 19 and ending January 15. Ammonium phosphate 16:20 and calcium nitrate fertilizers were applied just before seeding at the rate of 200 pounds per acre each date of planting. The average yields in bushels per acre of the unfertilized and fertilized plots at the October 19,

November 1, November 15, December 6, December 15, and January 15 dates of seeding were 40.0, 43.5, 38.8, 25.0, 18.8, and 15.4, respectively.

These data agree with those obtained in the Imperial Valley in indicating the necessity for early planting for satisfactory seed production. The high yields at the early seeding dates may have been due, in part at least, to the unusually mild winter temperatures.

Applications of ammonium phosphate 16:20 definitely stimulated increased yields, while calcium nitrate increased yields over the check plots but slightly.

Rust and Smut Resistant Wheat

There was very severe damage to wheat due to stem rust in the Yuma Valley and the western part of the Salt River Valley. In some areas the crop was not even harvested. The California stem-rust and bunt-resistant White Federation 38 has been distributed in the Yuma Valley. Likewise, the California Baart 38, also resistant to stem rust and bunt, is being distributed in the Salt River Valley. In the absence of rust and smut, tests at Mesa between Baart 38 and ordinary Baart have shown that the two yield approximately the same and also have the same plant characteristics.

Small-Grain Variety Tests at Buckeye

A number of varieties of wheat, barley, and oats have been tested for yield during 1939 and 1940 in the Buckeye district. The Baart 38 and Hard Federation x Martin Arizona No. 392 varieties of wheat had the highest average yields for the 2 years. The California Red was easily the highest-yielding variety of oats. Of considerable interest was the performance of the Scarab variety of barley. Scarab was grown in the field plots at Mesa from 1931 to 1939. During that time its average yield was just below that of Vaughn, the average yield of Vaughn being only 4 per cent higher than that of Scarab. The 2-year average yield of Scarab in the Buckeye district was about 20 per cent higher than either Vaughn or Arivat. The leaves of Scarab are much larger than those of Vaughn or Arivat. Scarab has rough awns and is highly resistant to lodging.

Perennial Weed Control under Irrigation

Bindweed

Factors affecting the eradication and control of bindweed under cultivation were tested in field plots started in 1937

and 1938 at St. Johns and Tucson, Arizona. After 2 years of bare fallow, bindweed was either eradicated or very much reduced so that at St. Johns the eradication could be completed in a row crop. At Tucson one shoot appeared on one of twelve plots planted to corn the third season after two seasons of continuous bare fallow. Winter grain planted in October or November each year for 3 years followed by spring plowing and cultivation after June 1 failed to eradicate bindweed in three seasons. Estimates of stand by three methods were shown to be unreliable when used as an estimate of degree of eradication or time taken to eradicate bindweed. Differences in soil moisture maintained in the field were not sufficient to effect bindweed eradication. At least 1 foot of soil was found in all plots which contained sufficient moisture for bindweed growth. Cultivation each week was much more difficult to maintain than cultivation each 2 weeks. Bindweed eradication was completed at the same time and in the same length of time when cultivated weekly or each 2 weeks at Tucson and St. Johns.

Hoeing bindweed was not as effective as cultivation but when continued over 3 years was effective in eradicating bindweed on small plots. Burning at 3-week intervals was as effective as weekly burnings but in no case was bindweed eradicated by burning. Carbon bisulphide applied with the hand prod or Mack gun was found to be effective against bindweed on moist but not waterlogged soils in the field when applied at the rate of 2 ounces per hole in holes 18 inches apart. The carbon bisulphide was ineffective on ditch banks 2 or 3 feet high and on high borders in the field. The crowns of many plants escaped at the top of the bank. In one case 2 ounces applied in each hole spaced at 1-foot intervals gave an almost complete kill on a high border. Digging out the few missed crowns was effective in the one case where the dose was doubled.

Sodium chlorate applied in the dry form to the soil in the fall of the year and either rained or irrigated into the soil was the most effective chemical found against bindweed. Sodium chlorate was equally effective at Tucson and at St. Johns. The average percentage of stand remaining on four plots at Tucson and four plots at St. Johns 1 year after 2 pounds of sodium chlorate were applied to the soil was 30.6. When 4 pounds per square rod were applied, 8.4 per cent remained. When 6 pounds per square rod were applied, only 2.5 per cent remained. Table 6 shows that at St. Johns the fall treatment left a smaller percentage of the original stand when compared with the spring treatment applied at the same rate and with the same method. Comparisons of spray and dry treatments show that less bindweed was left after the dry treatment than after the spray

treatment applied at the same time and rate. These data indicate that bindweed can be effectively controlled by applications of crude sodium chlorate at the rate of 6 pounds per square rod or approximately 2 pounds per 100 square feet applied as the dry chemical directly on the soil in the fall of the year. Follow-up treatments the second fall were sufficient to kill all of the bindweed in these experiments. The total dosage including spotting the escaped plants the second fall was about 6.5 pounds per square rod.

TABLE 6.—EFFECT OF SODIUM CHLORATE ON BINDWEED WHEN APPLIED AT DIFFERENT SEASONS AT ST. JOHNS.

Rate (lbs./sq.rd.)	Sodium chlorate	Percentage of original stand remaining 1 year after application		Spring-fall ratio
		Spring	Fall	
6	Dry	35.0	3.2	10.90
6	Spray	64.0	21.4	2.95

White horse nettle

White horse nettle was not eradicated by 2 years of continuous fallow and was apparently reduced as much in a summer fallow-winter grain rotation as in bare fallow. Two years of spring fallow and summer sorghum failed to reduce the weed stand. Chemicals effective against white horse nettle were carbon bisulphide and sodium chlorate. The minimum effective rate of sodium chlorate application is 6 to 8 pounds per square rod on heavy soils. The 2-ounce 18-inch application of carbon bisulphide and spotting each stalk were equally effective against white horse nettle. Seasonal and soil influence on control and eradication are similar for both white horse nettle and bindweed. Burning or hoeing each week, each 2 weeks, or each 3 weeks did not eradicate white horse nettle in two seasons.

Nut grass

Two years of summer cultivation and winter grain or continuous cultivation eradicated nut grass at Mesa. Less than 5 per cent of the original stand of nut grass appeared the third spring after 2 years of spring cultivation. Three types of cultivation treatment were used at Tucson in 1938: (1) plowed as the nut grass appeared, average once in 3 weeks; (2) disked at the time of plowing in (1); and (3) disked weekly. The soil was very dry at the end of the summer and was less dry, particularly below 6 inches, after treatment (3) than after

treatments (1) and (2). All of the plots were planted to hegari in 1939, and nut grass was observed on all plots. Growth was stronger on treatment (3) than on (1) and (2), and in 1940 nut grass appeared only on treatment (3). The growth in 1940 may have been due to a chance variation in moisture in 1938 rather than to different treatments.

Nut grass tubers were buried in the field in dry and moist soils at depths of from 1 to 6 inches. Some tubers were dug each week and planted under favorable conditions in the greenhouse. Fifty-seven per cent of the tubers in one experiment grew after 4 weeks' burial in wet soil where maximum daily temperatures averaged 100.3 degrees F., but in another experiment no tubers grew after 3 weeks' burial in dry soil where maximum daily temperatures averaged 100.5 degrees F. These experiments indicate that at the same temperature the moisture from the soil will keep the tubers alive. All tubers were killed after 8 days in dry soil where the average maximum temperatures were about 120 degrees F., while 40 per cent grew after 8 days' burial at an average maximum temperature of 112 degrees F., and only 4 per cent of similar tubers grew after 9 more days for which the daily maxima were 107 degrees. The tubers seemed to have been killed by the continued drying under conditions of high temperature and low moisture in the soil.

The possibility of killing tubers by exposure to dry soil was further tested by variations in turning soil in the field heavily infested with nut grass tubers. Twenty-one per cent of the tubers were alive after turning 12 inches deep three times when growth appeared. Thirty-five per cent of the tubers were alive after turning four times, once at 6 inches and three times at 12 inches when growth appeared. Eleven per cent of the tubers were viable after turning four times: first at 3 inches, 2 weeks later at 6 inches, 2 weeks later still at 9 inches, and still another 2 weeks later at 12 inches. Fourteen per cent of the tubers were viable after turning seven times at 2 inches deeper each time each week.

The soil was moist when the turnings were started on the plots described above and a heavy rain subsequently wet the soil to 6 inches. A significantly smaller number of tubers remained viable after initial turnings of 2 or 3 inches in depth than where the initial turnings were 6 or 12 inches. The high probability of heavy rains in the late summer indicates that this work would be better carried on in the early spring or summer when the soil is usually hot and dry.

The accumulative percentages of tubers by 2-inch depths in the soil were calculated from counts made in check plots. The top 2 inches contained 19 per cent of all of the tubers;

4 inches, 43 per cent; 6 inches, 66 per cent; 8 inches, 86 per cent; 10 inches, 93 per cent; 12 inches, 96 per cent; 18 inches, 99.9 per cent; and only occasional tubers were found below the top 18 inches.

Soybeans

Data from a replicated variety test with eight of the most promising soybean varieties to date are given in Table 7. Yields were higher in all cases than in 1938, but Tokio and Arisoy (formerly U.S.D.A. 86736) again produced the highest yields.

TABLE 7.—DATA FROM SOYBEAN VARIETY TESTS IN 1938-39.

Variety or strain	Length of growing season (days)	Yield per acre[a]		Yield index	
		Hay[b] (tons)	Beans (bushels)	Hay	Beans
Arisoy	149	4.36	37.7	125.6	123.1
Tokio	137	3.97	37.1	114.6	121.2
Georgian	131	3.48	33.8	100.3	110.4
Charlee	138	3.39	32.4	97.7	105.8
Laredo	131	3.39	30.5	97.7	99.6
Palmetto	136	3.48	29.4	100.3	96.0
Haberlandt	135	2.65	22.8	76.4	74.4
U.S.D.A. 86728	149	2.99	22.8	86.2	74.4
Average	---	3.47	30.6	100.0	100.0

[a]Based on three replications.
[b]Yields for 1939 only.

Arisoy beans grown in rows spaced 40 inches apart produced 19.3 bushels of beans per acre, while a drilled planting which was otherwise treated the same as the row planting yielded only 11.3 bushels per acre.

Hegari and soybeans when planted in alternate rows spaced 40 inches apart yielded 14.4 tons of green forage per acre. The soybeans produced only 800 pounds of the total acre yield. Another seeding of soybeans and Sudan grass sown in alternate 7-inch rows by the use of a grain drill produced 5 tons of green forage per acre, but here again the soybeans constituted a very small percentage of the total yield—so small that it was not measured. Both the hegari and Sudan grass were apparently too close to the soybeans and tended to shade them so much that the plants could not develop normally.

A seeding of eleven different strains and varieties of edible soybeans on the Campbell Avenue Farm near Tucson gave some very promising results. Although the growth period was only 86 to 109 days, yields ranged from 20 to 44 bushels per acre. These edible strains are extremely susceptible to shattering.

ANIMAL HUSBANDRY

Ration Comparisons for Fattening Cattle

Previous feeding experiments conducted by this Station have demonstrated that a combination of hegari silage, alfalfa hay, cottonseed meal, and grain barley or hegari is a very satisfactory ration for fattening cattle in Arizona. This particular ration is not always available to cattle feeders and other feed combinations of locally produced feeds may be used as economical fattening rations. A study of the suitability of newly introduced feeds and the relative economy of different rations with and without silage is the general purpose of the annual fall and winter cattle feeding tests conducted at the Salt River Valley Experiment Farm. The results reported herewith are interpreted on the basis of a single test as being only indicative.

Silage vs. no silage

Results obtained with heifers from adding silage to a ration of alfalfa hay, hegari grain, and cottonseed meal are in agreement with those of previous tests conducted by this Station. Hegari silage proved to be worth at least 50 per cent the value of alfalfa hay. The steers in lot 1, fed the silage ration, gained at the rate of 2.41 pounds per head daily with a feed cost of $8.57 in comparison with the steers in lot 6 receiving no silage that made a daily gain of only 2.01 pounds per head and at a feed cost of $11.02 per hundredweight of gain. Figuring alfalfa hay at $7.00 per ton, the silage ration produced 100 pounds of gain at a cost of $8.15 and the hay ration $8.86 or a difference of 71 cents in favor of the silage ration. This gives a value of $4.36 per ton for silage with alfalfa hay at $7.00. With heifers (lots 3 and 7) the difference was practically the same, giving a value of $4.50 per ton of silage with alfalfa hay at $7.00 per ton.

Hegari silage vs. Manko silage

In this trial Manko silage was equal to hegari silage for the 65-day period it was available. Heavy spoilage of silage occurred in the Manko silo due to an insufficient removal of fresh silage daily. There was some indication that the Manko silage molded more quickly than the hegari silage but this apparently did not affect its palatability; it was in fact "cleaned up" more readily than hegari silage.

The Manko silage (lot 2) had a slight but insignificant advantage over the hegari silage (lot 1) during the 65 days it

was fed. The steers receiving Manko silage gained 2.57 pounds per head daily at a feed cost of $8.00 per hundredweight of gain as compared with a daily gain of 2.50 pounds and a feed cost of $8.13 per hundredweight of gain for the hegari silage fed steers.

The value of grinding alfalfa hay

The steers fed ground alfalfa hay (lot 4) made a slightly greater daily gain of 2.50 pounds compared with 2.41 pounds (lot 1) and 2.37 pounds (lot 2) both of which received unground hay. The additional weight made by these steers was sufficient to pay the grinding charge of $2.00 per ton. The feed costs per hundredweight of gain of the three lots in this study were practically equal.

Whole cottonseed vs. cottonseed meal

The steers fed whole cottonseed (lot 8) made slightly more rapid gains at a lower cost per unit of gain than did the steers in lot 6 that were fed cottonseed meal. Both lots were fed a basal ration of hegari grain and alfalfa hay. The daily allowance of cottonseed was just twice the amount of the cottonseed meal so as to equalize the amount of protein from these two feeds. Had these feeds been priced the same, the cost per hundredweight of gain would have been slightly lower for the cottonseed ration, showing that cottonseed is as valuable as cottonseed meal for fattening yearling steers with a basal ration of alfalfa hay and hegari grain.

The value of ensiled grapefruit cannery refuse

Grapefruit rinds taken directly from the Tempe cannery and ensiled in a trench silo on the experimental farm without any processing were fed to one lot of steers (lot 5) together with alfalfa hay, hegari grain, and cottonseed meal. The silage had an appetizing odor but a somewhat bitter taste, which probably caused the steers to limit their actual daily consumption to 9.75 pounds per day. However, with this low consumption, it apparently took the place of hegari silage to some extent. The steers in this lot gained at the rate of 2.26 pounds per head daily, intermediate between the 2.41 pound gain of the hegari silage fed steers in lot 1 and the 2.01 pound gain made by the no-silage steers in lot 6. To compensate for the relatively low silage intake, these steers doubled their consumption of alfalfa hay in comparison with that of lot 1 fed hegari silage. Pricing the grapefruit refuse silage at $1.50 per ton,

this lot (5) produced 100 pounds of gain at the lowest cost of any of the steer lots. If these results can be confirmed, returns from this product as a cattle feed should cover cost of hauling and ensiling.

Steers vs. heifers

Heifers were compared with steers on rations with and without silage. In both comparisons the heifers made as rapid gains with approximately $1.00 less cost per 100 pounds of gain. The heifers were weighed off 10 days earlier than the steers, but this would have made very little difference in the results of this trial. If heifers have the same relative margin as this year, they are more profitable feeders. There was practically a cent spread between the buying price of the heifers and steers and only 1/2 cent spread in the selling price.

All lots lost money except the heifer lot on silage due to the very narrow margin and the fact that the cost of production was close to or in several lots above the selling price. The actual selling price based on the final weight without the 4 per cent shrink was $8.64 per hundredweight for the steers and $8.16 for the heifers.

Pasture Studies

During the fall and winter pasture season this year some preliminary results of pasture studies with cattle and sheep in the Salt River Valley were obtained. This information was secured from farmers and stockmen by a field assistant under the direction of the Animal Husbandry and Animal Pathology departments working in conjunction with the County Agent's office in Phoenix. Records were obtained by noting the number of classes of livestock pastured on a particular kind of crop of known acreage and the duration of the pasture period. Lack of control over any of the pastures under observation made it impossible to secure accurate data. They are, however, probably fairly indicative of the pasture value of those crops studied, when used under commercial practices.

The pasture most commonly used, especially in the fall and winter, is alfalfa and barley. Records of twenty pasture periods with this type of feed are the basis of the results reported herewith. The information secured represents one pasture period only. Two and sometimes three pasturings are available from the alfalfa-barley crop in one season. Table 8 shows a summary of pasture records obtained in the Salt River Valley during the fall and winter of 1939-40.

TABLE 8.—SUMMARY OF PASTURE RECORDS, SALT RIVER VALLEY, 1939-40.

