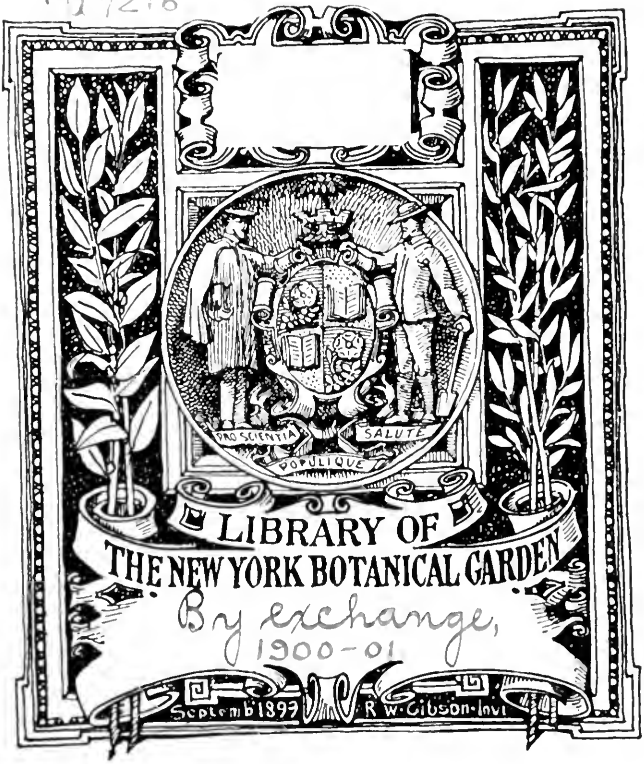
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The University of Arizona Agricultural Experiment Station

An Inquiry into the Cause and Nature of Crown-Gall

By J. W. TOUMEY

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AN INQUIRY INTO THE CAUSE AND NATURE OF CROWN-GALL.

By J. W. Toumey.

INTRODUCTORY.

In December, 1892, C. M. Woodworth[1] called attention to fleshy outgrowths occurring in California on the roots of deciduous fruit trees. As these outgrowths usually appear at the crown, the name crown-gall was applied to this strikingly characteristic disease. Several theories were advanced by Professor Woodworth to account for the disease. It was briefly described, and short comparisons were made between it and various root-galls and knots produced by known causes.

Professor Wickson, in an introductory note to the above account, wrote as follows:

"Almost everything imaginable has been cited as a probable cause; conditions of drouth or of excessive moisture were among the earliest causes assigned, and some prejudice against nursery stock grown by irrigation was created. An investigation by a committee of the State Horticultural Society about 1880 showed that the knotted roots were found quite as abundant in unirrigated land as in irrigated, and otherwise the inquiry yielded no definite results. For some time many nurserymen followed the practice of removing the knots from the trees as dug from the row, but this was abandoned when it was found that the knot commonly reappeared after planting in the orchard. At present no reputable nurseryman sells such trees; they are burned at the nursery.

"Probably during the last 20 years hundreds of thousands of such trees have spindled and died in the best soil and with the best treatment. If the disease has stunted the growth of a young tree, pluck it out and plant a new one. If knots are found on larger trees which are making satisfactory growth in spite of them, remedial measures should be tried. The final

[1] Bull. Cal. Agr'l Exp. Sta., **99** (1892).

result seems to depend upon whether the natural or the diseased growth secures the ascendency early in the life of the tree, for apricot trees have been taken up after 30 years of satisfactory growth and bearing and found to have roots badly infested with the knots."

PUBLISHED ACCOUNTS RELATING TO CROWN-GALL.

The writer's attention was first called to this disease in 1893, when many observations were made in infested orchards in the Salt River Valley. As the result of these investigations, a preliminary report was published.[2] In this report the disease was described under the name of crown-knot. Attention was called to the seriousness of the disease in the Salt River Valley. Some of the more characteristic features regarding its development were pointed out and possible corrective measures were given.

Various names have been applied to these outgrowths by different authors. Although Woodworth first used the term crown-gall to designate the disease, he later used the term crown-knot.[3] Orchardists frequently speak of the disease under the name of black-knot and root-knot, but as these names are in common use to designate other well-known diseases and outgrowths they had best be discarded in speaking of this disease. Erwin F. Smith, in writing regarding it in 1894, also uses the term crown-gall.[4] He, however, discusses these excrescences or outgrowths on the stems and roots of plants under the general title "Stem and Root Tumors." Bailey uses the name root-galls in his publication regarding the swellings.

So far as the writer is aware, all more recent publications on the subject have been under the name crown-gall. As this term is applicable to the disease and is not likely to be confusing, it is adopted in this bulletin in preference to crown-knot used by me in my previous writings on this subject. Although public attention in the United States was first directed to this disease in 1892, and then only in California, it has since been recognized in nearly every fruit-growing region in this country. The more important reports regarding it have appeared during

[2] Bull. Ariz. Agr'l Exp. Sta., **12** (1894).
[3] Rept. Cal. Agr'l Exp. Sta. 1894-'95, 231.
[4] Jour. Myc., VII, 376. (Field notes, 1892.)

the past eight years and in the following States, viz: California, Arizona, Texas, New Jersey, New York, Michigan, Alabama, and Ohio. Woodworth,[5] Wickson,[6] and W. E. Smith[7] have published regarding it in California; Toumey[8] in Arizona; Yates[9] and Price[10] in Texas; Halsted[11] in New Jersey; Atkinson[12] and Bailey[13] in New York; Taft[14] in Michigan, and Selby[15] in Ohio. Dr. Erwin F. Smith[16] has also called attention to this disease in various publications. Atkinson, Selby, and Bailey consider the disease the same as the Wurzelkropf which occurs in Germany and other European countries. Sorauer[17] discusses the foreign disease at some length and concludes that it is not caused by the action of a parasite, but by some disturbing influence occasioned by the short cutting or bending of the roots of the plant when transplanted or by the abnormal development of adventitious buds, possibly induced by an unusual flow of sap.

Sorauer's description certainly corresponds in many particulars with the disease as it is in Arizona, and the figures which accompany his description fairly well illustrate the crown-gall as known in America. The following quotations, translated from Sorauer's work, are descriptive of crown-gall:

"The swellings appear generally at the crown of the roots of young trees, the enlargements having the size of hazelnuts or walnuts. In older specimens they may attain the size of

[5] Bull. Cal. Agr'l Exp. Sta., **99** (1892); Ann. Repts. 1892–'94, 436, and 1894–'95, 231.

[6] Bull. Cal. Agr'l Exp. Sta., **99** (1892).

[7] Cal. Fruit Grower (December 15, 1894, 481).

[8] Bull. Ariz. Agr'l Exp. Sta., **12** (1894); Ann. Rept. 1899, 235; Timely Hints for Farmers, **5** (1899).

[9] Cal. Fruit Grower 1895, 111.

[10] Bull. Texas Agr'l Exp. Sta., **39**, 841 (1896).

[11] Repts. Bot. N. J. Agr'l Exp. Sta. 1895, 359; 1896, 413; 1898, 354; Bull. Torr. Bot. Club, XXIV, 509.

[12] National Nurseryman (August, 1893).

[13] Bulls Cornell Agr'l Exp. Sta., **74**, 383; **117**, 367.

[14] Rept. Mich. Agr'l Exp. Sta. 1897, 96.

[15] Bulls. Ohio Agr'l Exp. Sta., **79**, 108, 127, 139; **92**, 208, and **104**, 211; Rept Ohio State Hort. Soc., **29**, 75.

[16] Jour. Myc., VII, 376; Bull. Torr. Bot. Club, XX, 363.

[17] Handbuch der Pflanzenkrankheiten, I, 737 (1896).

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one's fist. When they appear upon nursery stock they are usually limited to the crown, but occasionally are found deeper in the earth, or even upon slender one-year-old roots. The color of the gall is similar in its younger stages to that of the sound root. Later a dark color appears, in consequence of a deposit of dead matter, which forms the bark of the gall. If one examines the galls occurring upon the smaller roots, it will be seen that they are generally located upon one side of the root body. They have a softer tissue than the root, but their color within is normal. The large galls are a series of hemispherical growths superposed upon each other so that the surface has an irregular or warty appearance. In the spring the more prominent of these elevations have a light-brown appearance and a perfectly herbaceous consistency. In cross-sections the galls show an irregular fibrous mass."

Although Sorauer observed that the disease appeared much more frequently in certain nurseries than in others, and that the prevalence of its attack and the season of its appearance indicated a parasitic origin, he was led, on account of not being able to find the parasite, to consider it not a true infection, but as the probable result of mechanical injury.

Although I have considered the disease described by Sorauer and the various American authors as one and the same, it is possible from my experiments that we may have under consideration a number of closely allied diseases affecting various host plants and caused by true parasites, as will be seen later. It is further possible that the swellings described by Sorauer are caused, as he suggests, by mechanical injury. However, I suspect, from his description of the excrescences and their close comparison with the disease as it occurs in Arizona, that it also is of parasitic origin. So far as I can learn no experiments were made by Sorauer or other European investigators in order to ascertain its communicability.

OPINIONS REGARDING THE COMMUNICABILITY OF CROWN-GALL.

The general opinion of orchardists is that the disease is a true infection and spreads from tree to tree. They have come to this conclusion from observing its general behavior in the field. Most investigators that have given attention to it, having failed to find either an animal or vegetable parasite which would account for it, and not attempting to ascertain the readiness with which it can be communicated from one tree to another, have tried to account for the outgrowths in other ways rather than by infection. Nearly all investigators, however, have observed that its appearance in certain orchards and in certain portions of orchards, and more particularly in definite restricted areas in nurseries, is suggestive of parasitic origin. Selby, Woodworth, and Halsted have each had the disease under observation for several years, and have called attention to the probability of its communicability, but have, for the most part, refrained from making positive statements regarding it. Halsted,[18] by planting peach pits in soil with minced galls from the peach, found that the seedlings when seven months old were much more badly infested than similar seedlings grown in the same kind of soil without the minced galls. His experiments, however, were defective, in that he obtained some diseased trees among the check plants. I quote, however, the following as his conclusions:

"The results point to the conclusion that the peach crown-gall is decidedly contagious, and with the seedlings surrounded with minced peach galls the affection is almost certain to appear and in a violent form."

Selby[19] in his experiments transplanted a number of healthy peach trees to within about eight inches of a diseased peach tree of same age, and found that 25 per cent. of the healthy trees became affected during the first two seasons, while a number of healthy trees transplanted at the same time in similar soil, but not in the vicinity of diseased trees, remained at the end of the two seasons in perfect condition. His conclusions are as follows:

"In so far as present light enables one to judge, the conclusion that the crown-gall is a contagious disease appears to be warranted."

Woodworth frequently calls attention to the apparent conta-

[18] Rept. Bot. N. J. Agr'l Exp. Sta. 1895, 413.
[19] Bull. Ohio Agr'l Exp. Sta., **92**, 213.

gious character of the disease, and, in one of his later reports,[20] writes as follows:

> "Under every condition of soil, climate, and host plant the disease has the same characteristics and to be always and immediately distinguished from other forms of hypertrophied plant tissue. This fact is to be explained upon no theory other than that it is caused by the attacks of a particular organism."

Yates[21] and Lelong are the only experimenters with this disease, of whom I am aware, that conclude that the disease is not a true infection. As Lelong's experiments were not duplicated and were not tried under varying conditions, it is very probable that if tried at different seasons and with varying conditions they would have shown the communicability of the disease. Yates attempted to communicate the disease by budding and grafting, but without success. From the nature of the disease, this is to be expected. He also attempted to produce the disease by inoculation, but with no better success. His conclusions are somewhat in accord with those of Sorauer in his description of Wurzelkropf in Germany. Bailey[22] is inclined to accept this statement of the case, and in his account of the disease in New York concludes as follows:

> "The conclusion of the whole matter, then, as we now understand it, is that these root-galls are not the work of a parasite, but are a malformation following some injury of the root or some uncongenial condition in soil or treatment. The galls may seriously interfere with the nutrition of the plant, in many cases causing it to become weak and sickly. It is probable that the trouble is not communicable, and that cutting off the gall averts further trouble from that source. As a precautionary measure, however, we much prefer to plant only trees with perfectly clean and normal roots."

GEOGRAPHICAL DISTRIBUTION OF CROWN-GALL IN THE UNITED STATES.

In the fall of 1897 I addressed the following letter to each of the experiment stations in the United States in order to ascer-

[20] Rept. Cal. Agr'l Exp. Sta. 1894–'95, 231.
[21] Cal. Fruit Grower 1895, 111.
[22] Bull. Cornell Agr'l Exp. Sta., **117**, 375.

tain the prevalence of crown-gall in various parts of the country and what experiments had been made regarding it :

TUCSON, ARIZONA, *October 25, 1897*.

DEAR SIR : In giving some study to the crown-gall, I desire to know something in regard to its distribution and the work that has been done or is being done upon it at other stations. If prevalent in your State, will you kindly inform me what plants it is found infesting, and what has been done to counteract its injury. I will be pleased to receive anything that you have published on the subject.

Very respectfully,

(Signed) J. W. TOUMEY.

The replies received indicate that the disease was known and considered of more or less injury in the following States : New York, Connecticut, Massachusetts, New Jersey, Pennsylvania, North Carolina, South Carolina, Alabama, Florida, Georgia, Mississippi, Ohio, Michigan, Wisconsin, Iowa, Missouri, Nebraska, New Mexico, Arizona, California, Oregon, and Utah. Its widespread dissemination has been more fully recognized during the past two years, and without doubt it is now known in most of the other States.

SOME STATEMENTS OF OTHER OBSERVERS REGARDING CROWN-GALL.

The following excerpts taken from letters of various correspondents give a general expression regarding the disease throughout the country :

"Crown-gall is quite widely disseminated in Florida, but is not severe in fields generally. In new land it is almost or quite unknown, but upon old land that has been farmed indiscriminately trees are often badly affected with this disease. We find it most severe on peach trees."—P. H. ROLFS.

"Crown-gall is not doing much damage in Missouri, so far as I know. I have seen it on a few apple trees in the nursery, but it was not severe enough to impair their growth."—J. C. WHITTEN.

"The crown-gall is quite widely distributed in the eastern States. I do not hear of it to any great extent elsewhere. However, I recall that peach-growers have complained of this gall being upon young trees which they received from as far south as Georgia. These galls grow upon the apple and peach in particular, and it is not unlikely that if large numbers of trees were examined that the whole group to which the peach belongs would prove to be host plants for the disease."—B. D. HALSTED.

"Crown-gall is very abundant in Alabama on the peach, and is sometimes found on the plum. I consider it a very serious peach disease in Mississippi and Georgia, as well as in this State."—F. S. EARLE.

"The crown-gall is present in Ohio. It affects apple, pear, peach, poplar, and raspberry. It is reported to me upon plums and cherries, but I have seen no examples. One peach orchard in Ottawa county, two years planted, is now about 50 per cent. dead or affected with crown-gall. This is the worst case known to me at present. In most cases the disease has apparently come upon stock from the South and East."—A. D. SELBY.

"The crown-gall occurs in California on all our deciduous fruit trees and on grapes. It has been very abundant and serious, but I have not heard as much complaint regarding it during the past two years as usual."—C. W. WOODWORTH.

"The crown-gall occurs commonly on peaches in Connecticut. My predecessor, Dr. Thaxter, believed that he had established the contagious character of the trouble by means of green-house culture of sound plants in proximity to others infested with crown-gall."—W. C. STURGIS.

"The crown-gall is just now turning up in several places in Michigan. Our attention has recently been directed to extensive destruction of nursery stock in certain localities, due to this cause. Last week a nursery at Bangor, Van Buren county, was inspected and fully 25 per cent. of the trees were found infested."—C. F. WHEELER.

FIELD EXPERIMENTS IN THE SALT RIVER VALLEY.

My own investigations, aside from field observations, date from the spring of 1896. At this time a series of experiments was begun in a badly infested almond orchard at Glendale. This orchard comprised forty acres, the trees all being of the same age and practically uniform in size and general appearance. The field experiments in this orchard extended over a period of three years and were directed toward an effort to ascertain the communicability of the disease and the effect of various fungicides and corrective measures upon it.

In February, 1896, the first experiments were begun. The orchard was a square forty. The trees were set twenty feet apart and were five years from the nursery. Probably 85 per cent. of the trees were more or less badly infested with crown-gall. The soil was rather heavy, but uniform in character throughout the orchard, and the surface practically level. In order to make the work of as general an average as possible, two rows of trees were selected for the experiments, one being diagonal to the other. Row 16, counting from the east side of the orchard and extending north and south, was examined and the diseased trees treated with a fungicide. The work was begun at the north border of the orchard and forty consecutive trees of the above row examined. At the fortieth tree the diagonal row extended to the northwest, thirty-one trees being examined and treated.

A detailed record was kept of the condition and general appearance of the seventy-one trees examined, as the crowns were uncovered and the surface roots exposed. Photographs were made illustrating exactly the condition of many of the trees and a record was made of the number, size, and position of the galls on the surface roots and crowns. Of the forty trees examined in row 16 thirty-four were more or less badly diseased. Twenty-three of the thirty-one trees in the diagonal row were also affected.

The diseased trees in row 16 were treated as follows: The crown was exposed by carefully moving the soil. The exposed galls were all removed and the wounds treated with Bordeaux mixture. Afterward a coating of tar was applied and the earth filled in about the trees. The trees in the diagonal row were treated in a similar manner, with the exception that the wounds were coated with paint instead of tar.

These trees were examined in April and September, 1896; February and May, 1897; September, 1898, and when the orchard was visited in November, 1899, the trees that remained alive were being cut down and burned. As the complete history of each tree during the three years cannot be entered into, I present the records that I have regarding a few of the treated trees and the conclusions that the experiments seem to justify.