Type of crop	Animal days per acre per pasture period		Per cent utilization	
	Cattle	Sheep	Cattle	Sheep
Barley and alfalfa.....	44	---	81	--
Barley and alfalfa with hay.....	74	142	74	83
Hegari stalks (with supplement).....	42	---	---	--
Cotton stalks with Bermuda grass.....	23	---	99	--
Cotton stalks without Bermuda grass.....	18	---	100	--
Barley.....	29	245	76	96
Alfalfa.....	--	235	---	95

A 2.5 acre field on the University Farm subjected to an intensive pasturing program supported 1.4 cows per acre per year over a 3-year period. This figure would indicate that the carrying capacity of general farming land in this section, considered to be approximately one animal unit per acre, is not out of line.

Exotic Plant Study

The relative palatability of certain promising exotic plants and their adaptation to a grassland range type located near Sonoita, Arizona, is the title of a co-operative project among this department, the Soil Conservation Service, Southwestern Forest and Range Experiment Station, and R. C. Larimore. This work was started on the Larimore ranch in July, 1939, at which time the plantings were made. Sufficient time has not elapsed for any material developments to be recorded. The favorable growth and seed production of six exotics in local nursery plots warranted a thorough test of the following grasses under field conditions: *Eragrostis curvula, E. lehmanniana, Panicum antidotale, Astrebla lappacea, A. elymoides, Chloris berrori,* and *Agropyron cristatum.* Plantings were made in ten strips 218 feet long, each strip being bordered by a planting of side-oats grama and blue grama, respectively. A replication of each strip, 1/20 acre, will be closed to grazing and an equal number of strips opened to grazing.

Nutritional Studies of Arizona Range Plants and Cattle

Standard feed analyses plus calcium and phosphorus determinations have been made on 268 samples of range forages and are being continued on additional samples. Evidence is not sufficient to state a minimum requirement of either phosphorus or protein because of the great seasonal variations of these substances. It is hard to separate these two deficiencies because there is a distinct correlation between the stage of growth and the protein and phosphorus contents. There have been fifteen ranches under study and some have been dropped for lack of co-operation, drouth, death of owner, etc. Two of the ranches that have been dropped, while not showing indisputable evidence of phosphorus deficiencies, gave very strong indications, and both are using bone meal at the present time with good results.

Carotene analyses are being continued but have been changed to a dry-matter basis so that the results are of more value in comparison. Since this change has been made in technique, there are not enough analyses to give any results. The carotene analyses indicate, however, that on the browse ranges the cattle are not deficient in carotene unless these ranges are badly overgrazed. On a wholly grass range there is plenty of carotene with normal rainfall, but there probably would be carotene deficiency during drouth.

The blood analyses are being continued with the idea that a blood low in phosphorus is definite indication of P deficiency, whereas a blood with normal phosphorus content may not indicate sufficient phosphorus. This study is co-operative with the Department of Animal Pathology.

ANIMAL PATHOLOGY

Cattle Losses on Alfalfa Pastures

Losses in young calves on pasture were very light during the past year. This reduction in losses is due to the changes of management on many farms. Calves are fed in the dry lot for 2 weeks before they are placed on alfalfa pasture. In some instances dry alfalfa hay is fed with the pasture. The weather conditions were very mild during this pasture season. Death losses occurring in calves on one ranch were investigated. Blood studies showed severe anemia. Hemoglobin was reduced to 35 per cent, and erythrocytes were reduced to 3 million. Bacteriological studies were negative. This condition was corrected immediately by placing the calves on dry feed.

Nutritional Deficiencies of Arizona Range Forages

These deficiencies have been studied in co-operation with the Animal Husbandry Department, and the results of the work so far have been reported by that department.

Infectious Keratitis in Cattle on Range and Feed Lots

Studies of bacteria associated with keratitis and bacteria in normal eyes have been made. No organisms as possible primary etiological agents were isolated. The cocci including staphylococci which were isolated play a secondary role in the disease. Higher bacterial counts as well as more chromogenic and hemolytic bacteria were found in cultures from diseased eyes than were found in those inoculated from normal eyes under similar environment. The majority of coccus forms found have tentatively been placed in the genus *micrococcus*. In general, the in vitro tests for pathogenicity of the staphylococci have not been applicable to the micrococci. This laboratory has failed to transmit keratitis to the eyes of healthy animals either by introduction of pure cultures or by direct transfer of purulent exudates and curetted tissues from diseased eyes. The possibility of an association between two or more agents is being considered.

Miscellaneous

Poisonous plant losses on the range are being investigated. Weather conditions have not been favorable for the production of prussic acid in suspected plants. No new poisonous plants have been found.

Very promising results in the control of the ox warble (*Hyperderma lineata*) have been secured. Derris root powder (5 per cent rotenone) is being used. This treatment is being applied under range conditions where only one application is practical. Other materials containing rotenone are being tried, but results are not yet available.

The use of emasculators in range castration operations with the scrotal incision being made longitudinally is superior to the older methods because of rapid healing and lack of hemorrhage.

Artificial insemination projects were started in Arizona. Methods of collection and storage are being studied. Favorable results have been secured in most cases by not diluting the semen. This is possible because of the small number of co-operators.

BOTANY AND RANGE ECOLOGY

Sugar Beet Seed Production

Investigations on sugar beet seed growing have been directed at determining the environmental factors which promote uniform seedstalk production. In this connection the effect of time of planting, fertilization, spacing, and removing the leaves, as by grazing, have been studied.

In 1939-40 early plantings (Aug. 23) again gave much higher seed yields than later plantings (Sept. 16 and Oct. 7). The favorable effect of early planting is believed to be due to the lower soil temperature which results from increased shading. Temperature records of the surface soil showed that August plantings had significantly lower temperature at the growing point than had the October plantings during any given period up to May 1, 1939.

Adequate fertilization, particularly with nitrogenous fertilizers, has been shown to result in increased seedstalk production and higher seed yields. Chemical studies of the nitrogen metabolism of the sugar beet plant for the purpose of correlation with its seeding habits have been completed, and the results are being prepared for publication.

Spacing of the beet plants farther apart than 1 or 2 inches in the row has been found to be uniformly detrimental to seed yields as has removal of the leaves during the winter. Both of these practices decrease seedstalk production by exposing the growing points of the plants to higher temperatures during the critical winter season.

Forage Requirements of Range Vegetation by Jack Rabbits

The degree and nature of damage inflicted upon many grazing ranges by California and antelope jack rabbits is being indicated by quantitative measurements of food consumed during base-ration tests and during pen-feeding trials with green and air-dried native forage plants. The results of the base-ration tests with alfalfa and rolled barley and the pen-feeding trials with native forage species are summarized in Table 9.

The results for the past season show that the *L. californicus* has a higher food requirement than the *L. alleni*. This is apparently due to their more normal breeding habits under captive conditions, since pregnancy has been found to increase the food requirements of female rabbits.

The records obtained from twenty-four grazing tests on forage utilization plots, combined with records of past seasons, indicate that both species of rabbits show preferences

TABLE 9.—SUMMARY OF PEN-FEEDING TRIALS WITH CALIFORNIA AND ANTELOPE JACK RABBITS.

Type of test	Number of tests	Rabbit days	Average animal weight (lbs.)	Av. daily dry wt. consumed (lbs.)	Dry wt. consumed as per cent wt. of animal
Lepus alleni					
Base rations....	11	345	6.20	0.261	4.22
Green forages...	7	105	6.03	0.350[a]	5.66
Air-dry forages.	8	136	6.52	0.396	6.20
Lepus californicus					
Base rations....	12	392	4.52	0.233	5.04
Green forages...	9	110	4.17	0.304[a]	7.30
Air-dry forages.	14	252	4.29	0.268	6.25

[a]Results of pen-feeding tests with green forages in terms of air-dry matter.

similar to those of cattle for the common range species. *Muhlenbergia porteri* and *Heteropogon contortus* are two grass species which were not relished by the jack rabbits with as high a degree of preference as is designated in the palatability lists for cattle. These two grasses may prove valuable for reseeding depleted range areas where it is necessary to guard against rodent depredations

Climatic and Grazing Influence on a Desert Grassland Range

Nine years' observation of permanent quadrats established at Desert Grassland Station in 1931 have shown decided changes in species composition and density of forage grasses on areas open to grazing by both cattle and rodents, areas grazed by large rodents only, and areas entirely protected from grazing. Differences in trends of plant growth under the various conditions of grazing are attributed to the effect of grazing, whereas similarities of trends are ascribed to climatic influences.

Preliminary analysis of the data, with respect to the four most important perennial grasses studied, indicates that black grama (*Bouteloua eriopoda*) is the most sensitive to grazing influences, showing a definite increase in number and density of plants when under protection and a general decline under grazing by cattle and rodents. Poverty grass (*Aristida hamulosa*), a poor forage grass, increased generally under all conditions of grazing, while cotton grass (*Triachne californica*) showed a marked fluctuation governed largely by climatic conditions. Rothrock grama (*Bouteloua rothrockii*) showed wide variation in volume with fluctuations in climate, but this volume variation was less pronounced under controlled grazing.

The numbers of annual grasses and herbs varied considerably over the observational period, showing little correlation with grazing conditions or climatic conditions.

Detailed weather observations covering air and soil temperature, rainfall, humidity, evaporation, wind velocity, and sunlight intensity have been made at Desert Grassland Station and at two supplementary stations for the purpose of correlation with other phases of the study.

Fertilizer Investigations on Range Vegetation

The quadrat listings showed that under protection from grazing the grass density of the control plots increased gradually from year to year with no material change in the composition of the perennial species. Protected plots fertilized with calcium nitrate and ammonium phosphate showed very little increase in grass density but did show marked changes in vegetative composition. Considering that the forage production of the protected fertilized plots exceeded that of the control plot by as much as 100 per cent, the greatest effect of combined protection and fertilization was evidenced in the increased height and growth of the fertilized vegetation. Under conditions of cattle grazing, the attraction of the animals to the fertilized plots resulted in the somewhat harmful effects of concentrated cropping. No conclusive evidence has been obtained from the seed tests that might attribute the vegetational changes to differences in seed viabilities between fertilized and unfertilized plots.

Life History Studies on Burroweed

The continued invasion of shrubby plants such as burroweed (*Haplopappus tenuisectus*) into southern Arizona ranges has introduced the problem of range weed control. In experiments carried on since 1937, control measures such as cutting, grubbing, burning, and the application of various chemicals have shown wide variations in effectiveness depending upon the season of application and growing conditions. Clipping the plants above the crown level gave fairly effective control during the summer growing season, and no additional benefit was derived from retreatment of the same plants as later intervals. Spraying with 5 per cent sulphuric acid was generally effective as a control measure when application was made during the growing season and when surviving plants were retreated after a 1- to 2-month interval, complete control was obtained.

The amount of food reserves present at the time of control

treatment influences the effectiveness of the treatment. Data for the growing season of 1939 indicate a depletion of the starch content of roots and older stems of as much as 50 per cent during the development of flower buds in September. The sucrose content of all plant fractions increased during the same time showing that there was at least a partial conversion of stored food in the form of starch to sugar for use in seed production. This loss of food reserves during the late growing season is correlated with the better success of control measures such as clipping and acid spray treatments when applied at this period.

Grass Bulletin

Technical study has continued on Arizona grasses, and the preparation of a manuscript for publication is nearing completion. In addition to the general or scientific description, brief popular descriptions of the more important grasses together with economic notes are added. Included in these descriptions is the distribution of the species in Arizona, its habit of growth, relative abundance, and value for grazing, for soil conservation, and other uses.

Determination of Correct Scientific Names of Common Plants

In 1939 a project to clear up the confused scientific names of common Arizona plants was started. As a result, the proper names of the blue palo verde, a milkweed, a clover, and various other plants have been determined in accordance with the International Rules of Botanical Nomenclature. Materials have been secured for proper classification of three Arizona mesquites, each of which has passed under more than one scientific name.

Plant Collection and Identification

As a result of the activity of the herbarium staff in plant identification for individuals and for various state and federal agencies, about 4,000 specimens have been received, mounted, and added to the herbarium. About 1,000 additional specimens have been collected and pressed by members of the staff.

Several valuable collections of Arizona plants have been presented to the herbarium during the past year. Among these is a named collection of rare alpine and subalpine plant specimens made by Dr. Elbert J. Little of the U.S. Forest Service, in the San Francisco Peaks area near Flagstaff, Arizona; a

named collection of 225 specimens of southwestern grasses, including many species of the genus Muhlenbergia, made by L. N. Goodding of the U.S. Soil Conservation Service; and a collection of 250 mounted sheets of herbarium specimens of northern Arizona plants presented by Chester F. Deaver of the State Teachers College, Flagstaff, Arizona.

Economic Value of Some Range Plants Under Cultivation

In the fall of 1939 work was started on a project to select range plants which have products of known economic value and test their adaptability to propagation and cultivation under irrigation. Most of the work has been confined to *Yucca elata* (soapweed or palmillo) which is a source of fiber; to *Simmondsia californica* (jojobe or coffeeberry) for its oil products, and to *Haplophyton cimicidium* (cockroach plant) for its insecticide properties. Approximately 200 seedlings of *Simmondsia* and the same number of *Yucca* were grown in the greenhouse for transplanting to field plots. Survival and subsequent growth of the *Yucca* seedlings were extremely good (Pl. I) but very few of the *Simmondsia* seedlings survived

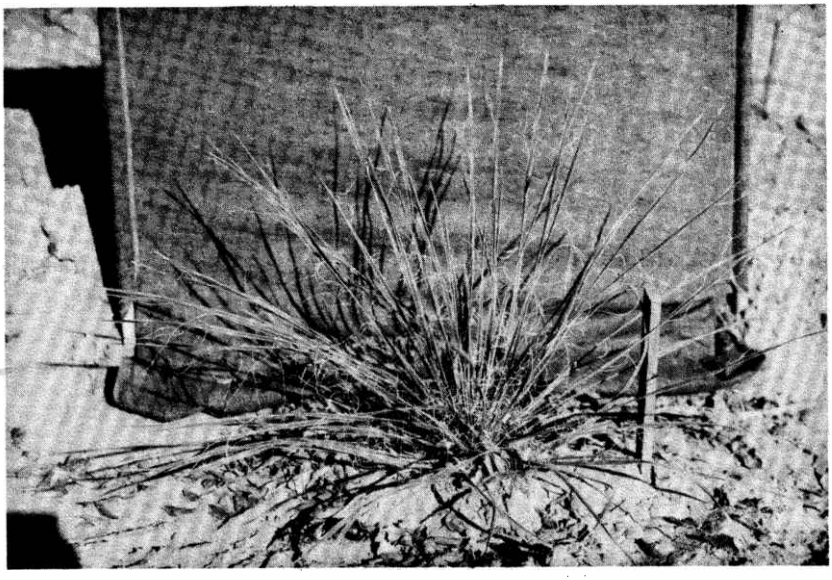

Plate I.—Plant of Yucca elata 10 months after planting seed.

transplanting. While *Simmondsia* has proved difficult to transplant, it develops readily from seed. Attempts are also being made to root cuttings, but so far the usual methods have not produced results.

The *Haplophyton* seed collected in the winter of 1940 was of very low viability, and as a result work with *Haplophyton* has centered on transplanting mature plants to field plots.

In addition to keeping growth records of the plants growing under irrigation, anatomical studies have been started to aid in developing suitable methods of propagation.

DAIRY HUSBANDRY

Normal Growth of Dairy Cattle in Arizona

Standards of normal growth have considerable value to those conducting dairy husbandry research and to owners of dairy cattle. In experiments with growing cattle it is important to have a standard of size for age for each breed. The rates of growth for animals on experimental rations can then be compared with the standard, and breeders of dairy cattle will find such a standard valuable in determining whether growing or mature animals in their herds are above or below normal size of the breed.

While data on the rates of growth in dairy cattle are available from a number of experiment stations, growth rates vary because of differences in systems of feeding and management.

The object of this investigation was to contribute further information on normal growth in dairy cattle and set up normal growth standards for the dairy cattle in the Arizona Experiment Station herd.

This project was started in August, 1939, and data collected to November, 1940, have been summarized in Table 10.

TABLE 10.—WEIGHT (LBS.) OF HEIFERS IN ARIZONA EXPERIMENT STATION HERD.

Breed	Birth	3 mos.	6 mos.	9 mos.	12 mos.	15 mos.
Jerseys.....	(9)50	(7)134	(8)245	(8)395	(10)484	(8)586
Guernseys...	(4)70	(4)163	(4)330	(4)430	(3)565	(3)655
Holsteins...	(4)101	(4)225	(4)407	(5)583	(5)750	(4)879
		18 mos.	21 mos.	24 mos.	27 mos.	30 mos.
Jerseys.....		(7)668	(7)740	(5)831	(3)935	----
Guernseys.....		(6)743	(7)806	(8)912	(3)985	----
Holsteins.....		(6)986	(6)1,063	(7)1,199	(7)1,420	(2)1,525

A comparison of these average figures with latest published data in Morrison's Feeds and Feeding (20th ed.), page 615, which represent averages for all experiment station data

available, shows significant differences. For example, Guernsey and Holstein heifers in the Arizona Experiment Station herd are 15 per cent above the Morrison averages at 12 months of age. Jersey heifers were only 4 per cent heavier. At 24 months of age the Arizona heifers averaged 11 per cent heavier for Guernseys and Holsteins and 10 per cent heavier for Jerseys.