HISTORY OF SOME OF THE TREES TREATED WITH BORDEAUX MIXTURE.

No. 11. This specimen was a large and apparently thrifty tree when examined, February 26, 1896. However, when the crown was exposed one gall two inches in diameter and nearly spherical was found on the northwest side of the crown, about six inches beneath the surface. Several small galls were also found in inaccessible places beneath the larger roots. The exposed gall was cut away, care being taken to remove it in its entirety. The other galls were only partially removed. The wounds made in removing the galls were liberally treated with the fungicide and later coated with tar.

When examined the latter part of April it was found that the scar caused by the removal of the gall from the crown had dried over, and a healthy growth of callus tissue had begun to inclose the wound. The deeper-seated galls had begun to form a quantity of rapidly growing diseased tissue at the point of union of the old galls to the roots. In September of the same year the callus tissue previously noted had continued to develop until the wound was nearly covered. However, at one side on the callus a young gall was rapidly forming. This gall could not have been more than three or four weeks old, and probably was the result of reinfection of the young tissue of the callus by the parasite in the soil. The deeper-seated galls had continued to grow during the summer and were larger than the ones removed in February. The tree was badly diseased and worthless when cut down, in the fall of 1899.

No. 46. This tree (Fig. 1) had a number of large galls almost completely surrounding the bole a few inches below the surface, the rapid development of which during the previous year had so checked the growth that practically no new wood had formed. The tree was in abundant bloom, as if making a great effort to fruit before succumbing to the destructive action of the gall. A large gall on the north side penetrated to the heart of the tree, and less than one and one-half inches of the entire circumference showed healthy growth. The galls, so far as possible, were cut away and the fungicide and tar applied.

When examined in April and later in September the tree was still alive and appeared better than when treated. The treatment seemed to have checked the rapid progress of the disease, although it reappeared in several places during the

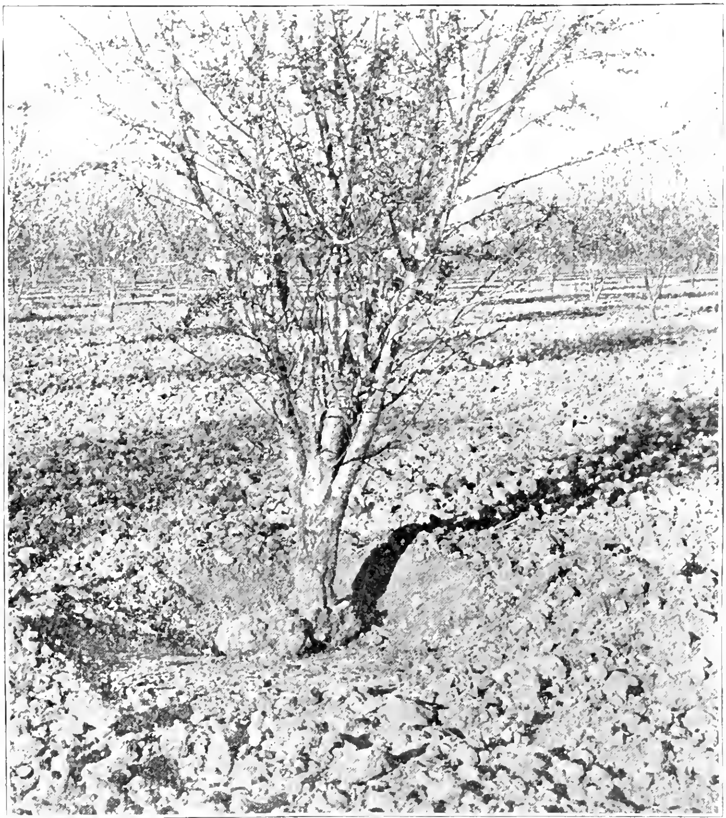

FIG. 1.—Five-year-old almond tree in the Glendale orchard, showing large galls almost completely surrounding the crown a few inches below the surface. The earth removed so as to expose the galls.

fall. The crown was so weakened that the tree broke off at the surface of the ground during a brisk wind the following winter.

No. 23. On examination a very small gall was found on the northeast side of the crown of this tree. A small lateral root on the east side was also badly infested. The small gall was removed February 26, 1896, and the diseased root completely cut away. The fungicide and tar were applied as in previous examples. At the time of the second examination, two months later, no evidences of returning galls were observed. In September, five months later, the gall had reappeared where the root had been cut away, and several new galls had developed on adjacent roots. The wound on the crown had completely healed. Normal callus tissue had entirely covered the wound made in removing the gall. The following year the tree was badly diseased and probably beyond remedy. The tree died during the summer of 1898. The evidence regarding the other trees treated is practically a repetition of the examples cited.

EFFECT OF BORDEAUX MIXTURE ON THE DISEASE.

The results that I obtained from these experiments seem to indicate that the Bordeaux mixture at its normal strength is at best but a poor remedy for the disease. This, however, will be more fully discussed under the subject of remedies and preventive measures.

OBSERVATIONS ON SEEDLINGS IN THE GLENDALE ORCHARD.

In February, 1898, I made a personal examination of a large number of seedlings in the Glendale orchard.[23] These seedlings were the result of almonds dropping from the trees and becoming covered with soil at times of cultivation. Not infrequently from fifty to seventy seedlings were growing under a single tree. These seedlings were only a few months old and from six to thirty inches high. I examined some four hundred of them and did not find a single plant infested with crown-gall when growing under trees which were free from the disease. On the other hand, under one badly diseased tree, five diseased seedlings were dug up within twelve inches of the bole of the tree. On this tree the disease formed large excrescences at the surface of the ground. In other cases one or more diseased seedlings were

[23] See Ann. Rept. Ariz. Agr'l Exp. Sta. 1899, 238.

found under infested trees. However, in most instances only a small percentage of the seedlings growing under diseased trees had galls upon them. This freedom was probably due to the fact that the seedlings were usually growing at some distance from the boles of the trees where the galls most frequently develop, and likely had not as yet come into contact with the contagion from the old trees.

A few seedlings of more than a year's growth were found in making this examination. A larger percentage of these were diseased than of the seedlings that germinated and grew during the previous summer. It is likely that many of the younger seedlings, which at this time showed no evidence of galls, would develop them at the beginning of the growing season, the coming spring. It appeared that the conditions in the orchard were not so favorable to the communicability of the gall as the conditions in the green-house, where the moisture was much more uniform.

The percentage of diseased to perfect seedlings growing under the old trees is strikingly shown in the diagram made to illustrate this point (Fig. 2). Although a comparatively small number of the seedlings examined were diseased, their position in relation to the galls at the crowns of the old trees is very significant.

A similar examination of seedlings in this orchard was made December 21 of the following year. At this time about nine-tenths of the trees had been dug up, those remaining being, for the most part, adjacent to irrigation ditches. It was observed at this time that most of the badly diseased trees had very few, if any, seedlings beneath them. It is possible that they had been previously killed by the action of the disease. At the time of this examination one hundred and twenty-five seedlings were dug from beneath the branches of diseased trees. As the results obtained were practically identical with those of the previous year, I do not present them in schematic form.

I took occasion to examine the excavations from which one hundred and thirty trees had been removed, and failed to find a single one free from fragments of galls broken from the roots when the trees were taken out.

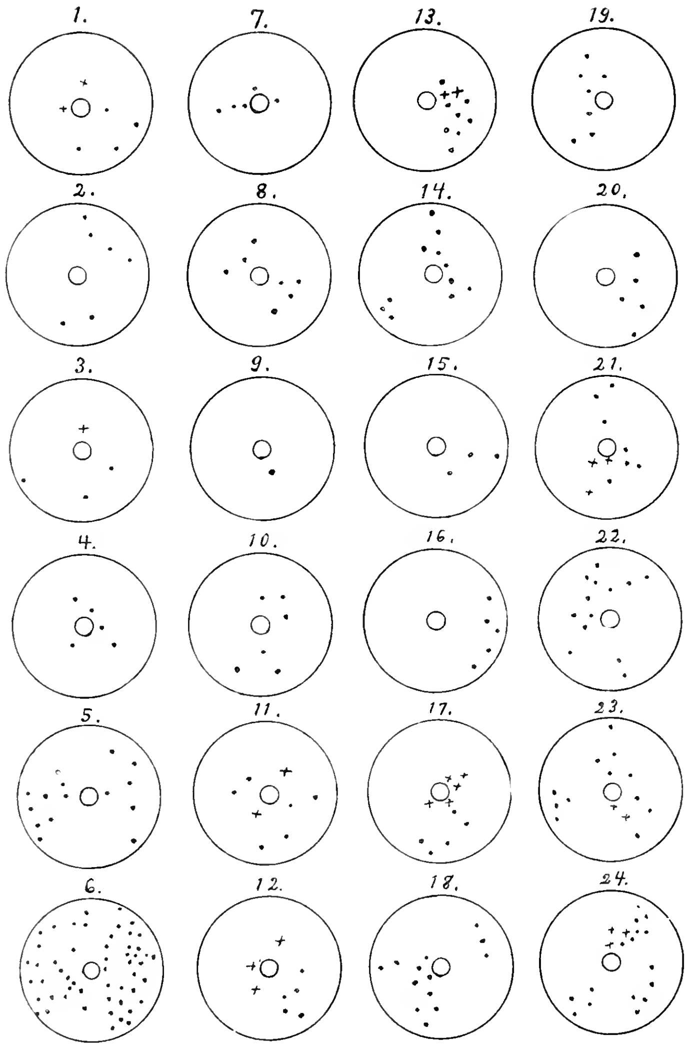

FIG. 2.—Diagram showing almond seedlings growing under old diseased trees in the Glendale orchard. The small central circles represent the old trees; the dots indicate the position of undiseased seedlings, and the crosses seedlings with galls upon them. The outer circle represents an area six feet in diameter.

EXPERIMENTS IN INOCULATING SOIL WITH MINCED GALLS IN 1897–1898.

In conjunction with the experiments carried on at Glendale a series of indoor experiments was begun in November, 1897. These experiments were all conducted in the station green-house at Tucson.

November 24 two hundred almond seeds were planted in good, porous soil, uniform in texture. The seeds were placed in scalding water for a few moments prior to planting, in order to facilitate germination, and then planted in plots on floor benches, as outlined in the diagram.

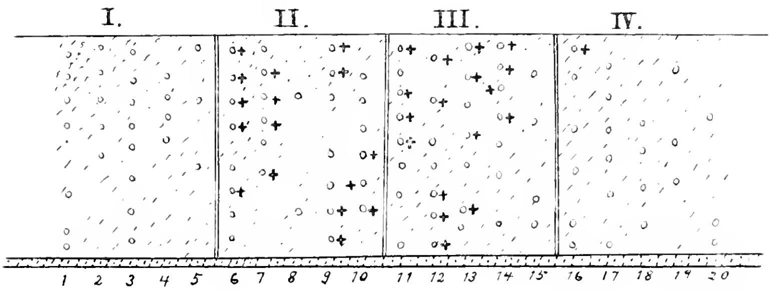

FIG. 3.—Diagram representing the number and position of diseased and undiseased almond seedlings grown in the green-house in 1897–1898. The small circles represent the position of the seedlings and the crosses the diseased trees.

The four plots were separated from each other by eight-inch boards, set on edge and buried six inches in the soil. Fifty seeds were planted in each plot, there being five rows with ten seeds in each row. A number of the seedlings damped off soon after coming up, and a few others died during the summer. As those that died were pulled up and destroyed by the gardener during my absence, I was unable to ascertain whether they died from the effect of crown-gall.

Plot I was planted without previous treatment of seeds or soil. The purpose of this plot was to act as a check to the other three. When the seeds were planted in plot II a number of galls obtained from the Glendale orchard were cut into small pieces and buried in the soil with them. The galls used in these experiments were of various sizes and ages; some were fresh and succulent, while others were dry and partially decayed. Plot III was treated in the same manner as plot II, with the exception that the minced galls were mixed with an equal weight of flowers of sulphur before placing in the soil. Plot IV was also treated the same as plot II, with the exception that the galls were mixed with one-half their weight of bluestone (copper sulphate) and enough water added to partially dissolve the fungicide.

At the end of eleven months the seedlings were harvested and the results tabulated. At this time there were twenty-seven seedlings in plot I, twenty-nine in plot II, thirty-three in plot III, and twenty-two in plot IV. The results are represented in the following table, and the position of the diseased seedlings is schematically shown in Fig. 3:

No. of plot.	Treatment.	No. of diseased trees.
I	Untreated	0
II	Several pounds of minced galls	16
III	Minced galls and sulphur	17
IV	Minced galls and bluestone	1

At the time of harvesting the seedlings were from two to three feet high and the stems a half inch or less in diameter. In most instances the galls appeared at the crown and were from one to three inches in diameter (Fig. 4).

In digging the seedlings from plot III it was observed that the sulphur was still abundant in the soil. In several instances galls were found that were partially surrounded by flowers of sulphur, and in all cases they were as vigorous as those that grew in the non-sulphured soil. In the sulphured plot one more diseased tree was found than in plot II, where no fungicide was used. The results of my experiments with sulphur seem to be in accord with those of Selby,[24] but are at variance with those of Halsted.[25]

[24] Bull. Ohio Agr'l Exp. Sta., **104**, 211.

[25] Rept. Bot. Dept. N. J. Agr'l Exp. Sta. 1896, 414.

In plot IV but one diseased seedling was found, and that in the extreme corner adjacent to the plot treated with sulphur. The results with this plot certainly suggest the value of bluestone as a remedy.

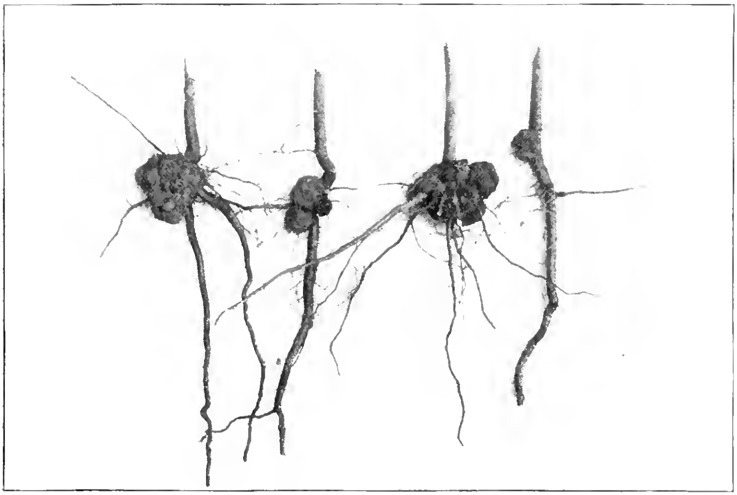

FIG. 4.—Diseased almond seedlings resulting from inoculating soil with minced galls in 1897–1898.

EXPERIMENTS IN INOCULATING HEALTHY SEEDLINGS BY MAKING INCISIONS THROUGH THE BARK AND INSERTING BITS OF THE YOUNG GALL, 1897–1898.

Twelve of the seedlings grown in plot I of the previous experiments were cut back to within three inches of the surface of the ground and reset in the same plot in which they grew. Before resetting a small incision was made at the crown of each plant, and a bit of young gall, carefully removed from the interior of a growing specimen, was inserted. These seedlings were reset October 24, 1898, and on examination a month later ten of them had rapidly developing galls at the places where the incisions were made. November 30 of the same year four perfect seedlings were cut back and reset as before. The incisions, however, were made both at the crown and at a

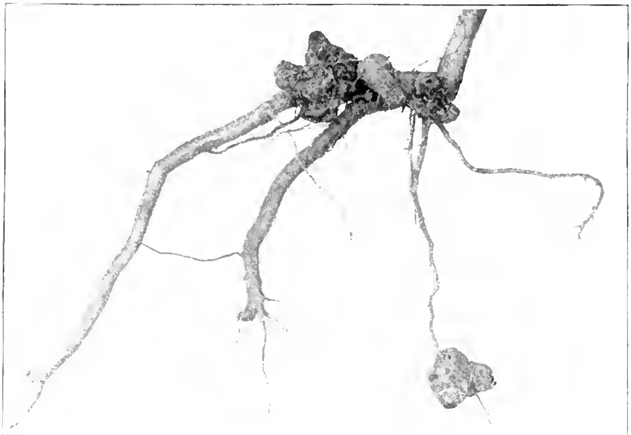

FIG. 5.—Diseased almond seedling resulting from inoculating a healthy seedling by making an incision through the bark and inserting a bit of fresh gall tissue. A small lateral root shows a large gall completely surrounding it, which developed later.

point fully three inches above the ground on the stem of the tree. Four similar seedlings were also inoculated at the crown with bits of a blackened, decayed gall placed beneath incisions made at the crown.

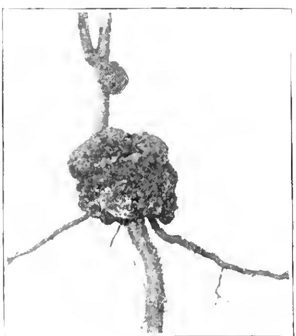

FIG. 6.—Diseased almond seedling showing two galls, both the result of making incisions through the bark and inserting bits of gall tissue. The larger gall developed at the crown, under ground; the smaller one on the stem, two or three inches above the surface of the soil.

The twenty seedlings above noted were left undisturbed until November 10, 1899, when they were again pulled up and examined. Without a single exception all were badly diseased. The old gall seemed to be as effective in producing the disease as the young tissue. In every case galls had developed at the places where the incisions were made. In many instances, however, galls developed deeper down on the roots as well. It is probable that the galls which appeared at places where no incisions were made were caused by the spreading of the infection from the points inoculated. At each of the inoculations above ground galls appeared, but they were not so large as those below the surface of the soil.

AN EXPERIMENT WITH WATER CULTURES.

In December, 1898, two healthy seedlings were cut back to small cuttings and placed in jars partially filled with water. Incisions were made at the crown a few inches above the water. These jars were kept in the laboratory for two months, the water was changed about twice a week, and as the room was kept at a fairly low temperature the growth of the plants was not seriously disturbed. Nineteen days after inoculation the first evidences of the gall became visible on one of the plants. In another week the gall was fully four millimeters in diameter. The gall on the other plant did not become apparent until the twenty-sixth day. These galls grew rapidly, and, as they were not in contact with water or moist soil, they were comparatively free from saprophytic fungi, and provided excellent material for microscopical study. One of the seedlings, six weeks after inoculation, is illustrated in Fig. 7.

FIG. 7.—Almond seedling grown as a cutting in water culture, showing a developing gall six weeks after inoculation

EXPERIMENTS IN INOCULATING SOIL WITH MINCED GALLS IN 1898–1899.

Although the experiments with seedlings in the green-house the previous year clearly indicated the infectious character of the crown-gall, the almond was the only tree experimented with. As the disease occurs upon a great variety of trees, a series of experiments were undertaken in 1898 in order to ascertain if the disease occurring on the almond could be communicated to the peach, apricot, apple, grape, and other plants. I also desired to duplicate my experiments of the previous year and to vary them somewhat before drawing definite conclusions respecting the communicable nature of the disease. Therefore, on January 5, 1898, thirty-four rows of various seeds were planted in the green-house in freshly prepared soil. Twenty-five seeds were planted in each row, unless otherwise stated, and the seeds used, with the exception of those planted in rows 6 to 11, inclusive, were obtained from non-infested plants. Rows 1 to 5, inclusive, were planted with almonds. The purpose of this planting was that the resulting seedlings might serve as a check on other plantings, and that healthy seedlings might be secured for inoculation experiments the coming fall. Rows 6 to 11, inclusive, were also planted with almonds. The seeds used for these rows were, however, obtained from a badly diseased tree and were not allowed to come in contact with the soil in the orchard before collecting them. Rows 12 and 13 were planted with apricots, and rows 14 and 15 with peaches, all under normal conditions. Rows 16 to 22, inclusive, were planted with almonds. In rows 16 to 19, inclusive, about one quart of minced galls from the Glendale orchard was mixed with one-half pound of bluestone and placed in the rows with the seeds which were planted as in the experiments of the previous year. In every instance boards were placed between the rows, representing different conditions of planting and soil infection. In rows 20 to 22, inclusive, minced galls were mixed with one-fourth their weight of a mixture of bluestone, copperas, and quicklime in the following proportions, namely: Two parts of bluestone, one part of copperas, and three parts of quicklime.

The bluestone and copperas were crushed to a fine powder, thoroughly mixed with the lime after slaking, and enough water added to form a paste. This paste was mixed with the minced galls and placed in the drills with the seeds. Rows 23 to 25, inclusive, were planted with almonds; 26 and 27 with peaches; 28 and 29 with apricots; 30 and 31 with English walnuts; 32 with prunes; 33 with grapes, and 34 with apples. Minced galls from the Glendale orchard were placed in the drills with the seeds in all the rows from 23 to 34, inclusive.

As in the previous year, a portion of the seedlings damped off soon after coming up. A sufficient number, however, remained alive to give value to the experiment. They were

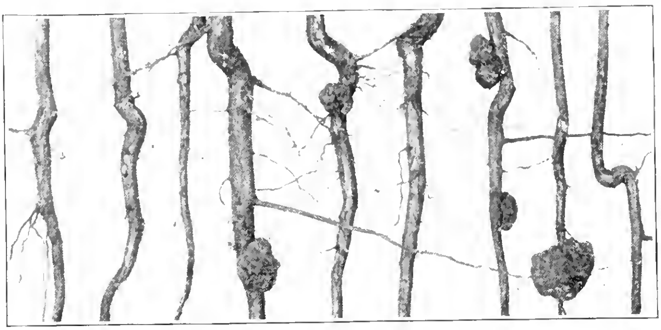

FIG. 8.—Almond seedlings from a single row, showing the relative number of diseased to undiseased trees, in soil previously inoculated with minced galls.

harvested October 26, 1899. The thirty-seven trees obtained from rows 1 to 5, inclusive, had no galls upon the roots or stems. The eighty-three trees which grew in rows 6 to 11, inclusive, also showed no galls upon them, and as the seeds from which these trees grew were obtained from a tree with badly diseased roots it clearly shows that the infection is local and cannot be carried by the seed. This inference is confirmed by the recent experiments of Halsted. No galls were found on the nine apricot and eleven peach trees grown in rows 12 to 15, inclusive. Only three plants with galls upon the roots were found among the nineteen trees which grew in rows 16 to 19, inclusive, which were treated to minced galls and bluestone, while only one diseased tree was found among the twenty-four trees which grew in rows 20 to 22, inclusive, which were treated to minced galls and the mixture of bluestone, copperas, and quicklime.

Twenty-three of the forty-two trees obtained from rows 23 to 29, inclusive (almond, peach, and apricot, treated with minced almond galls), were badly infested with crown-gall. The percentage of diseased trees was in the order of almond, apricot, and peach, the peach being the least diseased of the three. Fig. 8 is a photographic reproduction of all the trees in row 25 in the order in which they grew.

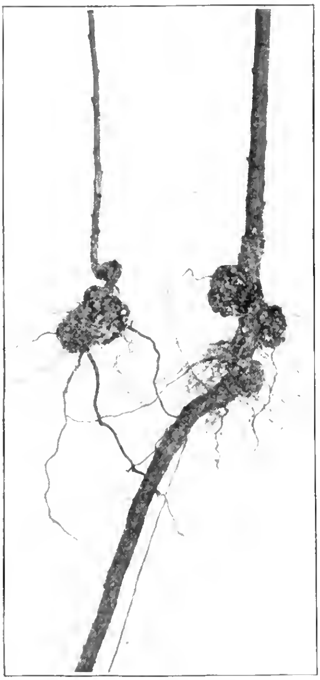

FIG. 9.—Diseased almond seedlings grown in pots of crushed quartz, in which were placed small pieces of the gall.

No galls were found upon the fourteen specimens of English walnut which grew in rows 30 and 31, the nineteen seedling grapes obtained from row 33, or the seven apple seedlings from row 34, although each row received an equal quantity of the minced galls. The prunes failed to germinate. An indefinite number of seeds were planted in rows 33 and 34, but the greater number did not germinate.

EXPERIMENTS IN GROWING SEEDLINGS IN POTS FILLED WITH CRUSHED QUARTZ.

In January, 1899, six large pots, each containing about one-half cubic foot of finely crushed quartz, were planted with almonds. The almond seeds used for planting were carefully removed from the shells and ten seeds planted in each pot. In three pots minced galls were placed with the seeds when planted. When harvested, in November, 1899, no diseased seedlings were obtained from among the sixteen plants in the check pots, but sixteen of the twenty seedlings which grew in the pots in which the soil was inoculated with minced galls were diseased. Two seedlings from one of these pots are shown in Fig. 9. November 8, 1899, eight seedlings in one of the check pots were cut back to within two inches of the ground and incisions made at the crown of each in order to ascertain if excessive pruning or injury at the crown would cause the galls to develop. New growth immediately began to develop and the wounds healed over in the course of a few weeks, and on January 1, 1900, when last examined, all were entirely free from the disease.

SECOND SERIES OF EXPERIMENTS IN INOCULATING HEALTHY SEEDLINGS BY MAKING INCISIONS THROUGH THE BARK AND INSERTING BITS OF THE GALL.

November 10, 1899, a large number of inoculations were made by inserting bits of both old and young galls into incisions in various seedlings. Ten healthy almond seedlings were cut back and reset in the green-house. Previous to planting, incisions were made at the crown and bits of old and partially decayed galls placed therein. Ten almond seedlings were also treated in a similar manner, with the exception that fresh, young galls were used instead of old, dead ones.

As all previous experiments were made on seedlings that had been severely pruned and reset at the time of inoculation, five almond seedlings, unpruned and undisturbed in the soil, were also at this time inoculated with bits of young gall. Ten peach, ten apricot, twelve English walnut, ten grape, and five apple seedlings were also inoculated with bits of young gall from the almond.

The ten almond seedlings that had been cut back and inoculated with old galls on November 10, 1899, were examined January 1, 1900. Developing galls were found on three specimens at the places where the incisions were made. On this date six diseased trees were found among the ten inoculated with bits of young gall. The five plants inoculated without cutting back or otherwise disturbing them more than necessary in making the small incisions at the crown had all begun to develop galls at the places where the incisions were made. In two instances galls from two to four millimeters in diameter were found on the seventeenth day after the inoculation. The evidence seems to be conclusive, therefore, that severe root and stem pruning has nothing whatever to do with the development of this disease. When last examined, January 1, 1900, two of the inoculated peach seedlings and four of the apricot showed small developing galls. None were found on the walnut, grape, and apple. However, as the latter had made no growth since cutting back and replanting, it is possible that galls may develop upon them during the coming summer if they are allowed to remain in the soil. It is likely also that more of the inoculated almond, peach, and apricot trees will contract the disease.

THE EFFECT OF EXCISION OF THE GALLS AND OF THE APPLICATION OF FUNGICIDES.

Five almond seedlings with large galls at the crown were treated on November 12, 1899, by carefully removing the galls and placing a quantity of the flowers of sulphur on the wounds. In every instance the galls returned, the sulphur having no apparent effect upon them. On the same date five other almond seedlings were similarly treated, with the exception that the paste of bluestone, copperas, and quicklime was placed on the wounds. Two months later the galls had not reappeared. It is probable that the corrosive action of the mixture prevented the growth of the soft succulent tissue of the gall, and thus checked the development of the organism itself.

SOME MISCELLANEOUS EXPERIMENTS RELATING TO CROWN-GALL.

A large number of fungi, mostly, if not entirely, saprophytic, are nearly always found on the surface or in the outer portion of old galls—sometimes one fungus, sometimes another. Some, however, send their mycelium to some distance into the living hypertrophied tissue. Thinking that possibly one of these might be the cause of the disease, as suggested by the observations of Halsted,[26] four of the species (unidentified species of

[26] Bull. Torr. Bot. Club, XXIV, 508.

Torula, Polyporus, Chalara, and Pythium?) most frequently found associated with the gall were grown as pure cultures on sterilized pieces of boiled potato and the cultures used in inoculating almond seedlings. Twelve seedlings growing in the open were inoculated with these cultures, three seedlings being inoculated with each culture. In not a single instance were galls obtained during the period of observation, which covered nine months. In some instances, however, there was considerable decay at the places where the incisions were made, but no hypertrophied tissue developed.

FIG. 10.—Characteristic galls produced on the roots of an almond seedling by the action of the common gall-forming nematode worm.

Nematode worms are frequently found associated with the old galls. This is particularly true of seedlings grown in the green-house and subject to overwatering. As it has been suggested by Selby[27] that these worms possibly account for the disease, a careful study was made of the species found associated with the gall in order to ascertain, if possible, their relations to it. At least three species were found. Two of these were undoubtedly free-living nematodes, one of which agrees with a free-living Rhabdites figured and described by Stone and Smith.[28]

A number of these worms were separated from the partially decayed tissue forming the outer portion of the gall, washed through several changes of distilled water, and transferred to a piece of partially decayed wood. The wood was placed in a pot containing several small almond seedlings growing in crushed quartz. Two months later no galls were found upon

[27] Rept. Ohio State Hort. Soc., **29**, 75; Bulls. Ohio Agr'l Exp. Sta., **79**, 112; **92**, 214.

[28] Bull. Mass. Agr'l Exp. Sta., **55**, 16.

the seedlings, although the worms in the decayed wood had increased in number to a marked degree.

The other nematode observed was the common gall-forming species, *Heterodera radicicola*. In a few instances the galls formed by this worm and the crown-gall were associated together in the same specimen. The galls, however, are very distinct and cannot ordinarily be mistaken for each other. In Fig. 10 the galls formed by this nematode are shown on the roots of an almond seedling. A description of this worm and its effect upon the peach has been published by Atkinson.[29]

PLANTS SUBJECT TO CROWN-GALL.

Although at present I am unable to state that all plants upon which these characteristic galls appear are of identical origin, it is reasonable to expect that if not they are caused by nearly related parasites. No matter upon what plants the galls appear, they are always readily distinguished from all other forms of hypertrophied tissue.

Personally I have found the crown-gall upon the peach, apricot, almond, prune, plum, apple, pear, English walnut, and grape, and have examined specimens from Arizona, California, New Mexico, and Utah. Further east it is reported as infesting the raspberry, blackberry, cherry, and poplar, as well as the plants named above. I am informed by W. W. Ashe that it is indigenous in South Carolina on the chestnut, and that it frequently kills the trees.

Although I have repeatedly succeeded in communicating the disease on the almond to the apricot and peach, I have not succeeded in communicating it to the English walnut, apple, and grape, either by soil inoculation or by incisions through the bark. Halsted's[30] experiments indicate that the galls on the raspberry have no power to induce the formation of galls on the peach. On the other hand, Selby[31] concludes from his experiments that the disease can be communicated from the raspberry to the peach. The question whether the galls found on

[29] Bull. Ala. Agr'l Exp. Sta., **9** (1889).

[30] Rept. Bot. Dept. N. J. Agr'l Exp. Sta. 1896, 414.

[31] Bull. Ohio Agr'l Exp Sta., **92**, 214.

all the plants cited above are caused by the same organism or by closely related parasites still remains unsettled.

THE STRUCTURE AND DEVELOPMENT OF THE GALL.

The crown-gall is usually annual in its period of growth. The galls ordinarily begin their growth in the spring and mature in the fall. Those, however, which begin to develop late in the summer or during the fall months nearly always in this climate continue their growth throughout the winter, even when the normal tissue of the tree is dormant.

Specimens of nine months old almond seedlings having young galls upon them no larger than small peas were heeled in in October, and when these plants were removed, in the latter part of February, just as the buds were beginning to start, the galls averaged more than a half inch in diameter.

FIG. 11.—Seedling almond one-half natural size, showing a large gall with small pustules of fresh, hypertrophied tissue developing on its surface.

Seedlings from one to six months old are most susceptible to the disease. When trees of this age are attacked the gall almost invariably appears along the side of the main root a few inches below the surface or in the region of the crown. With more mature trees the root-galls often develop at a greater depth, but most frequently on lateral roots. The crown is also commonly attacked on large trees.

Two or three days after a gall first becomes visible to the naked eye it is a clear, white, translucent mass of soft succulent tissue a millimeter or less in diameter and usually nearly or quite spherical in shape. It is most frequently attached to the root by a narrow neck one-half or one-fourth of the diameter of the body of the gall. If it appears on the parts above ground or on a seedling in water culture, so that the light has access to it, after a time it changes to light green from the development of chlorophyl in some of its outer cells. Its growth is surprisingly rapid. When kept in a water culture for purposes of observation the increase in size can be readily recognized from day to day. In a month's time a rapidly developing specimen may grow from a scarcely discernible speck on the side of the root to a body more than a quarter of an inch in diameter.

At first the gall has a uniforn outer surface, but after a time it becomes somewhat warty from unequal growth. Under adverse conditions the growth may be checked for a time, but if this continues the outer portion begins to assume a reddish brown color, which gradually darkens and extends over and through the entire gall. Decay soon sets in and the whole of the hypertrophied tissue falls away or can be readily broken from the root. Early in its life the surface of the gall loses its white appearance and darkens to a reddish brown, probably from the disorganization of the contents of the outer cells and the action of various species of saprophytic fungi upon them. After any portion of a gall has changed color that portion has lost the power for further growth. Specimens are occasionally observed where a new growth begins as clear transparent globular pustules in hundreds of places on the surface of a large gall (Fig. 11). In such instances the places immediately under the new growths retain their normal whiteness, while the remainder of the surface is discolored to a considerable depth.

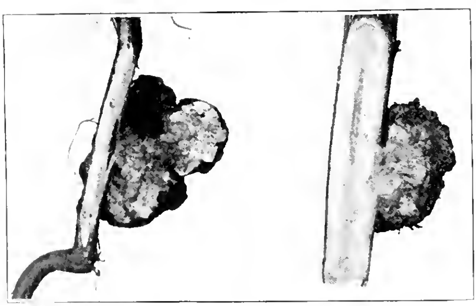

FIG. 12.—The root and stem of an almond seedling, cut longitudinally so as to show the gall attachment.

Figs. 12 and 13 show sections through both stem and root with galls attached. In these specimens the galls have completed their growth and the outer portions have begun to discolor to greater or less depths. These illustrations are excellent examples of the mode of attachment of fair-sized galls to the roots and stems.

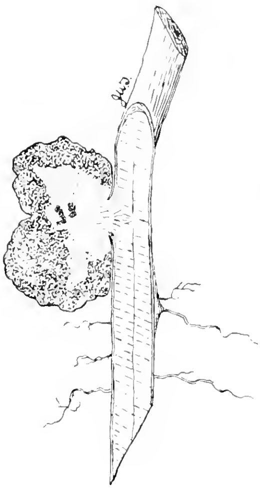

FIG. 13.—A longitudinal section through the crown of an almond seedling and attached gall, showing the darkened, discolored outer portion of the gall tissue a short time after growth had ceased.

FIG. 14.—A portion of the stem of a seedling almond, twice natural size, showing the returning hypertrophied tissue after excision of the gall.