The number of animals weighed at successive ages is given in parentheses. It is recognized that the numbers are relatively few to draw any definite conclusions. If the same results are secured with the additional data of another year's study, then it may be well to determine whether the increase is due to better feeding, alfalfa of higher nutritive value, more favorable climatic conditions and abundance of Arizona sunshine, or a combination of these factors.

Table 11 gives average weights of cows of the three breeds at successive intervals in the lactation period and prior to freshening. These data are useful in checking fluctuations in

TABLE 11.—WEIGHT (LBS.) OF DAIRY COWS.

Breed	Before freshening	After freshening	Months after freshening	
			1	3
Jerseys.....	(14)1,054	(14)944	(8)887	(8)900
Guernseys.....	(15)1,218	(15)1,116	(13)1,046	(12)1,094
Holsteins.....	(17)1,628	(17)1,471	(12)1,419	(10)1,391

	Months after freshening			Average, all weights
	6	9	12	
Jerseys.....	(7)950	(6)1,012	(5)1,070	960
Guernseys.....	(11)1,100	(7)1,224	(6)1,275	1,153
Holsteins.....	(9)1,446	(7)1,544	(4)1,666	1,509

weight due to advancing lactations of animals on experimental feeding. Average of all weights in each breed is substantially higher than for similar data at other stations.

Influence of Season on Butterfat Percentage in Arizona

Source of data: Dairy Herd Improvement Association records involving some forty-eight Arizona herds and 2,152 cows.

It is common observation that milk tests higher in the winter than in the summer. The extent of this fluctuation is a matter of interest to Arizona dairymen. The question is frequently raised: Does the long-continued period of summer weather with accompanying high temperatures produce a greater decrease in butterfat percentage here in southern Arizona than in cooler areas, and what is the extent of the decrease?

The Dairy Extension Specialist, Clyde Rowe, provided the records for use in this study. The butterfat percentages for all herds on test in 1938-39 were averaged by months, irrespective of time of freshening, involving some 2,152 cows of the four major breeds.

The average butterfat percentages by months are as follows:

January	4.38	July	4.02
February	4.34	August	4.22
March	4.24	September	4.35
April	4.02	October	4.23
May	4.01	November	4.30
June	4.02	December	4.40

A high point is reached in December, with a low point in butterfat percentage in May, June, and July, months of highest temperatures in southern Arizona.

The average difference between winter (December, January, and February) and summer (May, June, July, and August) is 0.31 per cent. A maximum range between high and low months is approximately 0.4 per cent. This compares with an average difference found by Brooks in Kansas on a total of 409 lactations of 0.37 per cent between the winter and summer months.

A breakdown of data for the Arizona Experiment Station herd shows the widest variation in butterfat percentage between winter and summer for the Jersey breed, 0.5 per cent, while for the Holstein breed the difference obtained was 0.25 per cent.

Pasture Studies

Clippings have been made from Sudan and barley pasture this past summer and fall as a start in studying the value of pasture in the Arizona dairy ration.

Square-meter samples were collected just prior to pasturing throughout the summer months and two collections to date this fall.

Protein content on the air-dry and green basis of successive samples of Sudan grass from the sample plot representing four successive pasturings is given in Table 12.

For the barley the results to date are shown in Table 13.

There is an urgent need for a good project on pasture utilization in Arizona. Dairy farmers are the most intensive users of pasture, but practically no data are available for Arizona conditions beyond a few analyses. There is need for a comprehensive study of the nutrients furnished by pasture

TABLE 12.

Sample no.	Date collected	Per cent protein	
		Air dry	Green
1	5/11/40	12.05	2.65
5	6/5/40	11.4	2.62
6	7/25/40	10.3	2.47
8	8/7/40	16.5	2.97

TABLE 13.

Sample no.	Date	Fresh weight (lbs.) per acre	Per cent protein	
			Air dry	Green
15	10/28/40	4,398	20.84	3.83
16	11/25/40	2,444	15.31	3.35

crops best suited to the State and for a knowledge of what constitutes optimum and most efficient utilization of pasture in southern Arizona.

Solids-Not-Fat Content of Milk

In co-operation with the Agricultural Chemistry and Soils Department a study is being made of the possible influence of the following factors on the solids-not-fat content of milk produced under Arizona conditions: (1) breed, (2) season of the year, (3) stage of lactation, (4) time of year of freshening, (5) weather conditions, and (6) plane of feeding.

Semimonthly analyses have been made of milk from two Jersey and two Holstein cows for a complete lactation period for fat, specific gravity, acid, lactose, protein, ash, P_2O_5, CaO, Cl, and total solids.

Analyses were also made during the above period of composite samples of milk from the herd produced at the 3 a.m., 9 a.m., and 3 p.m. milkings.

The milk from fourteen individual cows in the University herd is being analyzed monthly, and other cows are being put on this project as they come fresh, the purpose being to include cows which freshen at different times of the year.

Milk is being analyzed monthly from five herds in Maricopa County and some four or five other herds will be added from that section as soon as satisfactory co-operators can be secured. These herds are selected on the basis of breed and conditions of feed and care. Three different breeds—Jersey, Holstein, and Guernsey—are represented in the herd selections as well as in the individual cows. Some of the herds are well

fed, others receive only medium care, while others are poorly fed.

There is a belief among some people that milk produced in Arizona is low in calcium and possibly phosphorus. Sufficient analyses have been made to disprove this assumption. Milk produced by cows in the University herd and milk from Maricopa County are normal in these constituents as shown by analyses made in connection with this project. On an average, cows of the Jersey breed produce milk considerably higher in solids-not-fat than do the cows of the Holstein breed. There is, however, a greater variation within the breed than there is between the breeds.

As the cows approach the end of the lactation period the lactose goes up and the chlorine goes down.

The work to date on this project has been to a considerable extent preliminary. We should get some definite results during the present year.

The Effect of Sunlight on the Vitamin D Potency of Milk

In co-operation with the Department of Human Nutrition a study is being made to determine the effect of Arizona sunshine on the vitamin D potency of milk caused by exposing the cows to the sun rays, and to compare the vitamin D potency of milk produced in southern Arizona with that of milk in other sections.

The milk from four cows, two Holsteins and two Jerseys, was fed to white rats by the Nutrition Department during the spring and summer of 1939. One cow of each breed was kept in a dark stall and one of each breed was kept in a corral where they were exposed to the sunshine. The feed was the same for all cows. The vitamin D potency of milk from the cows exposed to the sun was uniformly higher than that from the cows kept in the barn. The vitamin D potency of the milk from the cows protected from the sun was erratic, which indicated that the sunlight was not efficiently excluded from the barn.

Two Guernsey cows were put in dark stalls February 10, 1940, with complete protection from the sunlight. One of these was transferred to a corral exposed to the sun on April 2. The feed of the cows was the same. The vitamin D potency was determined for the milk produced by the two cows during April, May, and June. The milk from the cow exposed to sunlight when fed to white rats showed it contained somewhat more vitamin D than the milk from the cow in the dark. (See report of Nutrition Department for more detailed data.)

ENTOMOLOGY AND ECONOMIC ZOOLOGY

Range Rodent Investigations

A bulletin on the life history and ecology of the white-throated wood rat was completed and published, the third major publication in this series of investigations (see "Publications"). This bulletin concludes that "Increase of the white-throated wood rat appears to be an effect rather than a cause of overgrazing—an 'animal weed.' Its principal foods are the cactus and mesquite which ranchmen are actually being paid to remove in some areas; hence, it cannot consistently be rated as injurious."

Water Relations of Desert Animals

A bulletin on this subject is in preparation.

Grasshopper Investigations

With temporary appointment of a graduate assistant for the purpose, the task of abstracting and compiling the data of the original investigator has been pushed, and a bulletin is in preparation.

Scale Insects

An infestation of red scale (*Aonidiella aurantii*) was discovered in the Tucson area through specimens received from the staff of the State Entomologist. Through the valued cooperation of this staff, new infestations of important scale insects are likely to be discovered quickly and identified by means of the extensive collection of prepared mounts of scale insects. Control can thus be promptly applied. The collection continues to increase in size and importance.

Cotton Insect Pests

A new member (Dr. H. G. Johnston) has been added to the staff (half time), permanently located in the Salt River Valley, for work on insect pests of cotton. A new project has been begun specifically for study of the biology and control of *Creontiades femoralis*. This is one of five hemipterous insects causing rather severe damage to cotton in Arizona, control of which is difficult, and, until recently, unsatisfactory. The most satisfactory control yet devised is rather expensive, and it is believed that a cheaper method may be

found. The experimental work has been well started at the Mesa Experimental Farm, and preliminary results seem promising.

Other Insects

A midge which appears to be identical with that already studied on watermelons (*Itonida citrulli*) has been reared from squash and pumpkin in the Douglas area. The same pest has also been reported from squash at Mesa.

Aphis (plant louse) studies have been continued, with special attention to the black-margined, or pecan, aphis (*Monellia costalis*), which is the cause of much concern to pecan growers at Yuma.

Special search was made in the fall of 1939 for the new alfalfa weevil (*Hypera brunneipennis*) in the Tucson district. No positive evidence of its occurrence there was found.

Vertebrate Collections

With acquirement of some new storage cases the Herbert Brown collection of study skins of birds (and a few mammals) has been transferred from the University Museum to this department. These skins, which can now be adequately stored and protected from light, augment the department collections by about 2,000 specimens (about 1,500 birds, 100 mammals, and 300 to 400 miscellaneous nests, sets of eggs, etc.). Collections of birds and mammals to fill gaps in the Arizona series were made in the Pinaleno and White mountains.

HORTICULTURE

Vegetable Crops

Lettuce fertilization

During the season of 1939-40 fertilization studies were continued through tests in commercial fields of the Salt River and Yuma valleys. Fertilizers were applied by the band placement method 1½ inches to the furrow side and 3 inches below the seed row. Side dressings were later applied in most tests.

In three tests 11-48 ammonium phosphate at time of planting gave the highest yield of good quality lettuce. Due to greater prevalence of slime and cracked ribs, lettuce used in the fourth test (late spring at Phoenix) was inferior to that which had received fertilizer only as an early spring side

dressing. It was obvious that band placement at time of planting for spring lettuce may cause rapid growth in late fall and winter, and this must be reckoned with in determining planting dates.

Sulphur alone and in combination with ammonium phosphate was used in two of the tests. This year no consistently desirable effects were obtained. This was true also for band-placed goat manure, which gave a depressing effect. Organic mixes included in spring tests and made up so that they contained nitrogen and phosphorus in equal amounts to 11-48 and 16-20 ammonium phosphates did not increase yields over the latter.

On the basis of the experiments this year, 16 to 20 pounds per acre of simple nitrogen is indicated as the maximum band application that can be safely applied for warm weather planting. For November plantings of the spring crop the limit appears to be near 25 pounds.

Lettuce seed storage

In recent investigations, "new," pure-line seed of Imperial 152 has been stored for periods of 24 hours to 3 years at temperatures of 40 to 130 degrees F. and humidities of 10 to 75 per cent. The germinative power and seedling vigor of these seeds have been tested in the laboratory and in the field under the high soil temperatures of early fall. The highest germination and most vigorous seedlings have been obtained from seeds stored at 75 to 88 degrees F. with variable humidity.

Exposure of new seeds to temperatures as high as 130 degrees F. resulted in rapid decrease in germination. Thus, it would seem inadvisable for lettuce seed to be left exposed to the sun or placed under a metal roof during the summer in southern Arizona. Under such conditions the temperature build-up may be sufficient to damage the seed seriously.

New seeds from the first harvest or "shake" have been found to be larger, of higher germinative capacity, and productive of greater seedling vigor than seeds from later harvests.

Cantaloupe breeding and selection

In the Salt River Valley the powdery mildew-resistant No. 45 is now used almost exclusively for the commercial acreage. The immediate problem is one of maintenance of pure seedstocks. Reselection within existing commercial strains of No. 45 was begun in 1938, and four generations of some of the material had been grown by the fall of 1939. At that time the Seed Improvement Committee of the Central Arizona Vegetable

Shippers Association asked that the Experiment Station grow foundation seed for the Salt River Valley. Accordingly, in the spring of 1940 forty-two relatively pure lines were grown in isolation on the University Farm at Mesa. These proved to be very uniform. The 200 pounds of seed produced was massed and released to the committee. The vegetable growers plan to increase this seed in 1941 for the Salt River Valley 1942 commercial crop. Enough self-pollinated melons were produced in the field to provide seed for a 1941 foundation planting. This program is planned as a permanent feature in which self-pollinated pure-line seed is to be produced each year for planting the foundation stock. Seed from this will in turn be released for the vegetable growers. They will increase it 1 year to obtain seed for the commercial acreage of the following year. Thus, the commercial Salt River Valley acreage will be planted from seed that is only one generation removed from self-pollinated pure-line material.

While the No. 45 melon is reasonably satisfactory in the Phoenix area, it has not been popular with Yuma growers, and improvements would be desirable for Salt River Valley production. Breeding and selection have been directed toward the production of a variety having smaller melons of better flavor and a vine with heavier foliage and greater yielding capacity.

In the spring of 1940 all selections and hybrids made up until that time, many of which were in the F_8 generation, were planted in the Salt River Valley. Approximately 750 different lots were involved, each lot representing an individual fruit selection or selfed melon. Data were taken on foliage type, yield, and all fruit characteristics influencing marketability. Further selections were made for planting in the 1940-41 season.

In this material at least two promising lines have been obtained for Yuma. Both lines are selections from crosses between No. 45 and Superfecto. These crosses were made by members of the Bureau of Plant Industry from which the F_8 seed was obtained in 1938. The lines are designated in order of desirability as 15897 and 15898. Both lines are characterized by uniform 45 to small 36 size; slightly elongate shape; little or no stripe; heavy net; firm flesh; dry matrix; medium to small cavity; and medium to heavy vine. Purification of these strains has progressed to a point where test plantings will now be made in commercial fields.

Among the Arizona lots several F_8 selections from an original cross between No. 45 and Superfecto offer possibilities of smaller fruit size for Yuma, increased leaf coverage, slightly earlier maturity, and better edibility than No. 45.

Lettuce breeding and selection

Individual plant selections of Imperial 152 and Imperial 615 varieties of lettuce have been continued, and seed of selections made originally in 1935 has been further multiplied. These stocks have been compared with commercial stocks in growers' fields and have been found to be of greater uniformity, with a lower percentage of offtypes. In general, it would appear that the Arizona strains have a slightly smoother butt with somewhat less of the spidery appearance often found in trimmed lettuce. In addition, the head wrapper leaves tend to enclose the head closely, turning back at the tip only. Continued roguing for slick leaf types and elongate heads will be necessary, although not more than one half of 1 per cent of these types is appearing in comparison plantings. Foundation seed of these strains is to be produced in 1940-41 for release to the Seed Improvement Committee. This seed will then be handled similarly to the No. 45 cantaloupe.

Recently several promising selections for both fall and spring planting have been obtained from the Bureau of Plant Industry. These are in an early stage of development and will require much selection and observation before they will be ready for comparison with commercial strains.

Selections for tip-burn resistance, resistance to seeding, and other desirable characters are being carried on in progeny of crosses between 615 and 152.

Vegetable variety trials

Many new vegetable varieties are now being produced each year by commercial seed companies and other organizations. In order to answer requests concerning the merits of these varieties, it has been necessary to undertake systematic variety trials. These are intended as a permanent part of the vegetable crops program. During the past 2 years, varieties which have shown special possibilities are the Ohio canner beet and the Golden Cross Bantam sweet corn.

The variety trials are proving to be a necessary adjunct to the breeding work. They also provide an opportunity to test new types of plants that might have commercial possibilities for Arizona, such as the drug and herb groups. The possibility of seed production of the various vegetables is also considered. This aspect of vegetable growing has assumed especial importance at the present time, since foreign supplies of many seeds are now curtailed.

Vegetable crop adaptation tests on the Yuma Mesa

The trials begun in 1938-39 were continued during the 1939-40 season. They are designed to provide information on the possibilities of growing winter vegetables on the Yuma Mesa. Of the various crops grown the tests indicate that tomatoes and garden peas may offer the most commercial possibility.

A mimeographed circular covering the second year's trials is available.

Citrus Studies

Grapefruit maturity

A 5-year study of seasonal changes in Brix-acid ratio, color, juiciness, and their relation to maturity was completed this year. These studies indicate several major points bearing upon the establishment of maturity standards. This material has been published as Technical Bulletin 89 of the Arizona Agricultural Experiment Station.

Preliminary studies were started to determine seasonal changes in flesh tenderness. A close correlation appears to exist between the percentage of juice in the edible portion of the fruit and the tenderness of the flesh. This suggests the possibility of substituting tenderness tests for juice determinations. Such a method would be desirable since juice measurements based upon the whole fruit are laborious, not highly accurate, and are affected by the amount of peel.