When the gall decays, as it usually does at the end of the season's growth, it leaves an open wound through the bark, which extends for some distance into the wood. The following spring a more or less interrupted circle of gall tissue begins to form around the margin of the wound caused by the gall of the previous year. The wound becomes larger and deeper with each succeeding year, until finally it so weakens the stem that the tree breaks off. I have observed trees from nine inches to a foot or more in diameter upon which galls had begun to develop on opposite sides of the crown in early life, and which were so injured that a stick could be thrust completely through the tree from side to side. If a gall be removed during the first season of its growth, it will not only immediately begin to reappear around the margin of the wound, but over the central portion as well (Fig. 14.) On account of the greatly accelerated growth of some portions of the gall over others, many

FIG. 15.—Photo-micrograph showing a transverse section through an almond root with gall attached. The section is from a point a little to one side of the center of the gall and shows the margin of the outbursting cambium (× 20).

surface areas, where the growth has been arrested, become infolded; hence a section through a normal gall will almost invariably show small patches of broken and irregular brownish cells that originally were on the surface, but have been left behind and completely covered by the rapid growth of the surrounding tissue.

The almond seedling possesses a well-developed root system, comprising a strong tap-root, from which numerous laterals arise. The root is protected by a rather thick layer of cork. The first effect of the organism causing the disease is probably upon the phellogen meristem, which forms the cork, from whence it rapidly passes by means of intercellular spaces through the cortical parenchyma to the true cambium zone beneath. This view is entertained from the fact that the surface of the gall is never protected by cork or true epidermis, but the large parenchyma cells, with their enormous intercellular spaces, which form the outer portion of the gall, are directly exposed to the soil and the numerous saprophytic fungi usually found in decaying vegetable matter.

FIG. 16.—Same as Fig. 15, with the exception that the section is through the center of the gall and showing the central region of the outbursting cambium (× 20).

Again, when the gall first begins its development there is a pushing outward of a small area of the true cambium, which is transformed into large hypertrophied parenchyma cells, as shown in Figs. 15 and 16, which represent transverse sections across a small root having a fair-sized gall over a region of previous injury.

In its youngest stages the tissue of the gall is a mass of parenchyma with numerous minute areas of rapidly dividing meristem scattered through it. The areas of meristematic tissue are centers of growth (Fig. 17.), and probably originate in the outbursting of the normal cambium, stimulated by the growth of the parasite. As the galls become older these centers of growth increase in size and others originate in the newly formed parenchyma. The centers of these growths ultimately become most curiously twisted nodules of tracheides and woody fibers (Fig. 18). These nodules in their early growth are entirely surrounded by meristem tissue, and this tissue is in turn surrounded by parenchyma; thus it is entirely isolated from all other tissue of like nature. Frequently as the gall decays hundreds of these

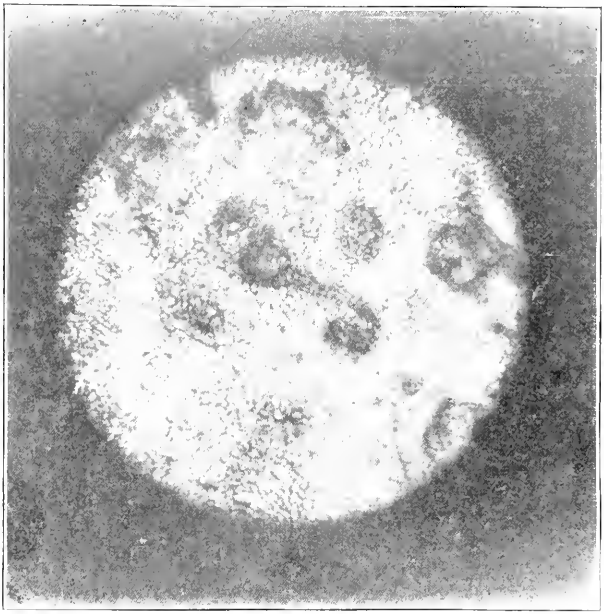

FIG. 17.—Photo-micrograph of a section through a young gall, showing isolated woody nodules surrounded by meristematic tissue in a ground tissue of large, thin-walled parenchyma (× 130).

intricately twisted nodules may be broken from its outer portion, while with galls that have been a long time in forming the centers of growth unite and form an irregular contorted mass throughout the interior of the gall, and as a result it becomes hard and woody. The rapid growth from these centers just underneath the surface of the gall gives it its characteristic nodular or warty appearance.

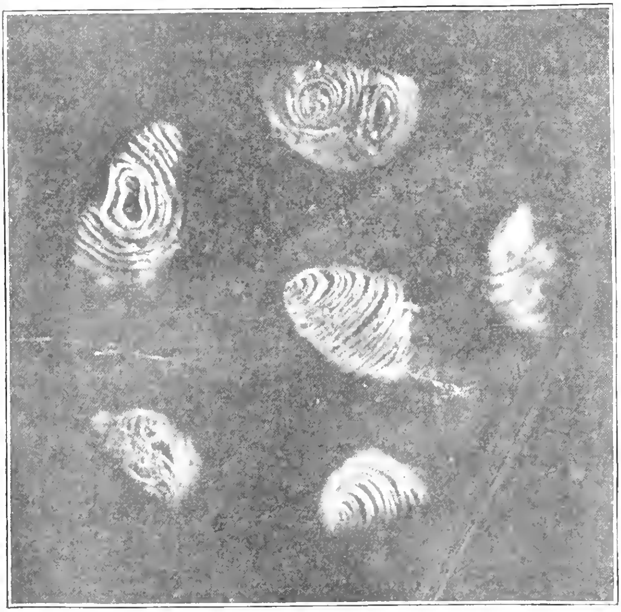

FIG. 18.—Photo-micrograph of isolated wooded nodules from the surface region of a fair-sized gall (× 20).

THE CAUSE OF CROWN-GALL.

The cause of crown-gall appears to be a specific organism, belonging to the slime-molds, or Myxomycetes. Altogether about 200 species of slime-molds have been published as occurring in North America. Of this large number but a single species is known to be parasitic, and this is considered by some authors as a doubtful Myxomycete. The parasitic species heretofore described is the common *Plasmodiophora brassicæ*, which causes the disease known as "club-root" in cabbage and allied plants, which was worked out and described by Woronin[32] in 1876, and which has in recent years been studied in this country by Eycleshymer.[33] It is also described at some length and figured by Sorauer[34] and Tubeuf.[35]

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[32] Prings., Jahr. f. wiss. Bot., Vol. XI, 1878.

[33] Jour. Myc., VII, 79.

[34] Handbuch der Pflanzenkrankheiten, II, 66 (1896).

[35] Diseases of Plants Induced by Cryptogamic Parasites (English translation, W. G. Smith), p. 522.

With the exception of less than a half dozen species, all slime-molds described from North America belong to the subclass Myxogastres, as defined by Macbride.[36] The many species of this subclass are characterized by their abundant, minute unicellular spores enclosed in more or less perfectly defined Sporangia. With the single exception of the species described below, all Myxogastres, so far as known, are saprophytic.

Introductory to the description of the species believed to be the cause of the crown-gall, the following may be given as descriptive of the class as a whole :

The Myxomycetes or slime-molds are common in moist situations in all parts of the world. They live, with rare exceptions, on decayed vegetable matter, and, as a rule, are extremely minute. In the course of their life history they present two phases, namely, the vegetative and the reproductive. The vegetative phase is remarkable for its extreme simplicity of structure, being nothing more than a nucleated mass of moving, naked protoplasm carrying with it occlusions of foreign matter. It is amoeboid in its movements, and is known as the "plasmodial" form of the organism. Under certain conditions the plasmodia pass into transitory resting stages, to again come forth when the conditions are favorable. After a variable length of time fructification takes place, when myriads of extremely minute spores are formed, usually in a well-defined spore-case or sporangium. The spores germinate shortly after ripening, at which time the spore wall is ruptured, and a bit of naked protoplasm comes forth as a zoospore or swarm cell, indistinguishable from an amoeba. After a few days the product of the spores flow or creep together, and ultimately fuse to form a new plasmodium, and the cycle of existence begins anew.

THE PLASMODIUM AND ITS TRANSITORY RESTING STAGES.

In its plasmodial or feeding stage the parasite infests the hypertrophied tissue of the gall and consumes the living protoplasm contained therein. The irritation caused by its presence stimulates growth and accelerates cell division, resulting in a

[36] North American Slime-molds, p. 20.

mass of soft, abnormal tissue generally known under the name of crown-gall.

For the purpose of successful study of a plasmodium in its earliest stages in the host, material must be carefully selected. In my investigations I found young galls from 1½ to 2 millimeters in diameter the most desirable. In order to obtain specimens free from soil and saprophytes, I grew the galls by inoculating almond seedlings and placing them in water cultures for a period of three or four weeks. In growing galls on inoculated seedlings in water culture, the point of infection should be from one and a half to two inches above the water line in the jar. They should be kept in a cool room and the water changed every two or three days. Material obtained in this way is particularly desirable for fixing, imbedding, and cutting into serial sections. Both free-hand and serial sections of the young galls were examined in large numbers. Free-hand sections were studied in water and in a weak solution of glucose. The serial sections were from material imbedded in paraffine, and were stained and mounted in balsam in the usual way. Various fixing fluids were tried, including corrosive sublimate, chromic acid, and Flemming's fluid of various strengths. After repeated experiments, Flemming was found to be the most desirable, especially the strong solution. The sections were stained on the slide, the triple stain of Safranin, Gentian violet, and Orange was the most satisfactory. The tissue of the young gall is so thin-walled that it is necessary to carry the sections from the Gentian violet to and through the Orange with great rapidity in order to obtain the best results.

Thin free-hand sections of the young gall examined in water show the characteristic thin-walled parenchyma with scattered centers of meristematic tissue as previously described. At this stage of the gall development there is no starch in any of its tissues. Many abnormally large cells are filled with compound crystals, probably of calcium oxalate. These crystals are much more frequent than in the normal tissue of the root. The cells as a rule have a surprisingly small amount of organized cell contents when compared with the size of the cell lumen, and the nuclei are clearly discernible in fresh unstained specimens.

In looking over the slide it is observed that the nuclei are abnormally large in certain cells, most usually in cells more or less adjacent to the meristem. Other nuclei appear as if caved in on one side, the nuclear membrane being pressed into the nuclear body. A somewhat similar observation has been made by Cavara,[37] who found that the mycelium of certain parasitic fungi not only cause the nuclei of infested cells to enlarge and assume various irregular forms before their final dissolution, but that the effect was apparent on the nuclei of adjacent non-infested cells as well. By a close inspection of these cells in a freshly mounted specimen, the protoplasmic contents appears vacuolar and frothy, or in some instances as a fine network of granular strands (Fig. 19).

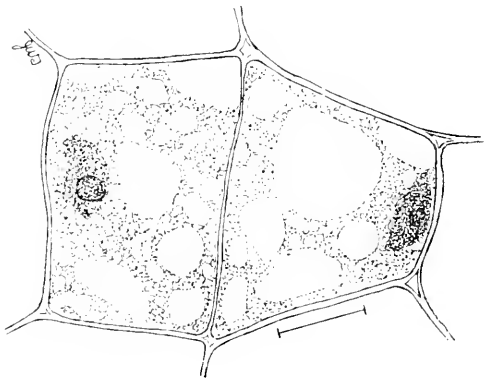


FIG. 19.—Cells of the young gall in fresh unstained section viewed in water; showing the frothy, vacuolar protoplasm of the plasmodium (Magnified same as scale; scale = 10 μ).

It is imperative, if free-hand sections are studied in water, that they be examined the first few moments after mounting, on account of the effect of the water on the protoplasm. If examined in a 1/2 per cent. solution of glucose, the sections may be satisfactorily studied for some time.

Under favorable conditions, if a fairly thick section of a young gall be quickly prepared by cutting with a dry razor, placing on a dry cover-glass, and immediately inverting over a moist

[37] Cavara, Dott. Fridiano.—Ipertrofie ed Anomalie Nucleari in seguito a Parassitismo Vegetale. Revista di Patologia Vegetale, Vol. V, p. 238.

cell, in the course of two or three days amoeboid bodies will appear on the cover-glass around the margin of the section. The first appearance of these bodies is as spheres having the granular protoplasmic contents arranged in various bands alternating with a perfectly hyaline portion (Fig. 20) and varying from 30 to 50 μ in diameter. After a short period of rest the enveloping membrane contracts or is drawn inward in folds, and the plasma becomes diffused. The hyaline portion disappears, with the exception of one or more vacuoles. Amoeboid

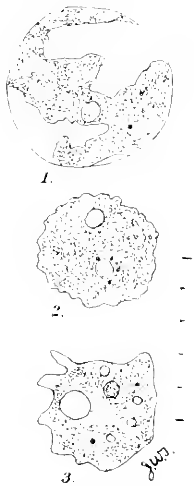


FIG. 20.—Amoeboid plasmodium about to form a thick-walled cyst. Three views of the same individual drawn at intervals of two minutes (Magnified same as scale; divisions of scale = 10 μ).

FIG. 21.—Cyst-forming plasmodium drawn at intervals of one minute, showing the rapid changes in the form of the organism (Magnified same as scale; divisions of scale = 10 μ).

movement now begins, and the vacuoles vary in size and number in the same individual with more or less rapidity. The organism is now only about one-half the size of its previous spheroidal form. Its transition to the amoeboid form is very rapid. When placed in water it moves with an undulating motion and momentarily varies in form (Fig. 21). As the vacuoles increase in size the surrounding plasma becomes more dense and streaming cytoplasm may be observed within.

By scraping the surface of young galls that have been kept free from saprophytes it is not difficult to find these bodies. I have repeatedly found them on young galls from the Glendale orchard, on galls from seedlings grown in the green-house and in water cultures. Specimens placed in a hanging drop keep up their movement for one or two days and gradually change to reddish yellow, until finally the organism contracts within the outer membrane into a thick-walled, rather dense cyst (Fig. 22). It closely resembles in its behavior the phenomenon observed by De Bary[39] in isolated cases in Fuligo.

FIG. 22.—Cyst-forming plasmodium, Nos. 1 and 2, drawn at intervals of two hours the first day after placing in hanging drop; No. 3, the fully-formed cyst of the same individual, the second day after placing in hanging drop. (Magnified same as scale; divisions of scale 10 μ.)

In certain cells of the diseased tissue peculiar vacuolate, amoeboid, or plasmodium-like structures abound, usually one to several in each cell. They are finely reticulated, and for a time it was thought that they might be the earlier stages of the amoeboid bodies described above. These bodies have been seen to slowly change their form and position (Figs. 23 and 24), passing round the cell from one side to another. They may be readily observed in fresh tissue as well as in stained sections, and are rapidly blackened by osmic acid.

They are surprisingly similar to the "plasmodes" of the so-called *Pseudocommis* of Debray and Brive, which more recently have been shown by A. F. Woods[38] to be nothing more than the albuminoid material of dying cells massed together, probably from the effect of slow oxidation. In fixed and stained sections these bodies lose their fine reticulum and usually appear as spherical masses, with a variable number of vacuoles. Repeated tests show the gall tissue to contain much larger quantities of oxidizing enzyme than the normal tissue.

If mature galls be cut from the tree in November, placed in moist sand, and kept at a cool, uniform temperature for a week

[39] Morphology and Biology of the Fungi, Mycetozoa, and Bacteria (English translation, Garnsey and Balfour), p. 428.

[38] Science, N. S., No. 223, p. 508.

or ten days, numerous pustules of gall tissue frequently begin to form on the cut surface or on the under margin of the old gall. If kept under proper conditions, the young galls con-

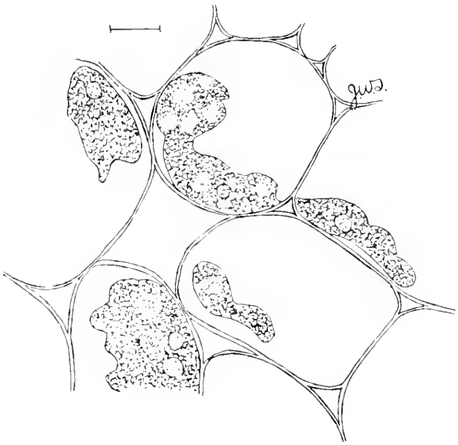


FIG. 23.—Section through the large parenchyma cells adjacent to the surface of the gall, showing the large intercellular spaces and the cells partially filled with finely reticulated, rather dense masses of vacuolar protoplasm. (Magnified same as scale; scale = 10 μ.)

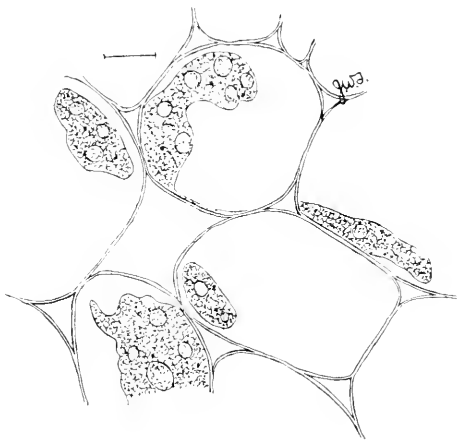


FIG. 24.—Same as Fig. 23, with the exception that the drawing was made an half hour later. (Magnified same as scale; scale = 10 μ.)

tinue to grow for days or even weeks or until the store of starch in the old tissue is exhausted. If the mature gall be cut open it will be found to have changed color in places, the contents of certain cells varying from dark brown to deep orange or red. If sections be made of this tissue and examined in water, these cells will be found to be completely filled with dense protoplasmic bodies. As the tissue becomes older these bodies deepen to dark orange and finally become reddish brown or almost black. If the gall be allowed to decay, they appear as dark oval bodies in the decayed tissue. These, possibly, are sclerotia or resting stages of the plasmodium. November 12, 1899, a large number of these bodies, which vary from 15 to 40 μ in diameter, were carefully selected from the decayed tissue of an old gall and placed in distilled water. They were washed through several changes of water and used in inoculating eight almond seedlings. On January 4, when first examined, three of the inoculated plants were diseased. At the time that this examination was made six small almond seedlings were pruned back to small cuttings about four inches long, consisting of two inches of the root and two inches of the stem. The root end of three of these cuttings was split open and a quantity of the washed sclerotia inserted. The shoot end of the other three was treated in a similar manner. The cuttings were kept in a moist chamber for one month and examined from time to time. At the end of the experiment one of the cuttings split in the stem had two galls, a millimeter or more in diameter, developing on the split surface near the pith. In both instances they were beneath buds on the stem.

THE EFFECT OF THE PLASMODIUM UPON THE CYTOPLASM OF THE HOST CELL.

Before describing the fruiting phase of the organism I desire to call attention to the effect of the plasmodium upon the host cell. This part of the investigation was worked out from the study of serial sections, fixed in Flemming and stained on the slide. The work was verified, so far as possible, from a study of fresh material. Flemming rapidly darkens the hypertrophied tissue in the process of fixing, particularly that portion infested by plasmodia.

If a thin section of a young gall be placed in water on a slide and Flemming be allowed to gradually work under the cover-glass, certain cells immediately begin to darken, and the whole or a portion of the contents appears in the form of spheroidal bodies. This appearance of dark spheroidal bodies under the action of Flemming is not observed in healthy tissue, and is thought to occur only in cells containing the parasite. Fig. 25 is a photo-micrograph of a thin section showing the position of certain cells darkened by the Flemming. The dark masses which appear to completely fill the cells are in reality dense aggregations of globular bodies.

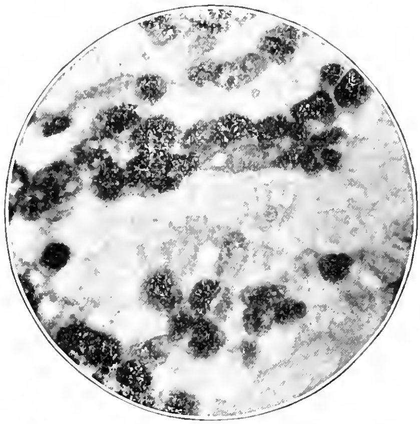
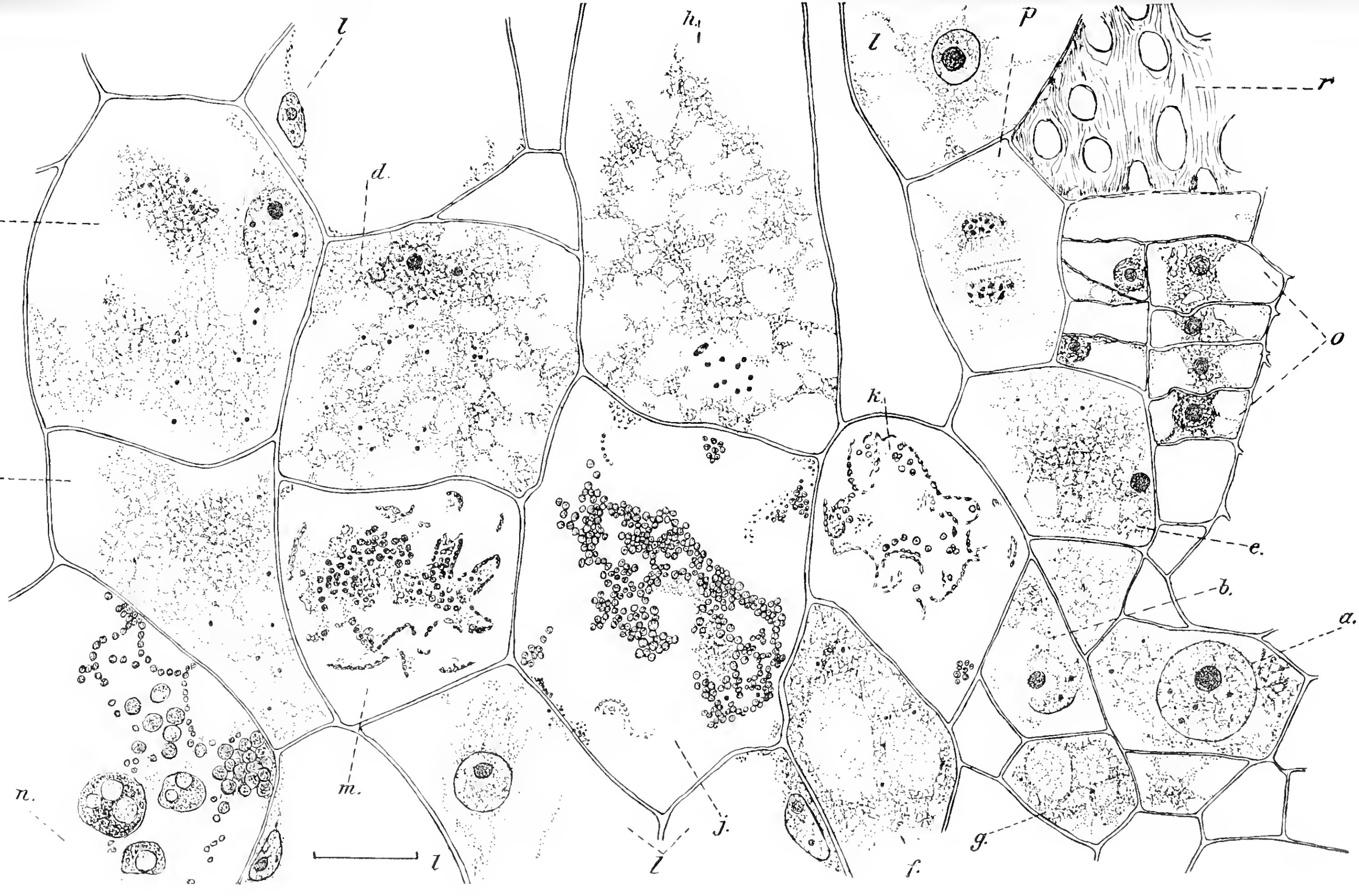


Fig. 25.—Photo-micrograph of a thin section showing the position of certain cells having their contents darkened by the action of Flemming. (× 360.)

It has been observed that the plasma of certain slime-molds in the plasmodial stage collects into small globular masses when about to die.[40] It is possible that the action of Flemming on this organism induces a similar phenomenon.

A satisfactorily fixed and stained section, when viewed with an objective of sufficiently high power, shows certain cells, usually adjacent to the meristematic tissue, more or less filled with frothy, vacuolar protoplasm, as previously described. The cell contents, however, now stands out clearly and well defined, and the protoplasm frequently appears as a close network of cytoplasmic strands completely or nearly filling the cell (see Plate). This condition is the first evidence of the parasite in the cell, but the plasma is so intimately associated with the cytoplasm of the cell that thus far it has been impossible to differentiate between them.

[40] Bütschli, O.—Protoplasm and Microscopic Foams (English translation), p. 117.



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EXPLANATION OF PLATE.

The material from which this plate was drawn was fixed in Flemming's fluid and stained with the triple stain of Safranin, Gentian-violet, and Orange. (Magnified same as scale; scale = 10 μ.)

a. A young cell showing the host nucleus greatly enlarged. The cytoplasm of the cell for the most part has been consumed and the cell lumen filled with the reticulum of the parasite.

b, *c*. and *d*. Three cells with the host nuclei in various stages of disintegration, vucuolar and ill-defined, the remainder of the cell lumen filled with the nucleated reticulum of the parasite.

e. Host cell showing no trace of the nuclear substance, with the exception of the nucleolus, the latter being the last of the nuclear body to be destroyed by the parasite.

f, *g*, *h*, and *i*. Four infested cells with host nuclei entirely consumed and the cell lumen almost completely filled with the dense reticulum of the parasite, and showing many small bodies surrounded by a hyaline area. These bodies are supposed to be the nucleoli, and the hyaline areas the remainder of the nuclei of the parasite. In *h* these bodies are mostly in pairs and in one instance appear as a nuclear spindle.

l. Non-infested cells.

j, *k*, and *m*. Infested cells with contents in form of dark, spherical bodies, some probably oil globules, darkened by the action of the osmic acid, but probably for the most part the reticulum of the parasite broken up into innumerable spheres by action of the fixing fluid.

n. An infested cell showing large vacuolate, spheroidal bodies, "plasmodes" probably arising from the disorganized protoplasm of the host cell.

l. Non-infested parenchyma cells, showing normal nuclei and the small amount of cytoplasmic contents.

p. A non-infested parenchyma cell with nucleus in process of division.

r. A cell showing early tracheary tissue, being the origin of a woody nodule.

o. Normal meristematic tissue.

After the plasmodium consumes the cytoplasm of the cell its visible effect may be observed upon the cell nucleus (see Plate). At first the nucleus swells to from three to six times its normal size, becomes less dense, and loses to a degree its normal fibrillar structure. At the same time the reticulum of vacuolar, frothy protoplasm in the cell becomes more abundant and apparent. (This condition and subsequent stages can be observed in fresh specimens if a drop of Flemming be run under the cover-glass a few moments before making the observation.) The nucleus now loses its normal form and appears as if eroded on the surface, and later gradually disappears as an organized body, vacuoles frequently appearing within its ill-defined margin.

The nucleoli are the last of the cell contents to succumb to the action of the parasite. In well stained sections they can frequently be observed in the cell long after every other visible trace of the nucleus has disappeared. Associated with the nucleoli in the enlarged nuclei are usually several small spherical bodies which take the safranin stain. These red bodies also remain behind after the body of the nucleus has been destroyed.

The protoplasmic reticulum of the parasite contains small spheroidal bodies $\frac{1}{2}$ μ or less in diameter, which take the safranin stain. These bodies are surrounded by hyaline areas and are believed to be the nucleoli of the nuclei of the plasmoodium, the hyaline area surrounding each nucleolus being the body of the nucleus. They are frequently in pairs and in one instance appeared as if in process of division by karyokinesis.

The cytoplasm of the plasmodium passes from cell to cell through the wall pits. The unequal growth of the cell tissue in closely adjacent regions soon causes the development of large intercellular spaces. Occasionally a strand of protoplasm is observed to stretch across one of these spaces joining the plasmodium in adjacent cells, the communication between the two cells being continued after the cells have pulled apart.

From the position of the diseased cells in relation to the meristematic tissue and the formation of new centers of such tissue, it is evident that the parasite stimulates growth not so much in the cells visibly affected as in adjacent ones. I have never observed cells in the process of nuclear division when the plasmodium was evident, although karyokinesis is frequent in adjacent ones. It may be inferred that invisible cytoplasmic portions of the parasite penetrate the cell walls and pass through adjacent cells to some distance from those in which the plasmodium is first visible, and that they create a stimulus inducing accelerated growth and cell division. Such a stimulus might also be produced by the effect of metabolic products of the parasite.

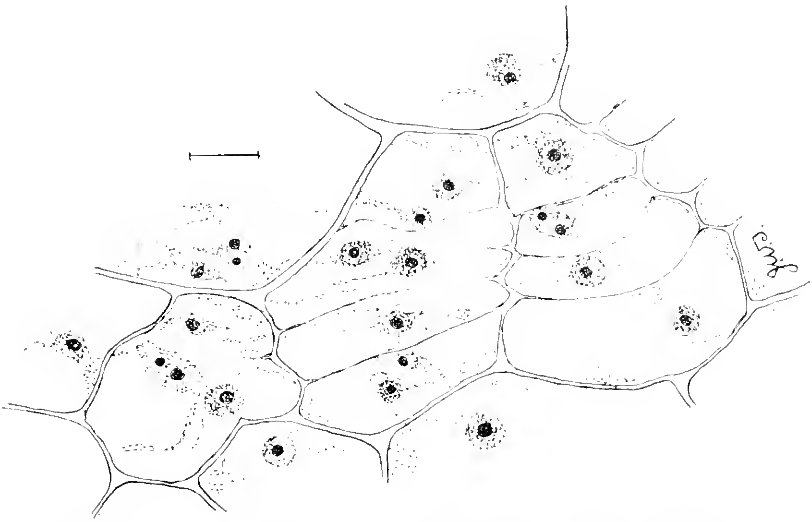


FIG. 26.—Multinuclear cells from the meristematic tissue of a young gall. (Magnified same as scale; scale = 10 μ.)

Karyokinesis frequently occurs in large parenchyma cells, even when poorly supplied with plasmic contents, if they be adjacent to diseased tissue (see Plate), and it is presumed that karyokinesis may occur in any normal parenchyma cell and a new center of growing tissue originate under the stimulus induced by the parasite. In such cases nuclear division frequently occurs without the formation of a cell plate, and as a result multinuclear cells are frequent (Fig. 26). Such cells are usually later divided by the formation of walls.

THE FRUCTIFICATION.

Under favorable conditions the plasmodium collects in various surface regions of the gall. At this time not only the cells, but occasionally the intercellular spaces as well, are filled with a complex network of protoplasmic strands (Fig. 27.) The portions of the gall from which the plasmodium has withdrawn show the cells entirely empty, and even in unstained sections are in marked contrast to the infested areas.

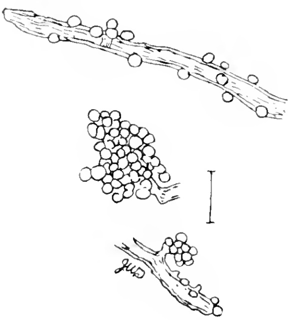
FIG. 27.--Section through the surface tissue of the gall, showing the plasmodium migrating to the surface prior to fructification. (Magnified same as scale; divisions of scale = 10 μ.)

If a gall be carefully examined at this time or a little later, minute globules (one to three in cases observed) may be seen in the process of forming on the surface above one or more of the regions noted. These are developing sporangia and resemble minute globules of exuded gum. At first they are a clear, transparent amber, but twelve to twenty hours after their appearance they become clouded from the development of the contained spores. Four to eight hours later they are ruptured by the bursting of the peridium.

During the fall of 1899 I had the opportunity to examine a number of galls from the Glendale orchard and others from Tucson at the time the plasmodia came to the surface and developed fruit. In not a single case was I able to find the fructification on galls immediately after cutting them from the trees. The galls upon which the parasite fruited were cut from the trees in November, at which time they were of large size, but had not as yet begun to become discolored. The specimens were kept for a period of ten days in moist, crushed quartz in a cool room and then placed in a moist chamber where they could be observed daily. In every instance they were in as fresh condition when placed in the moist chamber as when cut from the trees. A vigorous growth of hypertrophied tissue had formed in a number of places on the old galls, particularly on the exposed surfaces where broken from the trees. If a gall in this stage be cut into pieces, the sporangia will develope a few days later on the cut surfaces. The first sporangium was observed a few days after placing in the moist chamber, when it had already ruptured. It is probable that the keeping of the galls in a growing condition for some time after their removal from the tree induces the plasmodia to fruit by cutting off their food supply. Unlike all other slime-molds known to me, this one fruits best if kept in the dark, a condition no doubt arising from its parasitic habit on the roots of trees.

The mature sporangium is nearly spherical, slightly broader than high, and 1 millimeter or less in its greatest diameter. It rests directly upon the tissue of the gall and is smooth and shining under a hand lens. The color varies from dark, reddish yellow to lighter. With transmitted light the peridium, or wall of the sporangium, is deep orange. The outer surface is minutely granular. The peridium is exceedingly brittle and breaks in straight lines. As it is about to rupture to liberate the spores, the outer surface dries more rapidly than the inner, causing it to contract, creating a tension which finally causes the membrane to rupture elastically. If a ripe sporangium be taken from the moist chamber and quickly transferred to a slide and viewed with a $\frac{1}{2}$ or $\frac{2}{3}$ objective, the rupturing and the well-marked outward curving of the fragments of the peridium may be easily observed. The inner wall of the peridium is covered with various-sized nodules of protoplasmic matter, varying from less than $\frac{1}{2}$ to more than 12 μ in diameter. These nodules are either imbedded in the wall or piled and massed together and adherent to it.

A fragmentary capillitium is attached to the walls of the peridium, and is found to a limited extent associated with the spores within. The threads of the capillitium are hollow, irregularly nodular, and sparingly branched, as shown in Fig. 28. The numerous orange-yellow spores usually adhere in clusters and are exceedingly minute, being from $1\frac{1}{2}$ to $3\ \mu$ in diameter, and are frequently flattened at various points by mutual contact. They are perfectly smooth, and the comparatively thick episporium, or inclosing membrane, is well defined. The inclosed granular matrix appears homogeneous, or occasionally shows a few bodies of varying size and refractive power imbedded within it. It is probable that some of these bodies are nuclei; however, I was not able to ascertain their real nature.



No. 28.—Fragments of the capillitium, with adhering spore-masses. (Magnified same as scale; scale = 10 μ.)

FIG. 29.—*a*, spores; *b*, fragments of the spore membrane after germination; *c*, germinating spores; *d*, swarm-cells, showing cilia; *e*, swarm-cells immediately a ter germination.

By moistening a needle and inserting the point into a ruptured sporangium the spores can be conveniently transferred to a hanging drop and their germination studied. They begin to germinate almost immediately after being placed in water. The escaping swarm-cells are $1\frac{1}{2}\ \mu$ or less in diameter, and at first assume a form nearly spherical and move about with a slight, dancing, vibratory motion, but after a time they become pear-shaped and develop an elongated appendage or cilium at the small end, which enables them to move through the water with considerable rapidity. Although in this stage the prevailing form of the swarm-cell is pear-shaped, it varies momentarily in form in the same individual. A small refractive spot, probably a vacuole, was visible in the large end. I was not able to discern nuclei in the swarm-cells with the lens at my command.

Several efforts were made to ascertain if the swarm-cells fused, but these efforts were only partially successful. Fusing was not observed with any of the swarm-cells arising from sowing spores in hanging drops In one instance, however, several amoeboid bodies 10 μ or more in diameter were found on the slide, the material of which was obtained from a sporangium that had ripened several days before and had been kept in a moist cell in the meantime. On this slide were also found large numbers of the pear-shaped swarm-cells provided with the elongated cilium.