Winter temperatures in Salt River Valley citrus groves

The 1939-40 winter was exceptionally warm, with the first killing frost occurring on December 26 and the last frost on March 28. On the night of January 13-14, a minimum temperature of 21 degrees F. was recorded with a duration below 26 degrees F. of 6 hours at many stations. Fruit temperatures of oranges dropped to 26.5 at the location studied, but no freezing damage occurred.

Air temperatures were recorded at twenty-eight stations in the citrus areas. As in previous years, a wide variation in minimum temperatures was recorded at the various stations, but on any one night temperatures within each individual citrus district were rather uniform.

Temperature inversion data were obtained from thermometers and thermographs placed at four elevations on a tower located in the center of a grove. Average minimum temperatures for the fifteen coldest nights were: 2 feet, 26.4 degrees; 5 feet, 27.3 degrees; 15 feet, 31.8 degrees; 50 feet, 37.7 degrees. On

nights having considerable air movement less inversion occurred.

Orchard heaters, forty-eight per acre, raised the temperature on the night of January 13-14 3 degrees and maintained a temperature above 26 degrees. On this occasion temperature inversion at 50 feet was 14 degrees, and at 300 feet it was 18 degrees.

Grapefruit fertilization

The grapefruit fertilization plots on the Yuma Mesa have been continued. Again nitrogen is the only fertilizing material that has influenced production. Yields have been uniformly greater where nitrogen in any commercial form has been applied with the basic application of 3 tons of manure per acre. Six and 9 tons of manure alone have given no greater yields than 3 tons, and this gave but slightly more fruit than where no fertilizer was applied. This, perhaps, suggests that in the poor, sandy soil of the Yuma Mesa manure undergoes decomposition so slowly that nitrogen is not rendered available to the trees in time to influence the amount of blossoms produced or fruit retained through the period of spring drop. All fertilizer applications are now being made near December 1 rather than in February as was done during the first 4 years of the experiment.

Commercial quality of the fruit has not been visibly improved through the use of phosphorus or potash and, similarly, fruit on plots receiving calcium as calcium nitrate has been no better than that on plots receiving nitrogen as urea or ammonium sulphate. Actually, fruit from the plots receiving either phosphorus or potash alone or in combination has been inferior to that on plots receiving commercial nitrogen. This would seem to be directly related to the number of fruit on the tree. It is well known that where few fruit are borne they are likely to be of poor commercial quality.

Chemical analysis of leaves has given information possibly bearing upon the lack of difference in yield or quality of fruit from plots receiving phosphorus and calcium. The total phosphorus and calcium in leaves in the different plots has been determined (courtesy R. H. Kellner) and calculated as amount per leaf and percentage dry weight. As reported a year ago, in those plots receiving commercial nitrogen, the nitrogen content of the leaves is high and, surprisingly, calcium is also uniformly high whether calcium nitrate or a calcium-free form of nitrogen fertilizer was applied. Similarly, leaves from these plots were low in phosphorus even where phosphorus was applied. In those plots receiving no commercial

nitrogen the nitrogen content of the leaves was uniformly low, as was the calcium, but the phosphorus content was high even in those plots which received no phosphorus or any other form of fertilizer.

Quality and yield of grapefruit

The results of the third year's experiments on the Yuma Mesa have borne out the observations reported during the past two years. Practices leading to a high nitrogen content of the tree at time of bloom, if accompanied by adequate carbohydrate storage, tend to maintain satisfactory production; while practices which render nitrogen available during the summer lead to the development of a highly vegetative tree condition usually resulting in the production of late-coloring, coarse-textured fruit of relatively poor market grade. On the other hand, practices tending to reduce nitrogen availability during the summer, such as the growing of competing cover crops and withholding of nitrogenous fertilizers, favor the production of early-coloring, fine-textured fruit of relatively superior market grades provided a good set of fruit is present. Extreme nitrogen starvation coupled with a light crop may result in fruit of extremely low quality.

Ample nitrogen availability immediately following bloom may

Plate II.—Marsh seedless grapefruit. Practices tending to reduce nitrogen availability during the summer appear to favor the production of the type of fruit shown on the right if a good crop has been set.

reduce the May drop of fruit slightly but tend to lower the commercial quality of the fruit, particularly if harvest is delayed until the following spring. Summer nitrogen fertilization does not affect the yield of fruit in the current crop and appears less effective in maintaining long-time production than nitrogen applications of the same magnitude made during the winter months.

In evaluating the effect of summer starvation practices, it is evident that the use of competing cover crops and lack of nitrogen fertilization during this period are together much more effective in improving quality than is either practice alone. It is apparent that alfalfa exerts very little starving effect as a summer cover crop and consequently has much less influence upon quality than do such crops as Bermuda and Sudan grass.

Large-scale experiments have been carried out in several mature commercial grapefruit groves on the Yuma Mesa both in 1939 and 1940. The results indicate that where a good set of fruit is present, the quality may be improved by the use of a summer cover crop of Sudan grass and that production may be maintained if the cover crop is disked under in the fall and followed by adequate winter applications of a readily available nitrogenous fertilizer.

Tests and observations in Salt River Valley groves indicate that somewhat better quality grapefruit of smaller sizes may be expected where summer cover crops are grown than will be obtained where a system of clean culture or summer nitrogen fertilization is followed under strictly comparable tree and soil conditions. More intensive studies in Salt River Valley orchards are contemplated now that basic principles underlying fruiting behavior have been learned from the Yuma studies.

Nitrogen uptake by citrus trees

Studies of nitrogen uptake by grapefruit trees in the Salt River Valley have been continued. For all fertilizers tested it was more rapid in the fall and spring than in the winter. The rate of uptake from all fertilizers was slightly more rapid in 12-year old trees growing in a gravelly loam soil than in 26-year old trees in a heavier soil. Nitrogen uptake was most rapid from calcium nitrate, followed by urea, ammonium sulphate, and manure, in order. The time of application which resulted in the highest nitrogen content of leaves during blossoming and fruit setting was February for calcium nitrate, December for urea and ammonium sulphate, and August

for manure. When applied on these dates in the orchard on gravelly loam soil, all commercial fertilizers produced spring leaves having essentially the same nitrogen content.

Nitrogen from manure appeared to become available more rapidly in this younger grove on light soil than in the older one on heavier soil. Applications of manure in August produced marked increases in the nitrogen content of leaves within 40 days and gave as high a nitrogen content of spring leaves as the other materials applied in August, but not as great as where commercial fertilizers were applied later in the season. Trees receiving manure at any time tended to have more nitrogen in the leaves during the summer.

The grapefruit fertilization plots on the Yuma Mesa also afforded opportunity for studies of nitrogen uptake. Manure and commercial forms of nitrogen were applied December 1. Old leaves on trees on the manure plots did not increase in nitrogen following the manure application, and the spring leaves did not have any greater percentage of nitrogen where 3 tons of manure were applied than where no fertilizer was given. Six and 9 tons of manure produced spring leaves which were only slightly higher in nitrogen. Where mineral forms of nitrogenous fertilizers were applied the nitrogen content of old leaves increased markedly by January 15 in most cases, and in every case the new leaves contained a much higher percentage of nitrogen than where any amount of manure was applied. The uptake of nitrogen was as rapid and as high a percentage was reached in the new leaves where mineral nitrogen without manure was applied as where it was included. Differences between commercial forms of nitrogen were not apparent.

Pecan Studies

The pecan situation

It has been suggested in previous reports that many of the fruiting problems encountered with pecans in the Yuma Valley and, to a less extent, in other districts are basically related to the high temperatures prevailing. It is becoming clear that high temperatures influence pecan fruiting in two important ways: (1) Insufficient chilling during the winter months is followed by a reduced blossoming and an increased May drop of young nuts. The end result is low and irregular yields. (2) High summer and fall temperatures intensify problems of maturity and quality (hollow kernel, low oil content, germination, etc.).

Studies for many years on the Yuma Experimental Farm have revealed that yields can be influenced somewhat by nitrogen

fertilization and other practices but that for those varieties requiring considerable winter chilling, economic yields cannot be produced regularly and consistently. It has similarly been learned that maturity problems can be materially reduced through the use of cultural treatments which tend to reduce nitrogen availability in late summer and fall and which provide for full exposure of the leaves to sunlight, but it is doubtful if satisfactory maturity can be accomplished under the extremely high summer and fall temperatures of the Yuma Valley in any but those few varieties which are most tolerant to these temperatures.

The solution of the problem for the Yuma Valley appears to lie in top working the present acreage to one or two varieties which are most tolerant alike to warm winter temperatures and to high summer and fall temperatures.

Varietal tolerance to warm temperatures and adaptation to the several districts of the State

Observation and study of the performance of pecan varieties for the past several years suggest the order shown in Table 14 when these varieties are listed according to their tolerance of these two aspects of temperature influence.

TABLE 14.—PECAN VARIETIES LISTED IN ORDER OF TOLERANCE TO WARM TEMPERATURES.

Tolerance to warm winter temperatures (Ability to yield well in warm climates)	Tolerance to warm summer and fall temperatures (Ability to produce well-filled nuts in warm climates)
1. Halbert	1. Success
2. Humble	2. Humble
3. Mahan	3. Schley
4. Western	4. Kincaid
5. Delight	5. Mahan
6. Onliwon	6. Western
7. San Saba	7. Delight
8. Burkett	8. Halbert
9. Delmas	9. Delmas
10. Clark	10. Clark
11. Millican	11. Onliwon
12. Kincaid	12. Stuart
13. Success	13. San Saba
14. Stuart	14. Texas Prolific
15. Texas Prolific	15. Love
16. Love	16. Royal
17. Royal	17. Millican
18. Schley	18. Burkett

The above listing cannot be considered as entirely accurate. It is of value only in indicating an approximate relation of the varieties with regard to their temperature requirements for satisfactory yield and maturity.

Yields for all varieties except those occurring near the head of the left-hand list tend to be lowest in the Yuma Valley, and they increase progressively through the Phoenix,

Florence, Tucson, and Safford districts. Similarly, maturity problems are most intense in the Yuma area and become progressively less as the higher and less warm valleys are considered. Only those varieties occurring near the head of the right-hand list could be considered commercially free of maturity problems in the Yuma Valley. It is clear that for the Yuma district varieties which occur near the head of both lists should be selected. The majority of pecan varieties appear better adapted to elevations in the Phoenix to Safford range than lower. The studies would indicate that the temperatures of the Verde Valley might be suitable for pecans.

Because of the importance of temperatures not only in pecan production but in other phases of horticulture as well, an effort is being made to measure temperature situations more accurately. In the winter of 1939-40 the hours of chilling (45 degrees or below) for the different districts were as follows: Yuma Valley, 693; Tempe Date Garden, 874; Tucson (U. of A.), 841; and Safford, 1,400. Studies are being extended to include measurements of summer temperatures.

Pecan nut filling and maturity

Studies on nut filling and maturity have again been pursued through the use of cultural treatments to influence tree vegetativeness. In the Burkett and Mahan varieties those treatments which reduced vegetativeness improved the quality of the kernel and decreased the germination. The nuts were slightly smaller and had a higher specific gravity. The kernels contained a higher percentage of fat and a lower percentage of nitrogen and sugar. The response of Success, Kincaid, Humble, and Western was less marked.

The important role of full sunlight in nut filling was again revealed through shading experiments. Also, the black margined pecan aphid (honey-dew aphid) was controlled on some trees and not on others. The present indications are that this aphid contributes seriously to poor filling in the Burkett.

Studies on the breaking of the winter rest period

Studies on breaking the rest period through the application of chemicals and by other means have been continued. The most promising treatment seems to be dormant spraying with dinitro-o-cyclohexylphenol. Burkett trees sprayed four times at 2-week intervals through February and early March have come into leaf and blossomed earlier and heavier than unsprayed trees. While it seems that the best solution of the problem of incomplete dormancy or winter rest is to use varieties which require less

chilling, the value of a winter treatment which would cause Success trees to fruit heavily in the Yuma Valley justifies experimentation with treatments to break the rest period artificially.

Pistillate blossoming and pollen distribution

Data have been obtained for 5 consecutive years on the time of pistil receptivity and pollen liberation of certain pecan trees on the Yuma Valley Farm. Varieties of Burkett, Halbert, Humble, Kincaid, Mahan, Schley, and Success especially have been under observation. Pistils are receptive before pollen is liberated except in certain cases with Halberts. Burkett, Mahan, Humble, and sometimes Kincaid and Schley have the period of pistillate flowering almost completed before pollen is shed. Halbert and Success liberate pollen throughout the period of pistillate flowering. This supports the view that a mixture of pecan varieties in a planting may be advisable to assure proper pollination. The Halbert variety each season has been the first to liberate pollen.

While there have been a few days' difference between seasons in actual date of blossoming, the relative time of pistillate flowering and pollen liberation of Burkett, Halbert, Humble, Kincaid, and Mahan approximately coincide each season. The Schley and Success pistillate receptivity period is sometimes slightly delayed.

Growth and rosetting of young pecan trees receiving various fertilizers

In January, 1936, a pecan grove was planted on the Mesa Experimental Farm. Studies designed to provide information on the response of young trees to fertilization were started December 1, 1936. After 2 years, it appeared that plots receiving no fertilizer or ammonium sulphate were least affected by rosette, and those receiving ammonium phosphate were most severely affected. Various insoluble forms of zinc were applied in soil tube holes around the trees. In all plots trees showing rosette were treated as needed with zinc sulphate placed in a shallow trench around the tree.

Zinc oxides have controlled rosette quite satisfactorily, though not immediately or completely. Metallic zinc seems to be less effective. Because of the difficulty in controlling rosette in the ammonium phosphate plots, applications of this material were discontinued in the fall of 1939.

None of the fertilizers increased the growth of the trees above that of trees receiving no fertilizers. The evidence

from this experiment and other miscellaneous trials suggests that little benefit may be expected from commercial fertilizers in young pecan orchards where cover crops are grown and frequent irrigations given.

Date Studies

The 1939 date season

The 1939 date season was one of the most unfavorable for date ripening in history. Between September 3 and 13, 2.36 inches of rain fell. This was accompanied by cloudy weather and a high relative humidity. Losses were large in all varieties. A rather wide variation in splitting, tearing, and deep checking occurred in many varieties. This appeared to be related to the stage of maturity of the fruit at the time of the rain and was particularly evident in the Deglet Noor, Dayri, and Iteema varieties. Fruit ripening during this period of heavy rainfall absorbed moisture so that fermentation occurred both on the tree and during the dehydration process. This constituted the major loss in the Khadrawi and Hayany and was accompanied by an accelerated rate of ripening.

Cool, dry weather followed in October, but varieties ripening during this period were affected by checking, a sirupiness, blacknose, and alternaria infection, the latter causing the complete loss of Deglet Noor dates which were sufficiently immature to escape serious direct damage earlier. The Maktoom, which did not appear to be seriously damaged in September, shriveled, darkened, and in some instances checked seriously.

TABLE 15.—SUMMARY OF 1939 DATE SEASON.

Variety	Date blossomed	Date ripened	Per cent loss
Apdamdon...	Mar.30	Aug. 28	50 - fermentation
Bent Kebala	Apr. 4	Sept. 5	65 - splitting, checking, fermentation
Braim.....	Apr.12	Sept. 3	60 - fermentation, mold, splitting
Deglet Noor	Mar.30	Sept.12	100 - tearing, alternaria, mold
Halawi.....	Apr. 2	Sept. 1	70 - fermentation, mold, splitting
Hayany.....	Apr. 7	Aug. 28	95 - splitting, fermentation
Iteema.....	Apr. 1	Sept. 8	100 - tearing, fermentation, mold, checking
Khadrawi...	Apr. 2	Aug. 26	50 - fermentation, splitting, mold
Khir.....	Mar.28	Aug. 26	40 - fermentation, mold
Kustawi....	Apr. 1	Sept. 5	40 - fermentation, mold
Maktoom....	Apr.12	Sept.12	65 - fermentation, checking, darkening
Rhars.....	Mar.12	Aug. 25	100 - tearing, fermentation, mold
Sayer.....	Apr. 1	Sept. 2	60 - tearing, fermentation, calyx end rot
Saidy.....	Apr. 2	Sept.12	80 - fermentation, mold, alternaria
Tadala.....	Apr. 4	Sept. 5	40 - fermentation, mold
Zahidi.....	Mar.25	Sept. 7	85 - alternaria, deep severe checking
16-23.....	Apr.10	Aug. 30	50 - splitting, fermentation

Date maturation and storage studies

Due to heavy losses in the field and in curing, studies on the 1939 crop were curtailed and confined to the Khadrawi and Sayer varieties. Experiments included dehydrating cured dates to different moisture contents and storing in commercial storage at 32 degrees and in a small refrigerator at -5 degrees F.

After 160 days' storage Khadrawi dates, dehydrated to a moisture content of 30 per cent, were superior to fruit with larger percentages of moisture. As was the situation in previous years, fruit stored at 0 degrees F. was superior to fruit stored at 32 degrees F.

The Sayer variety showed less differences between fruit with high and low moistures and between that stored at 32 degrees and 0 degrees F. temperatures.

Observations on the 1938 crop after 17 months' storage showed wider variations between 32 and 0 degrees F. storage conditions than were observed after 5 and 12 months. Khadrawi fruit stored at 32 degrees was no longer marketable, while samples stored at 0 degrees were salable although reduced in grade.

The 1940 date season at the Tempe Garden

The 1940 date season was one of the earliest ever recorded. This is believed to be related to a combination of three circumstances: (1) blossoming was exceptionally early; (2) summer temperatures were above normal; and (3) low soil moisture was necessitated by the acute shortage of irrigation water.

TABLE 16.—SUMMARY OF 1940 DATE SEASON.

Variety	Date blossomed	Date ripened	Per cent loss
Apdamdon.....	Mar. 3	Aug. 8	10 - shrivel
Bent Kebala..	Mar.10	Sept.1	20 - blister
Braim.....	Mar.21	Aug.16	5 - shrivel
Deglet Noor..	Mar.10	Sept.1	25 - shrivel
Halawi.....	Mar.12	Aug. 6	35 - shrivel
Hayany.....	Mar.15	Aug.16	10 - checking
Iteema.....	Mar. 5	Aug.25	25 - checking, premature ripening
Khadrawi.....	Mar. 3	Aug. 8	25 - shrivel, premature ripening
Khir.....	Mar. 2	Aug. 8	5 - premature ripening
Kustawi.....	Mar.15	Aug. 8	20 - blister
Maktoom.....	Mar.18	Aug.30	20 - darkening, shrivel, water-soaked
Rhars.....	Feb.27	Aug.10	60 - darkening, checking, fermentation
Sayer.....	Feb.27	Aug.16	10 - premature ripening
Saidy.....	Mar.16	Sept.1	25 - shrivel
Tadala.....	Mar. 5	Aug.22	25 - blister
Zahidi.....	Mar.12	Aug.28	25 - shrivel
16-23.....	Mar.15	Aug.14	15 - premature ripening, blister

Ripening began in early August. Favorable weather conditions prevailed, and many varieties cured perfectly on the palms. Losses were confined largely to reduction in grade due to shrivel, blister, and premature ripening. All fruit on commercial varieties had ripened by early October.

The 1940 date season at the Yuma Garden

The date planting started on the Yuma Valley Farm in 1931 has been delayed in coming into bearing because of the saving of offshoots. This planting represents a selection of varieties which experience has shown to have a high degree of merit. Some varieties are beginning to produce now.

Most Khadrawi offshoots have been removed for the past 3 years. This variety quite noticeably produced more blossom bunches than other varieties still surrounded by a number of offshoots.

Only a few bunches of any variety were pollinated for fruit maturity observations. Fruit losses during maturity were negligible in all.

Miscellaneous Fruits

New varieties and rootstocks

New varieties and types of horticultural plants are being introduced as rapidly as promising ones can be located. Two objectives are receiving special attention: the finding of varieties of deciduous fruit having minimum winter chilling requirements, and of rootstocks resistant to nematodes and other soil-borne troubles.

The Jewell and Waldo peaches planted on the Mesa Experimental Farm in February, 1939, blossomed and fruited well in 1940. The Bruce plum also gives evidence of requiring somewhat less winter chilling than most varieties.

The Shalil peach has continued to grow well in soil infested with nematodes. No nematode galls have been found on the roots as yet. The fig stock (PI 52406) introduced more than a year ago has been grown on nematode-infested soil and thus far no root knots have been found.

On the Yuma Mesa the cassava or tapioca plant continues to thrive.

HUMAN NUTRITION

Vitamin Studies

Mineral oil ingestion vs. vitamin A and D assimilation

The study of the effect of continuous ingestion of mineral oil by experimental animals, rats and dogs, has been completed and published in part in Bulletin No. 84 entitled "Some Effects on Animal Nutrition of the Ingestion of Mineral Oil." Results of the effect of mineral oil ingestion upon the metabolism of calcium and phosphorus have appeared in the Journal of Nutrition, Volume 20, page 19, 1940, under the title of "Calcium and Phosphorus Metabolism in Rats and Dogs as Influenced by the Ingestion of Mineral Oil."

Further experiments of this type have thrown light on the method of action of vitamin D. It was found that mineral oil ingestion interfered with both the healing and prevention of rickets in rats which normally result from ultraviolet irradiation. It is concluded, therefore, that at least one role of vitamin D is to increase intestinal absorption of calcium and phosphorus either directly or indirectly. This work has been published in the Journal of Nutrition, Volume 20, page 197, 1940, entitled "Further Evidence of the Mode of Action of Vitamin D."

The effect of sunlight upon the vitamin D potency of milk

Preliminary studies carried out in co-operation with the Dairy Husbandry Department indicated that the cream from cows exposed to the sunlight had a higher vitamin D potency than the cream from cows kept in the dark. In February (when the ultraviolet rays from Arizona sunshine are at their lowest) two cows were placed in the barn and protected from sunshine. Samples of milk taken from these two cows on April 2 were tested for vitamin D potency. As butterfat is the carrier of the vitamin D in milk, each milk was adjusted to 5 per cent butterfat before testing. The same amount of milk was fed in each case. The rats, therefore, ingested the same amount of butterfat, and their diets had the same calcium to phosphorus ratio, which is an important consideration in vitamin D studies. The average healing (as shown by the Line Test) produced in twenty rats by 50 milliliters of the 5 per cent butterfat milk from cow 10 was 0.7^{+} and from cow 11 was 1^{+}. Cow 10 was then placed in the corral without any shade and cow 11 was continued in the barn. At various intervals 50

milliliters of milk having 5 per cent butterfat were tested, the results being as follows: samples from cow 10: May 2 gave 2^+, June 3 gave 2.2^+, and July 3 gave 2.5^+ healing; samples from cow 11: May 2 gave 1^+, June 3 gave 1.2^+, July 3 gave 1.5^+ healing. As the degree of healing is not arithmetically proportional to the amount of vitamin D fed, the amount of milk fed is being varied in order to determine that amount which will produce the same degree of healing in each case. The significance of these findings will be studied and evaluated as to the practical effect of exposure of the cow to sunshine upon the vitamin D potency of her milk.

Vitamin C metabolism in humans

Investigations in vitamin C metabolism have been begun. Initially, effort is being made to develop a practical and reliable method for testing the vitamin C nutritional status of children and adults which can be used in determining factors which affect vitamin C metabolism and thus cause variation in requirement for this vitamin.

Urinary excretions of vitamin C (8 a.m. to 12 noon) have been followed for several weeks in six subjects given a 300-milligram test dose of vitamin C as crystalline ascorbic acid at 8 a.m. Daily individual percentage excretions of the test dose of ascorbic acid in the 4-hour period ranged from 23 to 30 per cent in two subjects, from 30 to 37 per cent in three, and over 38 per cent in one.

In the course of this preliminary study, certain observations were recorded upon which more evidence is being sought. In comparing the availability of the ascorbic acid in citrus juice and strawberries with that given as pure crystalline ascorbic acid, no significant differences were noted. In two subjects a significantly greater urinary excretion of vitamin C when given as grapefruit juice of analyzed content was paralleled by an equally greater excretion when crystalline ascorbic acid was given with synthetic grapefruit juice containing the same amount of water, sugar, and acids other than ascorbic.

The effect of infection upon vitamin C metabolism was indicated by a precipitous drop in vitamin C excretion in one subject with the onset of a cold.

An effect of severe exercise was observed in two subjects. In seven tests on one subject the percentage of excretion of the test dose of ascorbic acid on the day after severe fatiguing exercise dropped 11 to 20 per cent from the previous day's excretion. A 13 per cent drop in excretion of the test dose in one graduate student was observed the day following

the nervous strain of an oral examination for the master's degree which resulted in a restless night's sleep.

In all of this work urinary excretions of ascorbic acid have been measured by titration with 2-6 dichlorophenol-indophenol. These preliminary studies are being extended to include blood plasma determinations of ascorbic acid.

Iron Studies

The study of the utilization of iron by anemic rats was continued with emphasis being placed on the total iron content of the rats rather than on changes in the hemoglobin concentration of the blood.

The effect of adding various ions to the anemia-producing diets of whole milk powder or two thirds ground white rice with one third milk powder had been investigated, but only very slight differences were noted in the iron content of the rats. When calcium ions were added to the diet, the iron content of the rat decreased in spite of the general feeling that the presence of calcium ions increased the utilization of iron. As the differences in the amounts of iron were very small since anemic rats were used in the study, the effect on the total iron content was investigated when 0.1 milligram of iron was fed to anemic rats daily for 6 weeks from a standard ferric chloride solution. Here a decided decrease was noted in the assimilation of this 0.1 milligram of iron when the rats were fed a basal diet of milk powder plus 2 per cent calcium carbonate or a basal diet consisting of two thirds ground white rice plus one third milk powder plus 2 per cent calcium carbonate. The milligrams of iron per gram of rat fell from 0.021 to 0.019 for male rats and from 0.027 to 0.021 for female rats when the basal diet was milk powder alone and milk powder plus 2 per cent calcium carbonate and from 0.022 to 0.017 for male rats when the diet was two thirds ground white rice plus one third milk powder, or this mixture plus 2 per cent calcium carbonate. The addition to the diets of the same amount of Ca^{++} as calcium chloride also caused a decrease in the iron retention. The growth of the animals was markedly retarded when 2 per cent calcium carbonate was incorporated in the diet. The carbonate ion, fed as sodium carbonate, did not affect the utilization of the added iron. Unfortunately the calcium to phosphorus ratio which has since been shown to be important in iron utilization was not determined for the diets used.

When investigating the availability of iron in foods, grains and dried fruits were used. The production of the

anemic rats, the method of feeding the supplements, the method of determining the hemoglobin concentration, and the analyses of the rats at the end of the test period were all the same as reported previously. The iron availability was calculated on three different bases: (1) the gain in hemoglobin during the 6 weeks' test period, (2) the milligrams of iron per gram of rat at the end of the 6 weeks' test period, and (3) the percentage of the total iron ingested that was retained by the rat at the end of the 6 weeks' test period. (This calculation was possible because it had previously been determined that anemic rats with hemoglobin concentration of 2.5 to 5.0 and so ready for the feeding test period had a remarkably consistent iron content with an average of 0.015 milligrams of iron per gram of rat.) Methods (2) and (3) gave more constant results than (1) in determining the availability of iron. It is therefore recommended that in making iron availability tests they be based on the milligram of iron per gram of rat or better still on the percentage retention of the iron that was ingested by the rat.

There appears to be an iron level characteristic of a litter of rats and so comparisons between the amount of iron retained from the ferric chloride solution and the food must be made on litter-mate rats which are, of course, of the same sex. The results do not give figures that are exact but give a definite indication of the availability of iron in the food.

It was found that sulphuring fruits or cooking grains had no appreciable effect on the availability of the iron present. Iron is about 50 to 60 per cent available in most dried fruits and 100 per cent available in most whole grains.

Fluorine Studies

(This work was done in co-operation with the Agricultural Chemistry Department)

Effect of addition of fluoride to soils upon the fluorine content of plant foods grown on these soils

Sodium fluoride in graded amounts was added to three plots of soil, while a fourth without added fluoride served as the control plot. Yams, alfalfa, tomatoes, carrots, beets, and string beans were grown on each plot. Wheat, soybeans, hegari, and corn were grown on soil fertilized with calcium fluoride. Upon harvesting, the plants were analyzed for fluorine using the thorium nitrate method.

The results at hand show that plants grown on soil containing added fluorides are in most cases higher in fluorine

content, but the increase is small compared with the increased concentration in the soil. Absorption of fluorine by plants appeared to be greater from the sodium fluoride plots than from the calcium fluoride plots. Higher concentrations of fluorine were found in the leafy part of the plant—i.e., in wheat stalks than in wheat.

Effect of presence of fluorides in drinking water of cows upon the fluorine content of the milk produced

Does milk from cows raised in communities in which mottled enamel is endemic because of the presence of fluorine in the local water supply contain fluorine in toxic amounts? In order to obtain an answer to this frequently asked question sodium fluoride has been added to the drinking water of two cows at seven concentration levels within the range of 0.2 to 500 parts per million of fluorine. The additions of the fluoride at the highest levels gave a slightly salty taste to the water and reduced somewhat the consumption of water and the milk supply.

Analyses of the milk of the cows drinking these waters showed only small differences in fluorine content within the range of 0.2 to 0.4 part per million. The fluorine of the urine of the same cows sampled at the same time of the day showed, however, an increase from 0.2 to 113 parts per million. It appears therefore that wide differences in the fluorine content of the drinking water of cows produces only slight increases in the fluorine content of the milk which is secreted.

The absorption of fluorine by foods cooked in water containing fluorides

Vegetables and cereals, including spinach, broccoli, cabbage, potatoes, cauliflower, beans, oatmeal, carrots, and beets, have been cooked, following the technique of usual household practice, in water containing 5 or 25 parts per million of fluorine. The cooked product was analyzed for fluorine by the Williard and Winter method and the results compared with analyses of the same foods cooked in the same way in distilled water. A significant increase in fluorine content of the foods cooked in fluorine-containing water has been found. This work is being continued.

PLANT BREEDING

Alfalfa

Winter growth studies were continued with the 246 inbred alfalfa progenies as reported in the Fiftieth Annual Report of the Arizona Experiment Station. During the winter of 1939-40 the heights attained at the end of each 10-day period were marked on the stakes placed within each progeny. Up to ten stakes were placed within each progeny, and the average height of the progeny at any given time was determined by averaging the heights recorded on these stakes. The height measurements in the winter of 1939-40 were marked on the same stakes used in 1938-39 without being removed from their original positions (see Pl. IV, p. 82, Fiftieth Annual Report, Arizona Experiment Station). The object in repeating these growth measurements was to study the effect of seasonal variation, due mainly to temperature changes, on the winter growth of the various progenies. Table 17 shows the average height distribution of 246 inbred alfalfa progenies February 1 at Tucson for both years 1938-39 and 1939-40.

TABLE 17.

Winter	Height in 2-inch classes						
	4 in.	6 in.	8 in.	10 in.	12 in.	14 in.	16 in.
1938-39	8	33	70	92	34	9	-
1939-40	3	16	43	81	70	28	6

These progenies were cut about November 20 both seasons. The height attained at the end of 30 days after this cutting was marked on the stakes. After this date (December 23 in 1938 and December 25 in 1939) the height was recorded on the stakes at the end of each 10-day period throughout the winter. The heights attained by these progenies at February 1 were assembled into distributions (Table 17) for the reason that by this date ordinarily the bulk of the winter is past, and the height of the plants at that time is a good criterion of their ability to grow during the winter months. Daily maximum and minimum temperatures were recorded, and the average temperature for each 10-day period was determined for both seasons. The winter of 1939-40 was much warmer than that of 1938-39, only one 10-day period of the former being as cool as the corresponding period of the latter. An inspection of Table 17

shows the advantages in growth to be had from a nondormant, winter-growing type of alfalfa under climatic conditions of southern Arizona. During the cooler winter of 1938-39, 55 per cent of the progenies had attained a height of 10 inches or more. During the warmer winter of 1939-40, 75 per cent of these progenies had attained a height of from 10 to 16 inches

Plate III.—Differences in winter growth of adapted vs. unadapted varieties of alfalfa: left, three rows of Arizona common; center, five rows of unadapted northern varieties; right, two rows of adapted Hairy Peruvian. Last cutting November 1, 1933. (Picture taken Jan. 1, 1933, at University Farm, Tucson.)

by February 1. This shows the ability of a winter-growing type of alfalfa to utilize the warm periods of the winter in making growth. It is interesting to compare this behavior with the growth of a dormant type, Turkestan alfalfa. This alfalfa grew among the progenies mentioned above, but by February 1 it had made a growth of only 2.3 inches. Plate III shows a photograph taken at Tucson January 1. This illustration shows the growth made by alfalfas having different degrees of winter dormancy.

Cotton Breeding

The plan for the breeding of upland cotton calls for the growing of progeny rows each year from the seed of the best plants from the best progeny rows grown during the preceding year and for the production in a parent seed field of seed for distribution from the remaining plants of the best progeny rows. The work in 1940 was thus a continuation of work done in preceding years.

Acala

Approximately 150 progeny rows were grown in duplicate at Tucson in 1939. From these rows approximately 1,500 plants were selected in the fall of 1939 for continuing the work in 1940. After the plant selections were made, each progeny row was harvested separately, and its yield per 100 feet was determined. This resulted in the discarding of more than one half of the progenies due to low relative yield. The selected plants from the remaining progeny rows were tested in the laboratory, and the seed of the best of these plants were planted in progeny rows in the spring of 1940.

Laboratory tests made on the selected plants include size or contents of boll, per cent lint, lint index, seed index, number of seeds per boll, the length and strength of lint, and the percentage of lint in each $\frac{1}{8}$-inch class as determined by sorting. Out of the 1,500 plants originally selected only 153 were kept for planting. These were planted in duplicate at Tucson in 1940. From the remaining plants of the best progeny rows approximately 500 pounds of foundation seed were saved for distribution to growers.