GENERIC AND SPECIFIC DIAGNOSIS.

It is evidently necessary to establish a new genus for this slime-mold. The generic name which I propose is *Dendrophagus*, intended to suggest the cancerous character of the gall tissue. The species may be appropriately named *globusus*, from the form of the mature sporangium.

Dendrophagus, gen. nov. Plasmodium parasitic; sporangia globose, sessile, simple; peridial wall brittle, non-persistent, shining, breaking in straight lines into small, irregular pieces; capillitium fragmentary, formed of a few irregular, branching tubules attached to the lower portion of the peridial wall.

D. globosus, sp. nov. Sporangia sessile, occurring singly or in groups of two or three, 1 millimeter or less in diameter, globular or slightly flattened and resting directly upon the tissue of the host, deep orange, shining, opening irregularly; peridium thin, minutely granular when highly magnified, the interior surface more or less covered with yellow protoplasmic nodules of variable size and refractive power; capillitium of a few thick, blunt, sparingly branched, and irregularly nodular hollow threads; spores orange yellow, adhering in masses, smooth, $1\frac{1}{2}$ to 3 μ in diameter.

AFFINITIES.

In its parasitic nature this organism resembles the *Plasmodiophora*. In all other respects it is allied to the true Myxogastres. From its parasitic habit and custom of fruiting under ground, it has become degenerate and differs materially from the saprophytic species. In the character of the sporangia and color of the spores, its affinities are with the *Trichiaceæ*, as defined by Schröter.[41] It differs materially, however, from the *Trichiaceæ* in having a poorly developed capillitium ; but it is likely that this organ has degenerated and is gradually disappearing, as it can serve in no possible way in the dissemination of the spores.

HOW THE DISEASE SPREADS.

The widespread dissemination of the disease has arisen by infested nurseries sending trees into many widely separated regions. A single nursery may be the means of spreading the disease over an entire State or over several States.

An orchard with a comparatively small number of diseased trees at time of planting will usually have few perfect trees remaining after the expiration of several years. This is particularly true of orchards in irrigated regions on account of the contagion being carried from tree to tree at times of irrigating. In the Glendale orchard some of the trees were diseased when planted. The actual number, however, that had galls upon them was very small. After the expiration of eight years less than 1 per cent. remained unaffected.

The conclusion seems to be warranted that the contagion can be carried in the old, decayed galls as well as in the fresh tissue. The spores are so small they can readily be carried by the wind. The amoeboid bodies elsewhere described are particularly adapted for carrying in water. The decayed galls which break from the tree from time to time may be carried about by the cultivator. If the bark at the crown or on surface roots be broken in cultivating, even on old trees, it gives the disease an opportunity to become established. Trees that are closely pruned frequently sucker at the crown, and as the young sprouts break through the bark an entrance is available for the parasite.

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[41] Die Natürlichen Planzenfamilien, Engler and Prantl, Teil. I, Abt. I, p. 20.

FIG. 30.—Stumps of diseased trees removed from infested orchard and distributed about the country for stovewood.

Carelessness on the part of orchardists, at least to some extent, accounts for the wide dissemination of crown-gall in the Salt River Valley. The following specific example is suggestive:

The diseased trees dug up at the Glendale orchard were cut into stovewood and sold to various farmers throughout the neighborhood.

The stumps of these trees had a great many large galls upon them, as shown in Fig. 30, and in the transportation of this wood the galls became scattered throughout the neighborhood. It hardly seems necessary to suggest that all galls should be carefully gathered and burned when removed from the trees, and that the diseased trunks should never be removed from the premises.

LOSSES CAUSED BY CROWN-GALL.

With a plant disease that has been so little studied and so little understood, it is not possible to arrive at definite conclusions concerning losses incurred. From its wide dissemination and the great variety of economic plants that it infests, the yearly losses caused by it must be very great. As the disease usually attacks its host-plant underground, it has frequently been overlooked by the fruit-grower and has not received the attention that it merits. Thousands of trees have dwindled and died or have failed to fruit or make a desirable annual growth of wood without the owner recognizing the source of the trouble. After carefully examining hundreds of trees in many different orchards during the past seven years, I am convinced that at least in Salt River Valley much of the trouble can be directly credited to crown-gall.

Fig. 31 shows the present condition of an almond orchard at Glendale, Arizona, that four years ago, at first appearance, impressed me as being one of the finest and most promising almond orchards that I had ever seen. Although at that time the trees were badly diseased, but little evidence of it appeared above ground. With each succeeding year a greater number of the trees died outright or broke off at or just beneath the surface of the ground, where developing galls had gradually weakened the stem. A very conservative estimate would place the losses

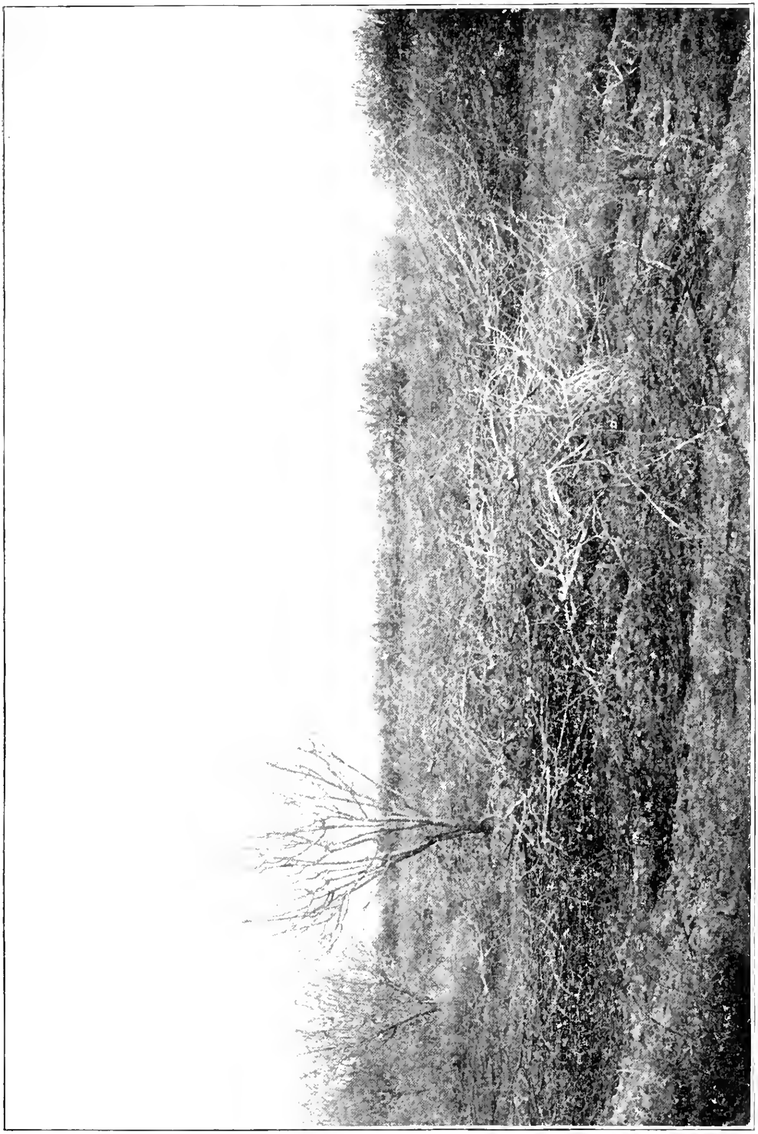

FIG. 31.—Present condition of the Glendale almond orchard; the dead and dying trees having recently been cut down.

in this one orchard at at least ten thousand dollars. Probably the losses to the deciduous fruit and grape growers of Arizona from this disease amounts in the aggregate to from forty to seventy-five thousand dollars annually ; possibly much more.

In California, where the fruit industry is many times what it is in Arizona, the losses must be correspondingly greater.

The following letter, recently received, is indicative of the loss to apples from crown-gall in the State of Washington :

OFFICE OF COMMISSIONER OF HORTICULTURE,
TACOMA, WASHINGTON, *December 22, 1899.*

Prof. J. W. TOUMEY, *Tucson, Arizona.*

DEAR SIR: Several nurseries in this State are affected with crown-gall in their apple stock, which has led to some extremely sensational statements on the part of interested parties. Authorities differ greatly regarding this affection, some assuming that if the gall is cut off the tree is unaffected, while others consider the affection so severe as to urge the entire destruction of the nursery stock grown upon the ground where it has developed. Some argue that the soil is so impregnated with the germs of the disease as to make it out of the question to grow nursery stock upon it again until after many years of cultivation in other crops. I would like an expression of your opinion regarding the trouble.

Yours truly,

(Signed) J. E. BAKER,
Commissioner of Horticulture.

The following, quoted from Selby, shows something of the losses resulting from the disease in Ohio :

"From observations made in Ohio there seems no reason to believe that peach trees affected with crown-gall at transplanting age will ever come to successful fruiting." "Those which actually survive will commonly be unprofitable." "The writer has made personal inspection of bundles of trees that contained quite a proportion of diseased ones. One lot of four hundred Smock had twenty-four diseased trees—that is, 6 per cent. Other varieties from the same lot had about the same amount of crown-gall." "One orchard in Lawrence county, containing two hundred trees purchased in New Jersey, was grubbed out at seven years of age without having borne a single profitable crop, although other trees of like age situated near them had yielded fruit. These trees were badly affected when delivered, and were nearly all of them diseased at the time of removal."

"Another parallel case occurred in Ottawa county. Two or three neighbors purchased one thousand five hundred peach trees in the fall of 1895. These were set in favorable land the following spring and were examined by the writer in June, 1897. At the date of examination about 50 per cent. of the trees in one lot were apparently affected with crown-gall."

The seriousness of crown-gall in various and widely separated portions of the country is certainly indicative of an enormous annual loss to the fruit industry. In estimating the amount of damage incurred by crown-gall, consideration must be given to the fact that it usually occurs under ground and is rarely seen except when the trees are taken from the nursery or when excavations are made at the crowns. The majority of diseased trees live on year after year, but make less growth and in all probability produce less and poorer fruit than healthy trees. It is not sufficient for a tree to simply live. It must grow and fruit abundantly in order to be profitable. The total annual loss from this disease in this country in all probability reaches the enormous sum of from $500,000 to $1,000,000, possibly much more.

REMEDIES FOR CROWN-GALL.

So little is as yet known regarding this disease that few systematic attempts have been made to treat it by the application of fungicides. My own experiments and those of Selby prove conclusively that sulphur is of no value whatever. Bluestone, when of sufficient strength, appears from the evidence that we now have to be of material value, and when mixed with copperas and lime it is the best of all materials yet experimented with. Although in all my experiments with the paste previously described copperas was one of the ingredients used, I believe that bluestone and lime made into a similar paste will be found equally effective. Lime is recognized as the most effective remedy known in treating, or rather preventing, "club-root," a well known and somewhat similar disease of cabbage.

From the position and character of the disease, it is evident that no remedy will completely overcome it after the orchard is once attacked. The best that can be done will be to keep the galls from forming on the crowns of the trees, where they do the greatest damage. The galls which form deep down on the lateral roots are of little moment compared with those which come at the crown; hence if an orchard be examined yearly and all galls cut from the crowns and the wounds covered with the bluestone-copperas-lime paste, there is no reason why a badly infected orchard should not live and fruit for many years. It is not reasonable, however, to expect that the trees will do as well and fruit as abundantly as trees with perfect root systems.

Mr. J. E. Bettler, of Mesa, Arizona, has been for the past three years foreman of one of the largest and best almond orchards in Salt River Valley. He has been very successful in keeping the crown-gall from his trees by inspecting them once a year, cutting off the hypertrophied tissue and applying the bluestone-copperas-lime paste.

This disease is primarily a nursery disease, and when the trees are in nursery rows it spreads with considerable rapidity. Trees in the first and second years of their life are apt to suffer more than older trees, and at this age the gall usually appears at the most critical point—*i. e.*, the crown; hence it is imperative that trees be entirely free from this disease when received from the nursery.

The safest advice that can be given to those planting orchards is to get trees from nurseries where there is no crown-gall. If young trees already having galls upon them be planted, there is not one chance in a hundred that they will ever come to successful fruiting. Of far more importance than this, however, is the fact that by planting a diseased tree one introduces the disease into his orchard. If bundles of trees are received having a few with galls upon them, it is not safe to simply throw out the visibly diseased ones. There is no reason why the remainder of the bundle should not have the infection upon them from contact with the diseased trees, and the whole should be destroyed.

The importance of this disease to the fruit industry of Salt River Valley is such that a rigid inspection should be made of all deciduous fruit trees planted. It is not sufficient, however, to simply inspect the trees before planting. No nurseryman should be allowed to sell a tree until his nursery has been passed upon by a competent inspector.

SPORE INOCULATIONS.

December 5, 1899, ripe spores were carefully removed from a sporangium by touching them with the tip of a moistened needle and inoculations made at the crowns of four one-year-old almond seedlings growing in the greenhouse.

January 2, 1900, one of these plants had galls developing at the point of inoculation.

December 20, 1899, six almond seedlings about four months old, growing in a pot of sterilized soil, were inoculated with great care as follows: The peridium was carefully removed from a ripe sporangium, a moistened needle inserted, and the spores which adhered to the needle point were transferred to a needle wound at the crown of each plant. January 20, 1900, the plants were examined and two were found with developing galls at the point of inoculation.

COMPARISONS WITH SOME RECENT INVESTIGATIONS ON PLASMODIOPHORA.

I fully recognize the incompleteness of this investigation and the uncertainties regarding certain portions of the work, but, as other duties make it necessary for me to lay aside the work for an indefinite period, I believe it best, on account of the great economic importance of the disease, to publish the results that I have obtained without waiting to make additional spore inoculations or to complete certain cytological investigations which I have in view and hope to make as opportunity permits.

Just as this paper was ready for the press I obtained a copy of Dr. S. Nawaschin's recent investigations of *Plasmodiophora*.[42] In Dr. Nawaschin's investigations the diseased tissue of the cabbage was fixed in strong Flemming and, with one or two modifications, stained in the usual way. As my work was not influenced in the least by that of Nawaschin, and as the diseased almond roots with which I worked were also fixed in

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[42] Nawaschin, Dr. S.—Beobachtungen über den feineren Bau und Umwandlungen von Plasmodiophora brassicæ Woron. im Laufe ihres intracellularen Lebens. Flora, 86 Bd., 404, 1899.

Flemming and stained in the usual way, the work admits of comparison. Both diseases being evidently caused by slime-molds, one would expect somewhat similar effects upon the tissues of the respective host plants and some similarity, at least, between the plasmodial stages of the parasites.

The following are some important similarities that may be noted:

1. Both parasites induce acceleration of growth and cause large galls of hypertrophied tissue on their respective hosts.

2. The cells infected by both parasites are almost instantly blackened by osmic acid.

3. Vast numbers of small, spherical black bodies in both instances appear in the diseased tissue when fixed in Flemming.

4. Both parasites appear in their respective hosts as densely filling certain cells with frothy, vacuolar protoplasm.

5. Amoeboid bodies are present in certain phases of the vegetative development of both parasites.

6. Both parasites consume the cytoplasm of the host cell and finally the nucleus.

7. The first visible effect of the parasites on the nuclei of their respective hosts is to cause them to enlarge and assume various abnormal forms.

8. In both diseases many "erythrophyllar" bodies appear in the diseased nuclei when fixed and stained.

In 1892 Hermann Müller-Thurgau published a short account of a slime-mold as causing galls on the roots of the pear.[43] I was unable to procure a copy of the publication containing this account and until the completion of my studies was unaware of its existence. At the last moment, however, I received a letter from the author inclosing a typewritten copy of this article. It is a brief notice of the microscopical examination of galls from the roots of the pear and an account of the finding of a myxomycete in the large parenchyma cells of the hypertrophied tissue. Small spherical bodies were also found in some cells which were thought to be spores.

[43] Müller-Thurgau, Hermann.—Ein Schleimpilz bei den Wurzelkropf der Birnen. Jahresbericht der Deutschschweizerischen Versuchsstation und Schule für Obst-, Wein-, und Gartenbau in Wädensweil, II (1891–1892).

UNIVERSITY OF ARIZONA.

Agricultural Experiment Station.

BULLETIN NO. 34.

TIMELY HINTS FOR FARMERS.

Tucson, Arizona, June 30, 1900.

(Distributed October 1, 1899 to June 15, 1900.)

ARIZONA AGRICULTURAL EXPERIMENT STATION.

STATION STAFF.

The President of the University . . . .
R. H. Forbes, M. S., ... Chemist and Director.
J. W. Toumey, M. S., ... Botanist.
A. J. McClatchie, A. M., Phoenix, Ariz. Agriculturist and Horticulturist.
G. H. True, B. S., Phoenix, Ariz. . . . . Animal Husbandry.
A. A. Tyler, Ph. D., ... Assoc. Botanist.
W. W. Skinner, M. S., ... Assist. Chemist.
E. W. Lewis, ... Clerk.

The Bulletins of the Station are sent to all residents of Arizona applying for them.

Address:

EXPERIMENT STATION,
Tucson, Arizona.

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PREFACE.

This bulletin is a collection of the "Timely Hints for Farmers" which have been issued and distributed by the Experiment Station twice each month from Oct. 1st 1899 to June 15, 1900, in Arizona and to others in the arid southwest. In this form and with the added illustrations the series is available and equally timely for succeeding years.

These articles are the result of an effort on the part of the station staff to reach the farmers of the Territory from time to time with useful information on living agricultural topics so presented as to be easily understood and, as far as possible, acted upon by those receiving them. The diversity of farming interests in the southwest has made it impossible to interest all readers all the while, although we believe that the series has something of value for almost everyone who is interested in the fruits of agricultural toil.