In co-operation with the United States Field Station at Sacaton, Acala breeding work is being carried on in the Queen Creek section of the Salt River Valley on the farm of Leo Ellsworth. One hundred ninety-two progeny rows and a parent seed field of approximately 20 acres were grown in 1940. The best plants from seventy-five of the best of these progeny rows have already been selected for carrying on the work in 1941. Six hundred pounds of seed have been obtained from the best progenies to plant another parent field in 1941, while from the parent field grown in 1940, 9 tons of seed have been obtained for distribution to growers in 1941. In 1940 registered seed fields of this strain, which has become known as "Santan Acala," were grown in Maricopa, Pinal, Pima, Graham, and Gila counties.

Stoneville

Since the growth of Stoneville is confined almost exclusively to the Yuma Valley, all of the field work with this variety has been carried on at the Yuma Experiment Farm. Each year sufficient foundation seed is furnished to a co-operating grower in the Yuma Valley for the production of several tons of registered seed for distribution. From this registered seed sufficient certified seed can be grown to supply the Valley.

Plant selections have been made for progeny rows in 1941, and sufficient foundation seed are on hand for continuing the work for another year.

Stoneville-Hartsville cross

The F_5 plants of this cross were grown at Tucson in 1940. Selections have been made and selfed seed secured for carrying on this work in 1941. Sufficient selfed seed have been obtained from the most promising selections to make plantings at Yuma in 1941 if land in a suitable location can be found. The F_5 was very uniform within progeny rows, and many of the rows show considerable promise from the standpoint of yield and length and strength of lint. On the other hand the percentage of lint in many cases is not so high as that of some other varieties.

It will be necessary to study the behavior of all available selections under the growing conditions prevailing at Yuma before any final decision can be made.

Lint strength tests

A new type of machine has been developed by the department for testing the strength of lint. The machine is simple, easily operated, and approximately ten times as fast as the standard method now in general use. In the method developed the number of pounds required to break a sample of fibers of a standard length is determined by the machine. The weight of these fibers is then obtained and divided into the number of pounds required to break them, and an index of strength is obtained. In tests made this strength index has run from approximately 550 for very weak fibers to as high as 1,050 for the strongest. Due to the fact that samples can be tested rapidly, it is now possible to test the strength of lint of all plants selected for increase.

Figure 2 shows the variation in strength obtained from individual plants of Santan Acala selected in 1939 and the difference in strength of the lint of two plants of the same

progeny row. The solid line represents the results obtained by testing the lint of 149 individual plants. Five breaks were made from the lint of each plant, and the total number of pounds determined.

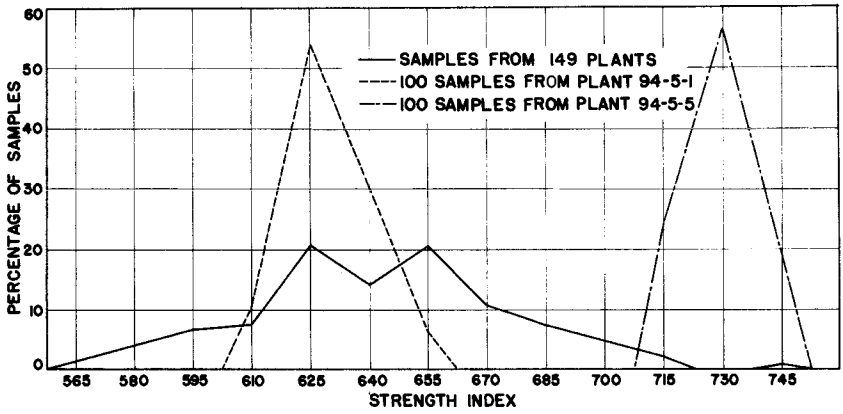

Figure 2.—Curves showing distribution of strength indexes for 149 plants and for two different individual plants.

The five batches of lint broken were combined, and one weighing and calculation was made. This was done as a means of saving time, since the results obtained in this manner are practically the same as those obtained when each break is weighed and calculated separately, and the average of the five was taken as the strength index. This sort of a sample is termed a "five-break" sample.

The dotted line represents the results obtained from 100 five-break samples made with the lint of plant 1 of progeny row 94-5. The broken line represents the results obtained from 100 five-break samples with the lint of plant 5 of progeny row 94-5. The mean of all samples was 629 for plant 1 and 729 for plant 5, or a difference of 13.7 per cent in strength. Mass samples obtained from the progeny rows grown from the seed of these two plants showed a difference of 9.4 per cent in favor of 94-5-5.

Results obtained from a large number of plants tested as well as from the two plants discussed above indicate that segregation for strength is taking place, and that the development of a strain of Acala stronger than that now being grown in Arizona should be possible.

The long staple crosses

In order to determine the yield among the better strains of the Pima x Tanguis cross, a yield test was conducted with strain No. 120 in comparison with both Pima and SxP. Table 18 shows the yield of seed cotton, yield of lint, weight of 100 seeds, lint index, and lint percentages of the three varieties:

TABLE 18.

Variety	Weight seed cotton (lbs.)	Weight of lint (lbs.)	Weight of 100 seeds (gm.)	Lint index	Lint (%)
Pima x Tanguis (strain No. 120)...	90.50	34.64	11.0	6.75	38.27
SxP.....	94.75	30.55	13.0	6.11	32.24
Pima.....	89.75	26.63	12.6	5.14	29.67

The weights of seed cotton and lint as stated in Table 18 were determined from the total yield of six 80-foot rows of each of the three sorts distributed across the entire field. Variety 120 produced 13 per cent more lint than SxP and 30 per cent more than Pima. While variety 120 has a smaller seed than SxP, it produces 10 per cent more lint on the same number of seed. This shows that the high lint percentage of variety 120 is not entirely due to its small seeds. Variety 120, however, has the disadvantage of a somewhat coarser lint than either Pima or SxP, and the cotton falls out of the boll soon after opening, being what is known among cotton growers as a "stringy" cotton. The lint is about $1\frac{1}{2}$ inches in length, comparing favorably with SxP in this respect. In order to improve the lint fineness of variety 120, it has been crossed with Pima. The first generation of this cross was grown during the summer of 1940. Sufficient self-pollinated seed was obtained from this cross for planting a large second generation in 1941, when selection will be begun for the purpose of establishing a strain with fine lint.

Wheat

Two hundred and thirty-six head selections were made from three double crosses. These double crosses had the following parents:

Double Cross No. 1:

F_1 (Hard Federation-Martin) x Soft Baart

on

F_1 (194-20 x 389)

Double Cross No. 2:

F_1 (1076-3 x 389)
on
F_1 (Hard Federation-Martin) x 389

Double Cross No. 3:

F_1 (Hard Federation-Martin) x Soft Baart
on
F_1 (Hard Federation-Martin) x 389

The particular merit of each of these parents as used in these crosses is as follows:

Hard Federation-Martin is early and resistant to all forms of smut found in Arizona and has strong straw but does not give a high yield of grain. Soft Baart is a high grain yielder and produces an excellent bread flour but is very susceptible to both smut and rust and lodges badly on rich soil; 194-20 is a true breeding strain from a cross between Ridit and Pusa-4, it has strong straw and good grain quality. A true breeding selection from a cross between Hard Baart and Ridit, 1076-3, is a good grain yielder and is resistant to smut; 389 is a very early selection with good straw from a cross between Ridit and Escondido.

Each of these double wheat crosses has now been grown through five generations without selection. Assuming that each of these double crosses was hybrid for ten major characters in the beginning, on the average about seventy-five heads out of every hundred selected should breed true for each of the ten characters. The major characters which it is desired to fix in a single variety are high yield of grain, smut resistance, strong nonlodging straw, high quality of grain, and earliness. Since each of these characters is found in one or the other of the parents of these double crosses, the expectation is justified that they may all be fixed in a single variety from this hybrid material.

Wheat rust also damages the wheat crop in Arizona in about 3 years out of 5. In smut years the injury is particularly damaging in the low, moist regions. In order to make progress in breeding for rust resistance, it is necessary to have rust infections on the breeding material every year. In some years in Arizona rust is light and fails to appear in some parts of the State.

Hope, a red spring wheat variety highly resistant to rust, has been crossed on both Early Baart and Sonora. By back crossing the hybrids of this cross on the Baart and Sonora parents and selecting for rust resistance in the succeeding

progenies, it is believed that Baart and Sonora types can be established which will have rust resistance.

PLANT PATHOLOGY

Angular Leafspot of Cotton

Extensive field studies of commercial plantings of cotton were made to determine the incidence of angular leafspot in fields of cotton from treated and untreated seed. The treated seed was (1) acid-delinted, (2) acid-delinted and ceresan dusted, and (3) fuzzy and ceresan dusted. No angular leafspot was found in cotton seedlings from acid-delinted seed, either (1) or (2); a few infected plants occurred in fields from dusted fuzzy seed, and from a trace to almost complete infection in fields from untreated seed. By July 20 angular leafspot had disappeared from most fields, but one field in the seedling stage in the Salt River Valley was ruined by the disease. The disappearance of angular leafspot from primarily infected seedlings apparently was due to unusually dry conditions existing in cotton fields. Owing to water shortage in reservoirs, the allotment for irrigation had been cut to 2 acre-feet, and the soil was very dry. The condition of the soil was reflected in the air around the seedlings, so that the spread of leafspot was restricted.

Characteristics of the fields from acid-delinted and dusted seed were quick sprouting (Pl. IV A) and uniform stand (Pl. IV B). No treatment prevented soreshin lesions on the seedlings, but more plants recovered in fields from treated seed of all kinds as compared with untreated seed. A further record of the fields must await next year's annual report.

Phymatotrichum (Texas or Cotton) Root Rot

The plan of field and laboratory experiments on root rot in pecan orchards of the Yuma Valley, initiated in 1937 under co-operative agreement with the Division of Fruit and Vegetable Crops and Diseases, U.S.D.A., has been continued with certain modifications.

Effect of intercropping and cover cropping

A history of intercropping and cover cropping of the pecan groves so far as possible (usually to date of planting to pecans) has been recorded for each experimental orchard. These

data, together with those of the past three seasons, have revealed that nearly all serious outbreaks of root rot occurred where an alfalfa intercrop was used, and that its elimination in orchards where root rot is prevalent is essential to a successful program of root-rot control. The evidence also indicates that after the orchard has been in immune intercrops for a few years relatively few chemical treatments may be necessary.

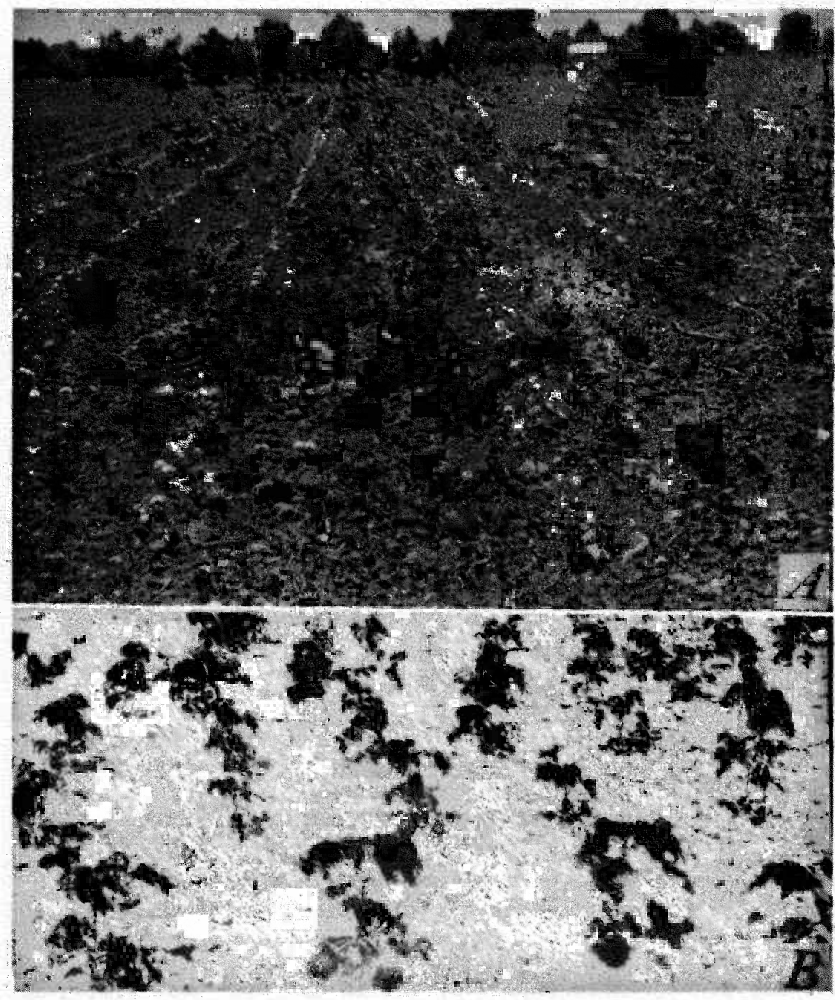

Plate IV.—A, Field of cotton on Wagner Ranch grown from acid-delinted and organic-mercury-dusted seed 10 days after planting. No angular leafspot or other seed-borne disease is found in this field. B, Even stand of cotton plants on Bauer Ranch. Field grown from acid-delinted and organic-mercury-dusted seed, 12 pounds per acre. No seed-borne disease present.

Mapping

Tree-by-tree mapping of the root-rot infected pecan orchards twice a year, June and November, has proved most valuable, from the standpoint of practical control of root rot, by furnishing accurate data on the response of trees to treatments applied and also on the progress of the disease under various types of culture.

Summary of 3 years' results

Figure 3 summarizes data obtained during 3 years (1937-39) on the number of new infections and the number of pecan trees killed each year by *Phymatotrichum omnivorum* under five different conditions of intercropping and soil treatment. The plots were 80-acre orchards containing a total of about 6,800 trees from 6 to 20 years old. Of this number 1,636 trees

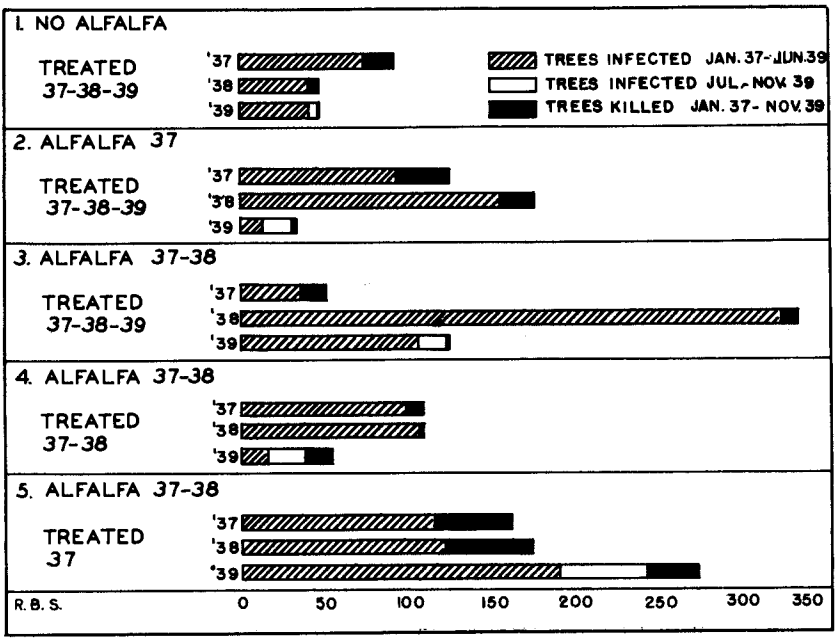

Figure 3.—Number of pecan trees newly infected or killed in 80 acres.

(24 per cent) became infected; and in the four best plots, in which infected trees were promptly treated, a total of 129 trees (1.5 per cent) died; while in the untreated plot 133 trees (10.6 per cent) died. Likewise, the small number of new infections and trees killed from June to November, 1939, in plots 1, 2, and 3 (five, twenty-one, and sixteen trees in-

fected; and one, three, and three trees killed, respectively) indicates that the disease is under control in these orchards. Most of the treatments were combinations of ammonium sulphate or ammonium phosphate (16-20) and agricultural sulphur in dosages varying from a basic treatment of 1 pound of each chemical to each 10 square feet of root area, followed by a 4-inch irrigation. The root area was treated to the drip of the branches. A 10-acre plot in a severely root-rot-infected but untreated grove that had an intercrop of alfalfa in 1937 and 1938 had 4.4 per cent dead trees in June, 1937. Two and one half years later 29.5 per cent more trees were dead and 37 per cent infected, leaving only 29 per cent apparently healthy trees.

Miscellaneous Studies

Black stem rust of wheat

The season of 1939-40 was very favorable for black stem rust (*Puccinia graminis tritici*) of wheat. Some fields were a complete loss. The strain of rust, as determined by the rust specialists in the University of Minnesota, was Race 56, the common one from northeastern Mexico to Minnesota.