The many expressions of appreciation which have been returned from time to time by those receiving the "Hints" is evidence of their usefulness and the series will be continued another year beginning about Sept. 1st.

R. H. FORBES,
Director.

TIMELY HINTS FOR FARMERS.

GREEN-MANURING PLANTS FOR ORCHARDS.

No. 1, October 1.

During the past year the Arizona Experiment Station has been testing plants that gave promise of being useful for plowing under to improve the soil. Special attention has been given to plants suitable for growth in orchards. The two best plants tested were Melilotus indica and alfalfa. The Melilotus is the plant commonly called "sour clover" in Arizona. Elsewhere it is known as Yellow sweet-clover or Bitter Melilot. It belongs to the same genus as White sweet-clover (Melilotus alba,) the flowers being yellow instead of white. It is an annual, while the white-flowered Melilot is a biennial.

Yellow sweet-clover (sour clover) grows naturally throughout the southwest, being commonly considered a weed. In southern Arizona it is quite common in grain fields, these being the source of the seed used for sowing in orchards. Seed can be obtained where grain has been threshed, or at grist and rolling mills, the cost being slight.

The seed will germinate only during the cool weather from September to April. The earlier it is sown in the fall the more growth will be secured for turning under in the spring. If sown the latter part of September or the early part of October it will ordinarily attain a height of three to six inches before being checked by the cool weather of December and January. It may be sown as late as December, but will not give as heavy a yield as if sown earlier. About 50 pounds of seed should be sown per acre.

The method of seeding found to be the best is to level the ground well, sow broadcast, furrow with a three-shovel furrower, roll, and irrigate by running the water in the furrows, which should be two or three feet apart. Irrigating it frequently during the winter will not only increase the yield, but will benefit the orchard.

It should be plowed under when beginning to blossom, which will ordinarily be early in April. At this stage the yield proved to be 15 to 18 tons of green matter or 3 to 4 tons of dry matter per acre last April. If permitted to grow longer it becomes more woody, does not turn under so well and decays less rapidly. By attaching a chain to the plow all growth can ordinarily be turned under.

The alfalfa may be sown earlier than the clover, as the seed

FIG. 1. Yellow sweet-clover in peach orchard, April 6, 1900, just before plowing under.

will germinate during warmer weather. It does best if sown in the same manner as described for the clover. As it does not grow as rapidly during the winter, it will usually not be ready to plow under as early. Thirty pounds of seed per acre will be sufficient.

Peas sown very thickly (125 to 200 pounds per acre) during fall or winter will give a small yield of vines and in addition furnish a supply of green peas. The best varieties for this purpose were found to be Yorkshire Hero and Champion of England.

The White sweet-clover already mentioned makes a luxuriant growth during the summer, but grows little during the winter when the trees are dormant. For summer growth it seems to be no better than alfalfa. If permitted to grow two seasons, it dies at the end of the second. It may be plowed under green, or simply be allowed to die and decay upon the surface.

The benefits from the winter-grown green-manuring crops are four-fold at least. In the first place, the soil is thus covered during a portion of the year and the exhaustion of decayed vegetation by the heat of the sun retarded. In the second place, plant food that would otherwise be washed away by rains and irrigation is appropriated by growing plants, and thus saved for the tree. One of the most important benefits is the improved physical condition of the soil, due to the decaying of the green matter turned under. This causes the soil to bake less after irrigation, and to hold its moisture longer.

The chief benefit to the trees comes from the addition to the soil of nitrogen, one of the most important plant foods. The nitrogen added is derived from the air mixed with the soil. Most plants are powerless to use nitrogen from the air with which they are surrounded, notwithstanding the fact that the latter contains about 80 per cent of this element. The members of the pea family (peas, beans, clovers, alfalfa, etc.) are an exception. They harbor upon their roots colonies of microscopic plants called bacteria which have the ability to absorb nitrogen and pass it along to the plants to which they are attached. The irritation produced by these colonies of bacteria causes the formation of small modules or knots by which their existence upon the plants may be known.

The plowing under of the plants that have secured their nitrogen elsewhere than from the soil adds to the latter the nitrogen thus secured, and in addition benefits the soil in the ways mentioned above.

It has been found by W. M. Ward, one of the leading orange growers near Phoenix, that, after sowing the Yellow sweet-clover seed one or two seasons in an orchard, enough seed will mature under the trees, and in other places not reached by the plow, to seed the orchard from year to year, the only work necessary being furrowing during early October and subsequent irrigation. Mr. Ward was one of the first men to sow the Yellow sweet-clover for this purpose, having begun its use several years ago. He believes it has been of great benefit to his orchard.

A. J. MCCLATCHIE,
Department of Agriculture and Horticulture.

PLANTING EUCALYPTS IN ARIZONA.

NO. 2, OCTOBER 16.

The Arizona Experiment Station has been studying Eucalypts, with a view to ascertaining which ones can be successfully grown in southern Arizona.

The Eucalypts are evergreens belonging to the genus Eucalyptus, of which there are about 150 species. They are indigenous to Australia and the adjacent islands, and have been introduced into many parts of the world having a similar climate. The different species require different conditions of soil and climate. About 50 species thrive in different parts of the southwestern United States. Few of the species have common names that distinguish them from each other, hence in speaking of them it is necessary to use the scientific names in order to be accurate. The one most commonly grown in California, where the Eucalypts have found special favor, is Eucalyptus globulus, commonly called Blue Gum there.

A much smaller percentage of the Eucalypts thrive here than in California. In fact, it has been commonly supposed that none would thrive here. This opinion was probably based upon the fact that E. globulus, the prevalent one in California, endured neither the heat of our summers nor the frosts of winter.

It has been found that several species resistant to both heat and moderate cold do thrive here, a few of which will probably grow nearly if not quite as rapidly as the Blue Gum does in California. A few plants of various species have been set in various parts of southern Arizona from time to time during the past eight years. Those that have done the best are E. viminalis, E. rostrata, E. leucoxylon, E. hemiphloia, and E. corynocalyx, the the first two having made the most rapid growth. Six-year-old E. viminalis trees near Phoenix range from eight to fourteen inches in diameter and forty to fifty feet high. One six-year-old E. rostrata tree is eighteen inches in diameter and about forty-five feet high.

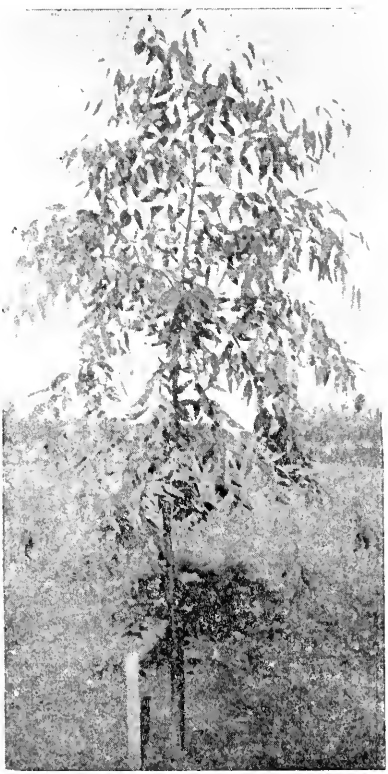


FIG. 2. Eucalyptus rudis, 1 year old, 7 feet 3 inches high, Station Farm.

The Eucalypts being of much economic value, it is desirable that such species as will thrive here be introduced as rapidly as practicable. Besides being useful shade trees, and consequently adding much to the appearance of the landscape, especially during winter when there are few other evergreens in southern Arizona, they are valuable for fence posts, for fuel, and for a great variety of purposes for which hard wood is needed. The hardy species mentioned can be grown in any part of Arizona where the temperature never falls below 15 to 18 degrees F.

Young Eucalypts may be obtained of nurserymen or grown from seed. Unless one has proper facilities for the propagation of seedlings and has had some experience in growing delicate plants, it will be cheaper to purchase the plants of a grower.

Probably the best time to sow the seed in our climate is November. Sow in boxes three or four inches deep and eighteen to twenty-four inches square, using for a seed bed a mixture of vege-

Fig. 3. Eucalyptus viminalis as a wind break, Blaisdell Heights, Yuma, protecting an orange orchard.

table mould and sharp sand. Scatter the seed evenly over the surface and cover about one-eighth inch deep with finely sifted soil. The seed should be watered lightly daily, care being taken that the surface never becomes dry. The young plants should appear in from one to two weeks. After this, be careful to avoid keeping the seed bed too damp, or fungi may attack and destroy the young plants. A good plan is to water only during the warm part of the day, that the soil may become partially dried promptly. If possible, rain water or distilled water should be used for watering the young seedlings, as the salt and alkali of the waters of Arizona are apt to cause corrosion at the surface of the soil.

When about three inches high the young plants should be transplanted into fresh soil—a mixture of clay loam, well rotted manure and sand. They may be set about two inches apart each way. Eucalypts make a better growth if planted out when six to twelve inches high than if left in the seed boxes until larger. During most seasons April will probably be the best month for setting them in the field. None should be set after the early part of May.

For fuel or timber they may be set six to ten feet apart each way. They grow straighter and make better timber if planted near together in blocks than if scattered over a farm. If cut to the ground when a sufficient size for fuel or posts, they will send up sprouts that may be cut again in a few years.

A. J. McCLATCHIE,
Department of Agriculture and Horticulture.

IMPROVEMENT OF ARIZONA SOILS.

No. 3, November 1.

For about two years past the study of a large and representative collection of soils from southern Arizona has been in progress with a view to finding out their merits and deficiencies for agricultural purposes. As one result of this study it has been found that in nearly every case the mineral elements of fertility are present in abundant quantity. Iron and lime are plentiful, while potash and phosphoric acid are present usually in more than sufficient amounts. Alkaline salts, though often present on lower irrigated levels in injurious quantity, are chiefly of the "white" or least harmful kind.

It has been found, however, that nitrogen and humus are almost always deficient. The average for twenty soils examined is .045 per cent of nitrogen and .65 per cent of humus or vegetable mould. When we consider that 0.1 per cent of nitrogen and 1 to 5 per cent of humus (according to the physical texture of the soil) is desirable, it is at once evident that the desert farmer stands in need of some remedy for a real defect. Associated with these peculiarities is a prevailing dense and packed condition of desert soils which is far from the light, loose condition of virgin turf or forest soils in humid regions.

It so happens, fortunately, that the deficiency of humus and nitrogen may be corrected, and the tilth of desert soils improved, by the one operation of green manuring. The humus or decomposed vegetable matter resulting from this process contains from 5 to 15 per cent of nitrogen, so that the one implies the other. The nitrogen of humus, also, is in a form not easily dissolved in soil water and carried away, which is far from being the case with Chile saltpeter and some other commercial fertilizers.

Also, humus improves the tilth of dense and lifeless soils because it separates the soil particles one from another and permits the circulation of the air and water needed by plant roots. The water holding and retaining power of soils is also increased because of the absorbent quality of humus, thus making them less droughty in character.

In this and other ways humus improves our desert soils both in chemical fertility and in their behavior with water, the latter being specially important in regions where water is often difficult to obtain.

In addition to these benefits the green manuring crops used for the production of humus, such as "sour" clover and alfalfa, send their roots deeply and in every direction into the soil. In this way they improve the drainage of heavy soils, bring the mineral elements of fertility from below to the surface, and open up the way for the tenderer roots of other crop plants.

The best kinds of green-manuring crops for southern Arizona, so far as known, and the ways of handling them, are pointed out in No. 1 of "Timely Hints," where alfalfa for summer and "sour" clover for winter are recommended.

But it must not be supposed that humus once added to the soil is permanent. Eternal vigilance is the price of humus, for it has enemies. The hot, dry desert air burns it up, and water containing the much dreaded black alkali dissolves it and carries it away.

The effect of heat upon humus may be seen by contrasting the soils of Arizona with those of Montana. The soils of Montana are alkaline, and the climate is arid and largely cold; the soils of southern Arizona are likewise alkaline, and the climate arid but hot. The average humus in 39 Montana soils is 3.32 per cent: in 20 Arizona soils it is .65 per cent. This great difference is chiefly due to the difference in temperature of these two states.

To prevent the loss of humus through the sun's action it is necessary to grow cover crops which shall protect the ground from the sun's direct rays, especially in hot, dry weather. Thus far the results at the Experimental Farm favor cow peas for summer and "sour" clover for winter. The broad leaves of the cow peas seem specially effective in shading the ground, while the plant is also valuable as a green-manuring and forage crop.

It is a matter of almost common observation that grain, roots, and even trees do better upon old alfalfa ground than upon virgin soil, a fact largely due to the enrichment of the soil in humus and nitrogen and its improvement in tilth in the ways stated above. In 1898, during the work of the Experiment Station with sugar beets it was noticed that the beets coming from old alfalfa ground were richer in sugar and of greater purity than those from virgin desert soil. On the Experimental Farm a careful observer can see the effect of one year's green-manuring in a small peach orchard.

It may be stated, in conclusion, that green-manuring is a leading means for the improvement of most Arizona soils in tilth, and in their humus and nitrogen content.

R. H. FORBES,
Department of Chemistry.

WINTER IRRIGATION OF ORCHARDS.

NO. 4, NOVEMBER 15.

At the Experiment Station Farm during the past year an experiment was made to test the effect of thorough winter irrigation of an orchard. An isolated peach and apricot orchard was the special subject of the experiment, although all the orchard on the farm was irrigated more or less thoroughly during the winter months. The object of the experiment was to ascertain how much summer irrigation might be rendered unnecessary by the application of an abundance of water during the winter.

FIG. 4. Orchard irrigated during winter and but once during summer; photographed October 8, 1899.

The orchard selected was irrigated (by the furrow system) eight times from December to March. The last irrigation, during the latter part of March, was an especially thorough one. As soon as the soil was sufficiently dry, to check evaporation, it was harrowed crosswise of the furrows, and was cultivated twice and plowed and harrowed once during the next three months. During the latter part of June the orchard was given a light irrigation, but received no more irrigating water during the remainder of the season. In general, the plan of the experiment was thorough winter irrigation followed by thorough summer cultivation.

The effect of the above treatment was recorded in two ways: (1) By making determinations of the amount of moisture in the soil soon after winter irrigation ceased, and (2) by noting the physical appearance of the trees and the character and amount of fruit borne.

For determining the amount of moisture content of the soil a sample of each foot from the surface to the ground water was taken during April, May, June and September. In taking the samples of soil, roots were encountered in abundance as deep as fourteen to sixteen feet, while one peach root was followed into the twentieth foot at a horizontal distance of eighteen feet from the tree, showing that the water of at least the upper twenty feet could be used by the trees.

The upper five and a half feet was a clayey loam; the next nine feet, gravel; then about a foot of clay; then another foot of gravel; and the rest of the way to water, a fine clay. Hence the roots had passed through ten feet of gravel and four feet at least into the clay beneath.

The results from the first set of samples indicated that the irrigating water had penetrated to a depth of twenty-four feet. The sixteenth foot was the wettest one, the soil being so nearly saturated that it was muddy. From this point the moisture was less and less abundant, until the twenty-sixth foot was reached. From here the percentage of water increased gradually until ground water was reached at thirty-four feet.

The second set of samples showed that the capillary action upwards had about kept pace with evaporation, the moisture in the upper four feet being about the same as the month previous. As a whole, however, the water had settled some. During the next month evaporation was more rapid than the upward capillary action, the third set of samples taken during June showing that the upper five feet had become quite dry. However, there was still plenty of water within reach of the roots, the soil from the fourteenth to the twentieth foot being still wet. The soil samples taken during September showed that while the upper fifteen feet were comparatively dry, the lower extremities of the roots were still surrounded by moist soil.

The conditions above ground were very satisfactory. The trees grew thriftily and maintained a vigorous appearance throughout the season. The trees were well loaded with fruit, the peaches and apricots being larger than the previous year, when the orchard was irrigated frequently during the summer. The quality of the fruit was excellent. At the close of the season, though having received but one irrigation since March, the trees were in fine condition.

The results of this experiment indicate the value of filling the soil with water during the winter. At this time, irrigating water is comparatively abundant, evaporation is slow, and the irrigating water is supplemented by some rainfall; while during late spring and early summer, when the trees are growing rapidly and consequently need the most water, the conditions are quite different. Most fruit growers consider it advisable in our climate to irrigate at least once a month from March to September. The above results demonstrate that in permeable soils much of this summer irrigation may be dispensed with providing the orchard be cultivated thoroughly.

The special object of this bulletin, issued at this time, is to impress upon orchardists the importance of beginning early and irrigating thoroughly throughout the winter. Permanent furrows may be plowed, into which the water may be turned at any time. If clover is to be grown in the orchard during the winter, as suggested in Timely Hints No. 1, the seed should be sown before the soil is furrowed for winter irrigation.

A. J. MCCLATCHIE,
Department of Agriculture and Horticulture.

THE CROWN GALL.

NO. 5, DECEMBER 1.

The crown gall is a disease very injurious to deciduous fruit trees, particularly so to the almond, apricot, peach, plum, and nectarine. The same, or closely allied galls, have been found upon the roots of the apple, pear, English walnut, grape, raspberry, and a number of other plants, both cultivated and wild.