Bacterial bud rot of cannas

This bud rot was recognized in Arizona for the first time in June, 1940. The parasite, a bacterium (*Phytomonas cannae*), enters the young leaves through the breathing pores when the leaves are still rolled in the bud and causes black spots. On the expanded leaves, water-soaked spots appear that become yellow to brown. Flower buds may be rotted also. Bud rot is controlled by selecting only healthy stock for planting and by care in watering.

Dodder on citrus

Dodder (*Cuscuta gronowii*) has seldom been reported on citrus in this State. Some complaints of such parasitism came in this year.

Stippen of apples

Stippen and subsequent secondary rots caused loss in stored apples in Coconino County during late fall and winter months. Small to conspicuous, somewhat sunken, discolored spots develop on the surface, mainly toward the calyx end (Pl. V, A, B). Brownish spots appear in the flesh (Pl. V, D). The spots may show on the apples when they are maturing on the tree or not until after they are stored. Tissue of the spots is dry

Plate V.—Stippen of Arizona apples: A, spots on calyx end; B, stem end of same fruit; C, blue-mold rot starts in stippen spots; D, brown, dead spots in flesh of A.

and spongy. Stippen is a physiological disease caused by a disturbance in the water relations. Some conditions that favor the development of stippen are alternating wet and dry soil; light irrigation in the early part of the growing season followed by heavy later irrigation, or light irrigation throughout the season; excessive water loss (transpiration) from the foliage. Uniform growth of the tree and its fruits reduces stippen. Baldwin and Stayman varieties are very susceptible. Secondary rots, especially blue-mold decay caused by *Penicillium spp.* (Pl. V,C), often follow stippen in stored apples and increase the loss.

Bud rot of Washington palms

This disease, referred to in the Fiftieth Annual Report of the Arizona Station (p. 92), has since been proved by isolation and inoculation studies to be caused by the fungus, *Phytophthora palmivora*. *Washingtonia gracilis* (robusta) is resistant to the rot and should be planted instead of *W. filifera* in the Salt River Valley where the disease has killed many palms.

Verticillium wilt of cotton

Verticillium (*V. sp.*) wilt of cotton, evident in many fields again this year, was fully as erratic in effect as heretofore. The disease affected the crop little or not at all in some heavily infected fields, and in other fields of the same variety it destroyed as much as 50 per cent of the yield (Pl. VI). This suggests that Verticillium fungus consists of strains varying in virulence.

Southern sclerotial rot of cotton

A new experience for Arizona cotton growers is loss from southern sclerotial rot. The causal fungus, *Sclerotium rolfsii*, attacks the cotton plant at and just below the soil line where the white fungus growth may or may not show. Sick plants may wilt suddenly, die, and become dry and brown. The gaps in rows (Pl. VII,A) thus caused may be very conspicuous. Extensive damage to cotton from sclerotial rot is new, and no control is known other than rotation of cotton with resistant or immune crops. One source of infection already found in Arizona is the decaying cotton stalks (Pl. VII,B) in the soil, plowed under from the preceding season.

Seed treatment against damping-off

Damping-off of seedlings is caused by various soil-dwelling fungi. Against the disease, disinfectant dusts applied to

seeds are often useful. Several such disinfectants were used in experiments during the year. On English seed peas, New Improved Ceresan, Cuprocide, Vasco 4, and Semesan gave percentage stands of 35, 55, 38, and 45 against 23 for the untreated seed. Results for the same disinfectants, in the same order, with sugar beet seed were 45, 48, 49, and 48 as compared with

Plate VI.—Part of a 150-acre field of Acala cotton in Arizona in which Verticillium wilt caused 50 per cent loss in yield, season of 1940.

23 for the untreated seed. Treatments of seed corn against seedling root rot, with the mentioned disinfectants, gave percentage stands of 14, 79, 83, and 84 against 81 for the control; New Improved Ceresan caused distinct injury to corn seedlings. The results of the treatment of seed corn indicate little or no benefit. Seed corn frequently contains internal parasites that are not affected by disinfecting the surface of the grain; that condition probably explains these results.

Tomato yellows

Yellows, a virus disease formerly called western yellow blight, is the worst disease of tomatoes in Arizona. The virus is carried from sick to healthy plants by the beet leafhopper.

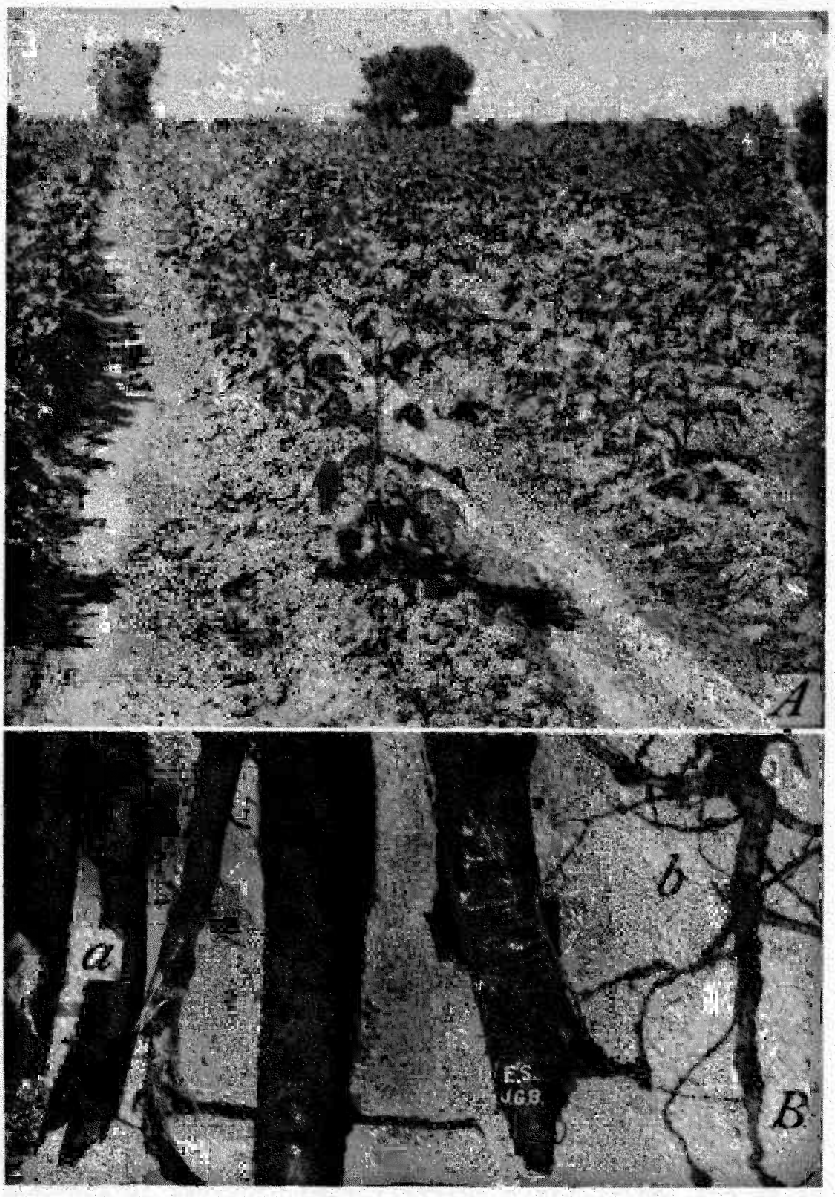

Plate VII.—Southern sclerotial rot (Sclerotium rolfsii) on Acala cotton: A, gaps in rows caused by the disease; B, a, fungus filaments and sclerotia on decaying stalks in soil and b, roots of plant with both the rot and root knot.

Although it has long been known that screening out the leafhopper from tomato plants prevents yellows, tomato growers in this State still suffer heavy or total loss of the crop. For demonstration and to determine approximate cost of screening, experiments were conducted in Yavapai County with Earliana, Rutgers, and Valiant varieties. Summarized results follow.

Earliana and Valiant plants grown from seed (sowed May 1) under hot caps that were removed on May 23, leaving the plants exposed were all killed by yellows; 90 per cent of the Rutgers variety grown in exactly the same manner were also killed. Plants of the three varieties that were covered with hot caps until June 10 were not killed by yellows, but 6.6 per cent of the Earliana plants were markedly affected by the disease at maturity, and stunting was evident in all three varieties.

Another lot of tomato plants was grown under cheesecloth in the greenhouse and immediately covered with cheesecloth tents upon transplanting to the field on May 23; the tents were removed on June 10. The varieties named above were used. Approximately 98 per cent of the plants matured and only the Valiant variety (10 per cent) showed symptoms of yellows.

A third lot of tomato plants was reared in the greenhouse under cheesecloth, transplanted to the field on May 23, and continuously kept under cheesecloth tents until the fruits were harvested. The plants remained absolutely free from yellows as was to be expected. The cost of cheesecloth for screening tents was $2\frac{1}{2}$ cents per plant.

Control tomato plants grown under cheesecloth in the greenhouse, transplanted to the field on May 23 and left unprotected, were mostly (81.4 per cent) dead by August 1.

The experiments plainly indicate that tomatoes can be grown in Arizona without loss from yellows. Protected plantings should prove profitable in a state that imports most of its tomatoes.

Bacterial rot of lettuce

Bacterial slimy rot of lettuce (*Erwinia carotovora*) was prevalent in some fields of the Salt River Valley in February and March, to the extent of 95 per cent infection, mostly in preheading and heading stages. Occasionally slime and watery brown rot (*Sclerotinia sclerotiorum*) occurred in the same field. Application of copper-containing disinfectant dusts did not appear to reduce the incidence of infection.

A new storage rot of grapefruit

During April, 1399, an apparently undescribed rot occurred in Arizona grapefruits held in cold storage. The only external symptoms were a blackening and loosening of the button and a

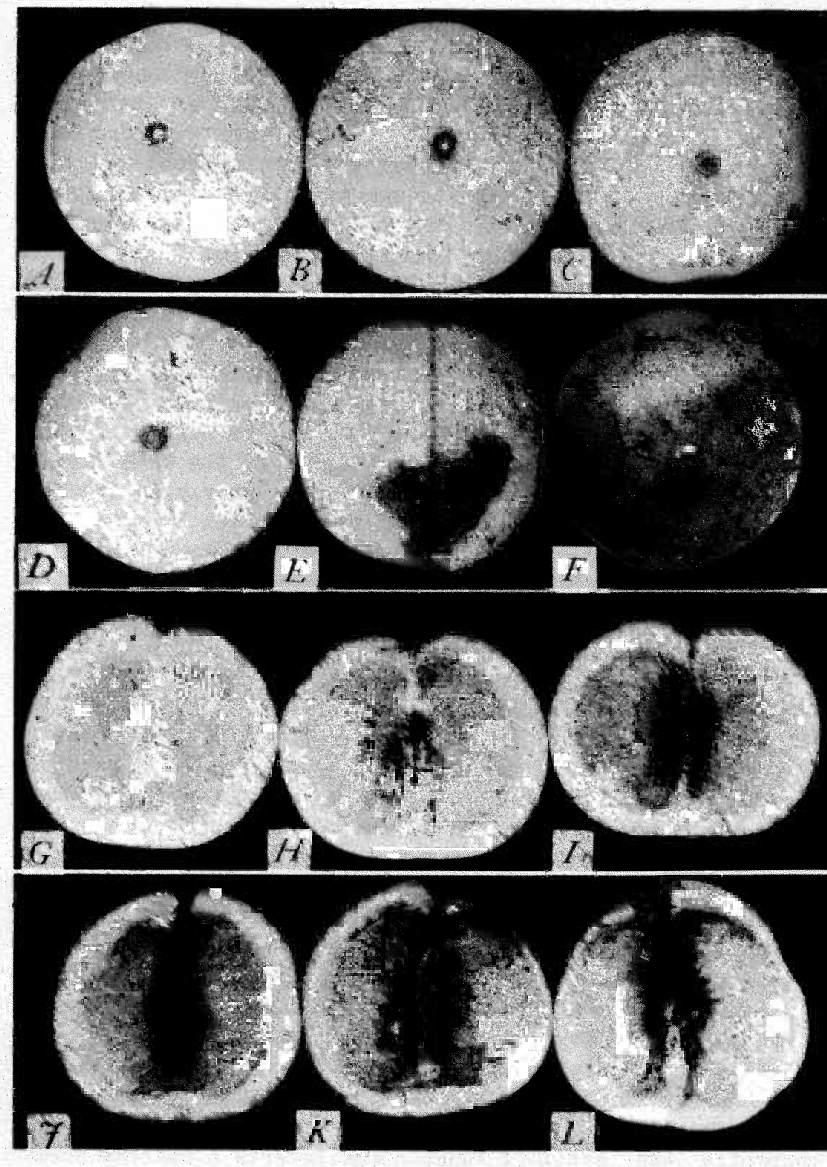

Plate VIII.—Stem-end and sectional views of internal black rot of grapefruit caused by Alternaria citri developed during and following cold storage: C and G, healthy fruit; A, B, and D, infected fruit showing only slight darkening and/or shedding of button and a brassy color; H and I, vascular discoloration and black rot in infected fruit in cold storage; E and F, leathery brown surface rot developing in infected fruit on removal from cold storage; J, K, and L, extensive internal decay following removal of infected fruit from storage.

slight "brassy" color of the peel, but longitudinal sections revealed, in early stages of the disease, a browning of the vascular bundles at the stem end. Intermediate stages, which developed within 7 to 14 days after removal of fruit from storage, showed a dark brown rot involving several of the segments (Pl. VIII). In advanced stages the peel was also affected by a pliable, dark-brown rot which eventually enveloped the entire fruit (Pl. VIII). All stages were accompanied by a mild to decidedly unpleasant flavor which pervaded the entire fruit. No external sporulation was observed, but the discolored tissues within the fruit were filled with the dark mycelium and muriform spores of *Alternaria citri*. The difficulty of detecting and removing all infected fruit in the packing house rather than the small percentage of fruit infected makes the disease worthy of note.

The end rot of the naval orange, caused by the same fungus, was at least twice as prevalent in Arizona groves in the fall of 1939 as in average years, but the storage rot in grapefruit was less in 1940 than in 1939, due largely to care in the selection of fruit which promised a good cold-storage life.

Bacterial necrosis of the giant cactus

A disease of the giant cactus (*Carnegiea gigantea*) has been present in southern Arizona for many years. The cactus is an attraction for winter visitors and an aid in selling tracts of land for winter homes. Recent demands of suburban residents and realtors for information concerning the death of giant cacti have required attention; therefore, the disease has been investigated. It is a bacterial rot or necrosis.

Symptoms of the bacterial necrosis are circular, pale spots on the trunk and branches that have a water-soaked margin. Tissues under the surface of the spot become discolored brown to black and decay. Rapid destruction results in the exudation of a dark colored, watery ooze that is absent in slower decay. Eventually the "flesh" falls from the cactus, leaving the more or less nude skeletal framework. Before this stage is reached, however, the weakened trunk may be broken off by wind. In denser growths of the giant, a weakened cactus (Pl. IX) frequently leans until it touches and infects a healthy plant.

Control measures for bacterial necrosis of the giant cactus can be suggested only for early stages of the malady. Plants on small estates should be watched for the appearance of decayed spots, which should be immediately cut out. The wound should then be disinfected and coated with a water-soluble asphalt paint. Badly diseased cacti and fallen plants should be destroyed. Until the carrier of the disease germ is found, no more can be done to restrict the spread of necrosis.

Dry Root Rot of Citrus

Dry root rot continues to be the one root disease of citrus of commercial importance. The 20-year-old grove of tangerines treated in March, 1938, continues to show improvement, except that one tree treated with manure applied in trenches died suddenly in March, 1940. Many of the trees, both treated and untreated, are not bearing normal crops or desirable sizes of fruit, and two trees in each treated plot and two check trees were pruned under direction of the Department of Horticulture. Approximately one third of the tops was removed to stimulate the production of new fruiting wood and commercial sizes of the fruit.

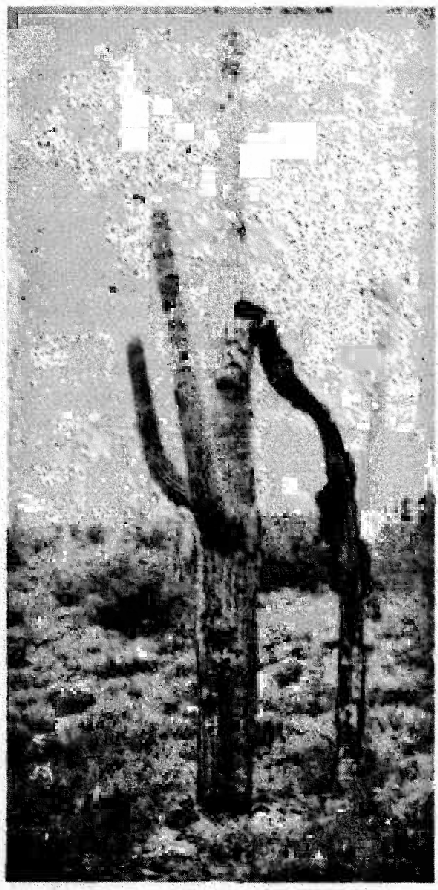

Plate IX.—Bacterial necrosis of the giant cactus (Carnegiea gigantea). The diseased cactus on the right leaned against a healthy cactus and broke off the small branch on the latter. Necrosis then started in the second plant; now it has numerous decayed spots and is "bleeding" from the base.

A 7-acre grove of Valencia oranges suffered a severe outbreak of dry root rot last fall, resulting in the death of fifty-two trees, while twenty-two additional trees were definitely infected and thirty-two more suspected of being infected. Treatments similar to those found effective in treating Phymatotrichum root rot were applied in basins and by pressure injection on December 14-15. Most of the treated trees showed improvement, but none of the untreated trees showed any recovery, and many of them became worse. A number of trees on rough lemon root showed no infection, and this understock is being thoroughly tested for resistance to dry root rot. If resistant,

lemon rootstock will be of great value in replanting groves where trees have been lost from dry root rot.

A preliminary survey of the citrus areas shows that dry root rot and possibly other root diseases are increasing, and in June, 1940, a project (Purnell No. 222) was approved for the study of citrus root diseases and their control.

Diseases unusually prevalent

Likewise noteworthy was the prevalence during 1939 of virus diseases of summer squash and other cucurbits in Cochise County; psyllid yellows of potato in Navajo and Greenlee counties; and scaly bark and dry root rot of citrus and big-vein of lettuce in Maricopa County.

New diseases reported

The following are believed to be the first reports from the State of Arizona of the diseases named on the host plants given: curly-top virus on spinach from Greenlee County; covered kernel smut and bacterial blight of sorghum on perennial Sudan grass, rust on yellow-flowered alfalfa, and root-knot nematode on *Menodora scabra* and *M. scoparia*, all from Pima County.

Plant disease survey

A total of approximately 300 cards recording plant disease inquiries and service calls was made during the fiscal year.

POULTRY HUSBANDRY

Poultry Feeding

That phase of poultry feeding regarding the utilization of locally produced grains in the ration has been completed. The data are being compiled at this time.

A second problem was undertaken on October 1, 1940. This involved the use of citrus meal and cottonseed meal in poultry laying rations. Five pens of White Leghorn pullets are being used. One lot receives 7.5 per cent citrus meal, another 11.3 per cent meal. The third pen gets a ration containing 5 per cent cottonseed meal, while the fourth receives 10 per cent cottonseed meal in the diet. The final pen serves as a check.

The Effect of Back Crossing and Reciprocal Crosses On Egg Production in Offspring

The routine work of this project is about completed. It is hoped that the completed manuscript will be ready before next fall.

Developing Strains of Chickens Resistant to Pullorum Disease and to Range Paralysis

Two breeds are being used in this study, the Rhode Island Red and the White Leghorn. Routine work in blood testing and checking mortality is continuing.

Environmental Factors and Their Effect on the Natural Egg Cycle

This project is being conducted in individual hen batteries. One group has access to an ordinary room without temperature or light regulation. The other is subjected to relatively constant temperature and is always under artificial light. Ventilation is supplied by means of fans.

This is a continuation of work that has been in progress. It is felt that valuable information regarding air conditioning of poultry houses in Arizona may assist in retarding the effect of adverse summer temperatures.

APPENDIX

ANALYTICAL SERVICE

The Department of Agricultural Chemistry and Soils analyzes all types of materials such as soils, irrigation water, and miscellaneous products for farmers of the State without charge. The number of samples and the character of the materials analyzed during the past fiscal year are given in Table 19.

TABLE 19.—COMPILATION OF ANALYSES MADE IN THE DEPARTMENT OF AGRICULTURAL CHEMISTRY AND SOILS.

	Tucson Laboratory	Phoenix Laboratory
Soils	942	869
Waters	332	697
Plant materials	875	609
Feeds	55	56
Fertilizer and manure	21	76
Minerals including gypsum	72	34
Milk	51	---
Poison	---	21
Miscellaneous	486	13
Total	2,834	2,375

ARIZONA EGG LAYING CONTEST

Due to the great demand for this medium of information, five additional houses were built last summer, each house containing two pens. Demands in the office at this writing would be sufficient to assure filling all thirty pens next fall, inasmuch as the breeders of Arizona are given first choice of space until July 1, and a call has not yet gone out to them. Many of the applications at hand will have to be refused.

SOIL SURVEY

Each year the Agricultural Chemistry and Soils Department co-operates with the Soil Survey Division of the Bureau of Plant Industry and the Soil Conservation Service in making a soil survey of some area in the State where the land is cultivated or where development is expected. During the winter of 1939-40 the northern half of the Sulphur Springs Valley,

commonly called the Willcox area, was surveyed. The area contains approximately 250 square miles. The report and map which will result from this survey will form the basis for choosing the best lands in the area for further development.

The report of the Casa Grande area which was surveyed in 1936 was edited, and a table was developed which indicates in general the relative value of six groups of soils into which the 130 types and phases in the area were divided. Special attention is called to the deep tillage practices which have been developed in the area to promote water penetration and to create a more favorable physical condition in the soil. By following these practices on soils which would otherwise produce about 100 pounds of cotton per acre, the yields during the past few years have been increased to well over 500 pounds per acre.

SUMMARY OF STATION PUBLICATIONS

TECHNICAL BULLETINS

No. 82.—Factors Influencing the Availability of Native Soil Phosphate and Phosphate Fertilizers in Arizona Soils, by W. T. McGeorge. 36 pages. Data are presented on a chemical test for available phosphate in calcareous soils—namely, extraction with carbonic acid—and the application of the Neubauer test for available phosphate in soils. There is a slight increase in phosphate absorption by plants grown on calcareous soils when soluble magnesium salts are present. Carbonic acid increases the absorption of phosphate by plants, and calcium carbonate reduces it. As for the efficiency of the various forms of phosphate fertilizer, bones and phosphate rock are of little or no value; calcined phosphates when ground to 100-200 mesh are fair; but best results are obtained with soluble phosphate, such as ammonium phosphate and treble superphosphate. The new T.V.A. calcium metaphosphate was found to be excellently suited to calcareous soils.

No. 83.—Distribution and Activity of Azotobacter in the Range and Cultivated Soils of Arizona, by W. P. Martin. 34 pages. This bulletin is a survey of the distribution of azotobacter in Arizona soils and the factors influencing their distribution and activity. Ninety-four samples of cultivated soils and 119 samples of range soils were examined. Azotobacter were found in 87 per cent of the cultivated but in only 22.7 per cent of the range soils. Multiple regression statistics showed that the sodium and calcium content of the soil

solution was closely associated with the activity of the organisms in the cultivated soils.

No. 84.—Some Effects on Animal Nutrition of the Ingestion of Mineral Oil, by Margaret Cammack Smith and Harry Spector. 26 pages. Experimental evidence shows that continuous ingestion of mineral oil by rats and dogs in amounts comparable to the therapeutic dose often recommended for human consumption interferes with the utilization of both vitamins A and D. Vitamin A reserves in the livers of both the rats and dogs receiving mineral oil, if present at all, were lower than found in the litter-mate animals given no mineral oil. The young of female rats reared on rations containing mineral oil possessed smaller stores of vitamin A and were correspondingly less able to withstand subsequent deprivation of vitamin A as indicated by an earlier break in resistance to respiratory infections and shorter survival periods on a vitamin-A-free regime. Mineral oil ingestion interfered with the utilization of vitamin D fed separately as cod-liver oil to rats and dogs to such an extent that three times as much cod-liver oil was necessary to induce healing of the rachitic lesions of rats when the base ration contained 5 per cent mineral oil, and somewhere between five and ten times as much was needed when 10 per cent mineral oil was incorporated in the base ration.

No. 85.—Fertilization of Lettuce on Alkaline-Calcareous Soils: Soil and Plant Studies, by W. T. McGeorge, M. F. Wharton, and W. A. Frazier. 52 pages. A study of several years on lettuce fertilization is reported in this bulletin. Studies were conducted on: changes in plant food availability in soils during the growth of lettuce; the chemical composition of the plant at different stages of growth; the plant food requirements of the lettuce plant; effect of fertilizers on yield and quality of lettuce; and the efficiency of different methods of fertilization.

No. 86.—The Life History and Ecology of the White-throated Wood Rat, Neotoma Albigula Albigula Hartley, in Relation to Grazing in Arizona, by C. T. Vorhies and W. P. Taylor. 77 pages. Economically, the wood rat may be rated as: (1) harmful, in consuming grass, as a nuisance about habitations, damaging range forage or cultivated plants, disseminating cactus and harboring blood-sucking insects; grass, however, constitutes but 4.79 per cent of the total food and is not a principal item at any time; (2) neutral, in food habits, its principal foods being not only abundant but even overabundant on some ranges; or (3) beneficial, as an aid to planting, in aeration and fertilization of the soil, as a food supply for man and valuable fur animals, or as a pet. Increase

of the white-throated wood rat appears to be an effect rather than a cause of overgrazing—an "animal weed." Its principal foods are the cactus and mesquite which ranchmen are actually being paid to remove in some areas; hence, it cannot consistently be rated as injurious.

No. 87.—The Groundwater Supply of the Eloy District in Pinal County, Arizona, by G. E. P. Smith. 42 pages. A quantitative study of the ground water supply during the years 1936-39 inclusive, to determine the diminution of the stored supply each year and the quantity which could be pumped annually without depleting the stored supply. The latter quantity was found to be of the order of 20,000 acre-feet per year. The quantity pumped in 1937 and also in 1939 was about 60,000 acre-feet. The method of investigation was unique. Volumetric measurement of the ground unwatered must be based on a ground water year from February to February, since the water table has depressions and ridges during the pumping season but is smoothed in February if there is very little pumping in winter.

GENERAL BULLETINS

No. 167.—American-Egyptian Cotton: Utilization, Supplies, and Prices, by E. H. Pressley, Rodney Whitaker, and George W. Barr. 39 pages. That portion of the domestic cotton textile industry utilizing extra-staple cotton wants high quality cotton in adequate, dependable quantities. SxP, a comparatively new variety of American-Egyptian cotton, seems to compare favorably in character with imported Egyptian varieties and has been found satisfactory by thread-yarn spinners. In this respect SxP seems to be superior to Pima but the extra-staple length of Pima cotton is preferred by certain manufacturers of fine yarns. This is notably true among mills manufacturing products advertised as containing Pima cotton. The bulletin discusses the chief uses for American-Egyptian cotton, also supplies and prices.

No. 168.—Second Annual Report of the Arizona Feed Control Office, 48 pages. A report of the second year's work on inspection and analyses of stock and poultry feeds in Arizona. It is composed principally of a tabulation of all the feeds registered in the State and their chemical analyses as compared with the guarantees registered by the manufacturers. Eight hundred eighty-three feeds were registered and 541 samples were collected and analyzed. Twenty-two brands of cottonseed meal were registered and forty-four samples were collected and analyzed. Twenty-five mineral feeds were registered and seven collected and analyzed.

No. 169.—Second Annual Report of the Arizona Fertilizer Control Office. 7 pages. This report of the second year's work on inspection and analyses of commercial fertilizers in the State is devoted principally to a tabulation of the fertilizer brands registered in the State and a comparison of the analyses of fertilizer samples with their registered guarantees. The number of fertilizers registered was ninety-three and the number analyzed sixty-nine.

No. 170.—Rations for Fattening Cattle in Arizona, by E. B. Stanley and A. H. Walker. 20 pages. Results are given of cattle feeding tests conducted at the Salt River Valley Experiment Farm at Mesa from 1930 to 1936. A total of five feeding tests is included in this study, four of which are devoted chiefly to a comparison of roughage feeds, alfalfa hay, hegari silage, and cottonseed hulls.

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TABLE 20.—CLIMATOLOGICAL SUMMARY FOR THE UNIVERSITY WEATHER STATION, 1939

	Jan.	Feb.	Mar.	Apr.	May	June
Highest temperature...	80	78	89	95	100	107
Lowest temperature....	26	25	28	40	49	55
Mean temperature.....	50.4	45.5	59.2	67.2	74.0	82.6
Mean temperature, 63 years.....	49.2	52.3	58.3	64.4	72.4	82.3
Total precipitation (inches).....	0.35	1.60	0.69	0.04	0.00	T
Mean precipitation (63 year av.).....	0.79	0.87	0.78	0.48	0.22	0.30
No. days with 0.01 in. or more precipitation.....	2	7	4	3	0	0
No. clear days.....	15	15	15	19	24	26
No. partly cloudy days	10	4	6	5	6	2
No. cloudy days.....	6	9	10	6	1	2
Av. ground velocity of wind (m.p.h.)....	1.10	1.03	0.99	1.21	0.82	1.08
Av. velocity of wind on roof of Agr. Bldg. (m.p.h.).....	7.2	7.2	7.0	7.8	6.8	7.4
Evaporation (inches)..	3.132	3.061	6.483	8.752	10.792	13.181
Relative humidity, 8 a.m.	64	65	64	38	27	27
Relative humidity, 12 m.	39	37	31	20	14	17
Relative humidity, 5 p.m.	33	38	26	17	11	13

	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Highest temperature...	106	104	104	92	91	85	107
Lowest temperature....	69	65	49	42	35	24	24
Mean temperature.....	87.2	84.6	79.4	67.5	62.2	56.2	68.0
Mean temperature, 63 years.....	86.7	84.6	79.9	69.0	57.6	50.4	67.2
Total precipitation (inches).....	0.61	1.24	1.53	0.18	0.54	0.27	7.05
Mean precipitation (63 year av.).....	2.28	1.93	1.11	0.53	0.95	1.04	11.28
No. days with 0.01 in. or more precipitation.....	5	9	6	3	3	2	44
No. clear days.....	16	12	17	24	17	20	200
No. partly cloudy days	12	15	8	4	6	7	85
No. cloudy days.....	3	4	5	3	7	4	60
Av. ground velocity of wind (m.p.h.)....	1.26	1.07	1.23	1.28	1.21	0.51	1.06
Av. velocity of wind on roof of Agr. Bldg. (m.p.h.).....	7.7	6.5	7.7	7.5	8.0	5.0	7.14
Evaporation (inches)..	12.188	10.237	8.409	7.146	4.214	2.476	90.071
Relative humidity, 8 a.m.	46	61	54	43	53	60	50.2
Relative humidity, 12 m.	27	37	35	25	33	31	28.8
Relative humidity, 5 p.m.	25	36	34	22	34	31	26.7

TABLE 21.—FINANCIAL STATEMENT, 1939-40, 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	$12,422.56	.....	.....	$102,422.56
State appropriations:							
Main station.....	.....	.....	.....	.....	.....	$ 90,695.45	90,695.45
Substations.....	.....	.....	.....	.....	.....	29,782.10	29,782.10
Balance and receipts from sales.....	.....	.....	.....	.....	$3,734.96	.....	3,734.96
Total receipts.....	$15,000.00	$15,000.00	$60,000.00	$12,422.56	$3,734.96	$120,477.55	$226,635.07
DISBURSEMENTS							
Salaries.....	$14,800.48	$10,358.73	$40,003.77	$ 9,310.54	.....	$ 65,772.94	$140,246.46
Labor.....	199.50	2,404.06	4,460.20	587.73	$ 852.65	19,299.53	27,803.67
Stationery and office supplies.....	.....	22.36	81.96	86.39	1.38	1,009.98	1,202.07
Scientific supplies, consumable.....	.....	552.94	3,709.33	234.36	28.33	1,666.48	6,191.44
Feeding stuffs.....	.....	.....	1,108.94	11.21	.....	526.61	1,646.76
Fertilizer and irrigation water.....	.....	17.50	691.28	.....	.85	1,879.43	2,589.06
Sundry supplies.....	.....	60.35	424.31	49.26	.....	2,342.62	2,876.54
Communication service.....	.02	14.15	51.84	39.90	12.19	1,361.07	1,479.17
Travel expense.....	.....	1,380.00	2,708.07	1,217.75	394.58	2,941.44	8,641.84
Transportation of things.....	.....	15.45	111.74	3.86	.....	231.74	362.79
Publications.....	.....	.....	1,660.33	255.84	29.81	1,664.08	3,610.06
Heat, light, water, and power.....	.....	.....	431.61	32.63	12.99	700.34	1,177.57
Furniture and fixtures.....	.....	.....	252.41	113.27	446.38	1,230.45	2,042.51
Library.....	.....	.....	.....	18.00	.....	46.05	64.05
Scientific equipment.....	.....	166.80	3,600.18	288.50	.....	.....	4,055.48
Tools, machinery, and appliances.....	.....	2.75	33.12	116.08	7.14	390.90	549.99
Livestock.....	.....	.....	63.45	19.00	.....	.....	82.45
Feed experiments and poultry contests.....	.....	.....	.....	.....	.....	16,604.98	16,604.98
Buildings and land.....	.....	.....	593.95	38.24	.....	349.38	981.57
Contingent expenses.....	.....	4.91	13.51	.....	23.19	2,459.53	2,501.14
Unexpended balance.....	.....	.....	.....	.....	1,925.47	.....	1,925.47
Total disbursements.....	$15,000.00	$15,000.00	$60,000.00	$12,422.56	$3,734.96	$120,477.55	$226,635.07