The disease may be readily recognized by the large knot-like outgrowths which develop at the crown of the plant just beneath the soil, or, in older plants, on the roots and rootlets. There is no disease of deciduous fruit trees in irrigated regions that is as

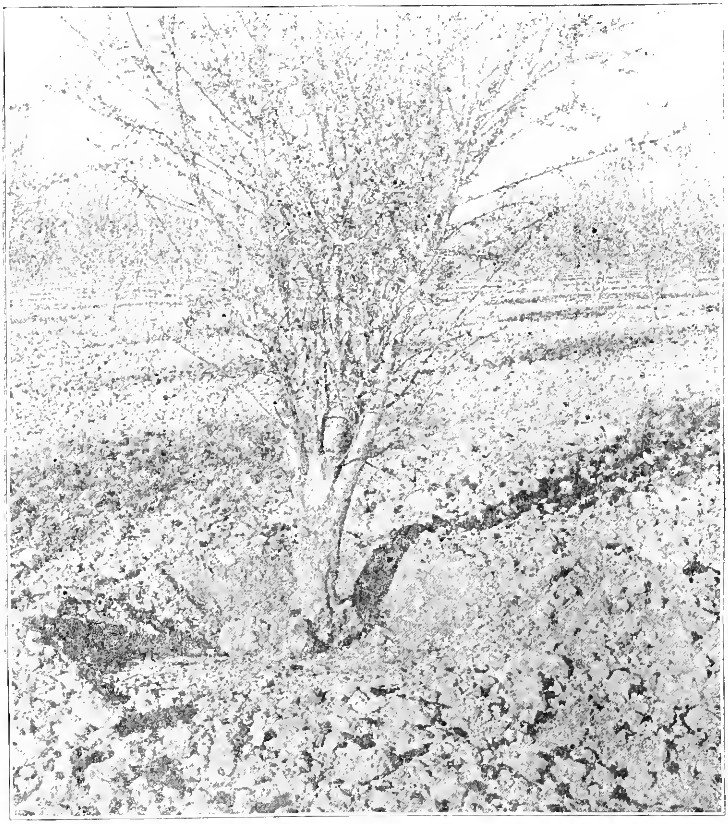


FIG. 5. Five-year-old almond tree in a Glendale orchard, showing large galls almost completely surrounding the crown a few inches below the surface.

widespread and that causes so much injury to the fruit industry as the crown gall. Not only is it prevalent and rapidly increasing in the irrigated regions of the southwestern United States, but it is becoming one of the most menacing diseases which threaten the deciduous fruit industry in practically all of the great fruit centers of the United States.

For the past six years I have had the crown gall under observation, and five years ago published a preliminary report regarding it, as Bulletin No. 12, of the Arizona Experiment Station. This report was based almost entirely upon observations in the field. Two years ago extensive experiments were begun to ascertain the communicability of the gall. It is sufficient at this time to state that I have repeatedly produced the disease by inoculation of young seedlings with small bits of the gall, in some instances the gall beginning to develop twenty days after the inoculation.

Again, I have repeatedly produced the gall on almond seedlings by planting the seeds in sterile soil, and at the time of planting, placing a few pieces of minced gall in the soil.

There is no question regarding the communicability of this disease; it is contagious. The disease is probably caused by a micro-organism known as a "slime fungus;" the plasmodia of the organism, through irritation, causing the galls to develop. Under certain conditions the plasmodia creep to the surface of the gall and form minute amoeba-like bodies which slowly make their way through the damp soil to other plants.

No details are here given, the reader being referred to Bulletin 33 of the Arizona Experiment Station, which is a detailed report of the investigations, including the cause and nature of the disease, and how best to deal with it. Knowing the nature of the disease, the question with the fruit grower is how to eliminate it from the infested orchards. The best advice that I can give to those intending to plant trees is to get trees from a nursery that is absolutely free from the crown gall. It is not sufficient to cast aside as worthless only those trees with galls upon their roots. Every tree that comes from an infested nursery is dangerous, and when such trees are planted, great chances are taken. If your orchard is already infested with crown gall, you cannot entirely get rid of it. All that you can do is to hold it in check and keep the galls as much as possible from the crowns of the trees. When it appears on the main stem of the tree a few inches below the ground, that is, at the crown, as it frequently does, particularly on young trees, it is almost certain in time, if unchecked, to cause the death of the tree. As this disease only affects the tree at the point where the gall develops and in the adjacent tissue, if the gall be removed and something be applied to the wound to prevent additional growth, it can be held in check, and a minimum amount of harm will come to the tree from its action.

From a number of experiments carried on in the greenhouse, where a large number of seedlings have been under observation for the past two years, it has been shown that bluestone is of marked value in treating the disease. In the field the following has proved to be the most successful of any treatment as yet known. The remedy should be applied in October and November or in March and April, as at these periods of the year the growth of the gall is the most rapid:

Two parts of bluestone;

One part of copperas;

Three parts of quicklime.

Crush the bluestone and copperas to a fine powder, thoroughly mix with the lime, and add enough water to make a thick paste. In treating the disease the crown of the trees should be exposed, all the galls cut away, and a quantity of the paste plastered over the wounds. This remedy prevents the growth of the soft, spongy tissue infested by the plasmodia. It is very important that all galls cut from the trees be gathered and burned.

J. W. TOUMEY,
Department of Botany.

DESIRABLE VARIETIES OF PEACHES.

NO. 6, DECEMBER 15.

Among the large number of varieties of peaches grown at the Station Farm near Phoenix are several promising varieties not generally grown in this region. For the benefit of prospective tree planters, the following notes upon some of the varieties are issued. The varieties are arranged approximately in the order of their ripening:

SNEED.—Fruit of fair size and quality, greenish white with red cheeks; ripens May 18th to 30th—earlier than any other peach in the orchard—and of better quality than Alexander, Waterloo, and other peaches of that group; tree vigorous and a good bearer.

FIG. 6. Peaches grown in orchard irrigated during winter, and but once during summer; harvested Aug. 21, 1899; one fifth natural size.

GOVERNOR GARLAND.—A very large peach with an excellent flavor and a rich rosy color, quality and color better than other early peaches; partially free; ripens May 25th to June 15th; tree a fair bearer.

WAGER.—Fruit of good size and superior quality, excellent for canning, deep yellow tinged with red; a freestone; ripens July 20th to August 5th; a good bearer.

NEWHALL.—Very large with a rich flavor, yellow with a dark red cheek; a freestone; ripens July 25th to August 15th; a good bearer.

SUSQUEHANNA.—Fruit large, and quality good, a rich yellow deeply tinged with red; a freestone; ripens July 25th to August 15th; tree a heavy bearer.

BELLE OF GEORGIA.—Fruit very large and quality excellent, light colored with rosy cheeks; ripens August 1st to 15th; tree a good bearer.

GENERAL LEE.—Fruit above medium, very juicy and high flavored, creamy white tinged with red; a cling; ripens August 1st to 10th; tree vigorous and a good bearer.

ORIOLE.—Fruit a good size, deep yellow with red cheeks, with a rich flavor; a cling; ripens August 15th to 30th; tree bears well.

SYLPHIDE CLING.—Fruit large, creamy white mottled with red, very juicy and of high flavor; an excellent cling for canning or table use fresh; ripens August 20th to 30th; tree vigorous and a heavy bearer.

BONANZA.—Fruit of medium size, creamy white tinged with red, of excellent quality; a freestone; ripens October 10th to 25th; tree a very heavy bearer.

TOPAZ.—Fruit of medium size, greenish white, tinged with red, not juicy but of good quality for so late a peach; a freestone; ripens November 20th to December 10th; the latest peach in the Station orchard; a good bearer.

All of the above varieties have grown vigorously and stood the heat of summer well, some other varieties not adapted to the region, but popular elsewhere, succumbing to the influence of our climatic conditions. In general, varieties originating in such peach states as Georgia and California succeed better here than many better known varieties that originated in the northern states.

For family use and home market a continuous supply of peaches will be furnished if the above are supplemented with Hale's Early and Early Crawford to fill in the space between the ripening of Governor Garland and Wager, with Salway to fill in between Sylphide Cling and Bonanza, and with Bilyean's Late to fill in between Bonanza and Topaz. If the above are supplemented with Triumph, a yellow-fleshed early peach, Greensboro, an early peach of good quality, and with Muir, a good drying peach, the result would be an orchard furnishing the possessor an excellent variety of fruit.

The foregoing notes apply to well cultivated trees. The cause of much failure in peach growing in this region is failure to cultivate properly. The peach will do fairly well a few years, if neglected, but will eventually succumb to the treatment.

Irrigation without subsequent cultivation causes the soil to become compact and kills the trees. In this regard, peach trees will not endure what pear trees, for example, will. The peach must have an open soil in order to thrive. If properly treated, there is no reason why the peach should not be a very profitable crop in southern Arizona, where a failure to set fruit is so rare.

A. J. McCLATCHIE,
Department of Agriculture and Horticulture.

THE DANGER OF INTRODUCING INSECTS ON TREES.

NO. 7, JANUARY 1.

At this time of the year it is appropriate to call the attention of those who may be importing young trees to the danger of introducing with them various insects. Inasmuch as there is at present no system of horticultural quarantine in Arizona, it is necessary for each individual importer to see that his own trees are clean; and it is to his interest to pursuade his neighbors, so far as they are importers of trees, to be similarly careful.

There is a common belief in the Salt River Valley that infested trees may safely be planted, because the scales or other pests which may be upon them will not survive. There is plenty of testimony proving that the black scale of California has repeatedly been brought to Phoenix on young orange trees, and the trees set out infested; yet at the present time no trace of black scale can be detected in the orchards. This points to what is indeed the fact, that scales and other insects brought from relatively moist regions to Arizona have a hard time to exist and propagate. Especially when they come on young trees, they are exposed to the direct rays of the sun, and are liable to perish before the plant affords enough shade to protect them.

Admitting all this, however, there is plenty of reason for the most scrupulous care. Under certain conditions, scales which normally inhabit moist and relatively cool regions, will flourish even in the Salt River Valley. The San Jose scale is a case in point. This has been brought in, undoubtedly, on young trees, and has survived for many years in Phoenix. In an orchard at Glendale, where the pear trees are fairly large, and are protected by shade trees from the full force of the sun, this scale is rampant, covering the bark of the trees, and overrunning the fruit and leaves, rendering the product quite worthless.

So, again, the pear leaf blister-mite has been introduced from the eastern states on trees, and is now common in Mesa and Tempe. It lives in a brown thickening of the tissue of the leaf, and is so protected from the excessive heat and dryness.

The soft scale has been introduced on ornamental plants, and is abundant on certain oleanders in the streets of Phoenix. Now this scale is a well-known pest of the orange, and while it might not live on young orange trees, it is more than likely that it would flourish in the dense shade afforded by trees of larger growth.

From Dewey, Arizona, we have received specimens of the woolly aphis, reported as injuring the apple trees. The owner of the trees mentions that he got them from a certain nursery in Missouri.

It is not always easy to detect pests on plants. Scales, when few in number, are very easily overlooked. Similarly, eggs of moths or of mites are extremely inconspicuous in many cases. Little cigar-shaped case-worms, which may be found on trees from New York state, are quite the color of the bark, and practically invisible unless one examines closely. Woolly aphis, from its mildew-like secretion, is much more easily seen than most things found on imported tress.

Just because it is so hard to see these things, it is best to have all imported trees examined by a man who knows what he is looking for, and is an expert at the business. The Salt River Valley should certainly have a horticultural quarantine officer with a suitable law giving him power to destroy infested plants. The Valley is isolated, and plants can only come in by rail; the interests involved are large and daily increasing, and the valley at present remarkably free from pests.

It is a good precaution, in case of insects being over looked, to apply some insecticide to imported plants before they are set out. When there is a suitable official to do the work, the gas treatment is doubtless the best. Unfortunately, however, scales will get into minute cracks and crevices in such plants as palms, and the gas does not always reach them.

Kerosene emulsion, however, is a good insecticide for domestic use. This is made with kerosene, soap and water, in the proportions of two gallons of kerosene to one gallon of water and one or two pounds of soap. The soap is dissolved in the water by boiling, and when this mixture is still at or near the boiling point, the kerosene is added, and the whole churned up until it is a thick, creamy mass. This can be kept and diluted with about ten times its bulk of water for ordinary use. The writer has made good emulsion in small quantities in a lard can, beating it up with a large spoon. The emulsion can also be made with kerosene and milk, in which case heating is not necessary.

T. D. A. COCKERELL,
Visiting Entomologist.

WHAT TO PLANT ON ARBOR DAY.

No. 8, JANUARY 15.

The planting of trees and shrubs for decorative and shade purposes and to secure pleasing landscape effects is desirable in all places inhabited by civilized man. In nearly every state in the Union a day has been set aside each year since 1885 for the purpose of planting trees and to commemorate with appropriate exercises, in school houses and elsewhere, the great value of tree planting from a civilizing and aesthetic standpoint. This day throughout the United States is known as Arbor Day, and in Arizona has usually been observed in February. Every one who has a village lot or a farm should observe this day and plant trees, shrubs, and vines, that their pleasing flowers and cooling shade may give him pleasure in the days to come.

The question that a great many will ask is, what had we best plant in order to attain the most satisfactory results with ordinary care and attention? For all Arizona this question cannot be answered in a few words. Everything depends upon the moisture, temperature, soil and cultivation. Without attempting to enumerate the exotic plants that have been grown and should be grown by those having plenty of water and ample time, and money to pay for cultivation, I call your attention to a number of plants that will thrive with little or no care and will survive prolonged drouth.

Too many trees have been planted in Arizona to live for a year or two and finally die. The trouble in many instances has been that we have attempted to grow trees from cooler and more humid regions, or have depended too much upon exotics that nurserymen have pursuaded us to buy at fancy prices.

The basis of decorative and landscape planting in humid regions is the trees and shrubs that are indigenous to those regions. Imported plants are only used to secure special effects. In Arizona we are not going to succeed in similar planting until we take advantage of a portion at least of the eighty-four indigenous trees,

FIG. 7. An unirrigated desert garden.—Bagote tree in center.

and the large number of decorative shrubs and vines that are growing wild on our plains and mountains. This paper is much too brief to discuss all the indigenous plants desirable in decorative planting. For street planting, where there is a fair supply of water for irrigation, the native Ash is probably the most desirable tree that we have for elevations below three thousand feet. In cooler regions, the native Box Elder, Walnut, and Alder can be planted to advantage. The Cottonwood and Willow should only be used for a street tree where there is plenty of water and where extremely rapid growth is desired. In the southern portion of the Territory the Mesquite, three species of Palo Verde, the Ironwood, the Acacia, and Hackberry are particularly desirable in localities where there is little water. Even where there is ample water for irrigation my observation has been that the Mesquite and Palo Verde invariably excel the Umbrella tree and most other imported trees from an effective and decorative standpoint at the expiration of five years after planting.

This certainly has been the experience on the University grounds at Tucson. Contrary to the general opinion, the growth of the Mesquite, Palo Verde and most other indigenous trees of our foothills and plains, is remarkably rapid, particularly when grown for decorative purposes, where they may be given more water than under natural conditions. A specimen of one of our native species of Palo Verde, namely, the Bagote (Va-go-tay), now growing on the University grounds, has a trunk ten inches in diameter and a wide spreading, handsome top, fully twenty-four feet in width. This tree grew from seed since 1893. In rapidity of growth it has far outstripped the Ash, Locust, Umbrella, Catalpa and Mesquite, growing in like situation. The Station has on hand a quantity of the seeds of this tree which will willingly be distributed free ofcharge to those desiring to plant them.

Our foothills and lower mountains abound in trees and shrubs, many of which grow with great rapidity and are more attractive than many of the things that we get from away, particularly if we cannot give them special attention. Our Yuccas and Agaves are especially decorative and should receive much more attention than they do. In order to introduce the native plants into our gardens, they must usually be grown from seed. It is only in rare instances that the ordinary person will succeed in digging a plant in its wild state and in successfully planting it.

In addition to our native plants, those which grow in and adjacent to the deserts of the Old World are especially desirable. There is no reason why avenues of date palms should not border our canals and ditches instead of worm-eaten cottonwoods. Date seeds germinate readily, and if thrown out along ditches will grow without any further attention and in a few years' time will grow into attractive, wide-spreading plants.

WINTER REMEDIES FOR INJURIOUS INSECTS.

No. 9, FEBRUARY 1.

It is not altogether easy to realize that all the different kinds of insects which were seen flying and crawling about during the summer, are still in existence, in one form or another, during the winter. What was then a moth or a butterfly may now be an egg, fastened to the twig of a tree, or a worm under the bark, or a pupa in the ground. The beetles, which were then running across the path, may now be hidden away in some hole. The bees, then so busy on the flowers, are now deep in their subterranean tunnels. The grasshoppers exist as eggs in little pockets in the soil. And so, whatever may have happened to the "individuals" of the summer time, the "species" are still with us, quiescent but alive, and ready to appear again with the warm weather.

Though our enemies the insect pests may be quiet at this season of the year, it is no reason why we should be. They got ahead of us, perhaps, during the summer; now is our chance to get even. Many of them are now at their lowest ebb, and one individual killed now is worth many deaths later on.

For example, take the plant-bugs; the squash-bug or the false chinch-bug. One winter day I brought in an armful of wood for the stove. Immediately after, I noticed a peculiar pear-like odor, which suggested that some one had been buying candy flavored with that coal-tar product which is supposed to taste like pears. No candy being discoverable, I turned to the wood-box, to find many healthy-looking individuals of the common squash-bug. It was these creatures, which had come in with the wood, that had produced the peculiar odor. The female squash-bug lives during the winter under piles of wood, boards, and such things, and by placing suitable shelter about the garden can be trapped and killed. Each female so dealt with would have been the mother of a lively brood later on.

At Las Cruces, one winter, I was turning over the dead leaves and trash which had gathered along the garden fence. This debris was found to be swarming with little greyish bugs, the false chinch-bug or Nysius angustatus. Later on, in the spring time, these bugs were found in myriads in a strawberry patch not far away, doing considerable damage. It was then too late to do much with them; the trash should all have been swept up and burned during the winter, and the bugs so destroyed or compelled to go elsewhere.

It is to be remarked, with regard to the last case, that the owner of the strawberries kept his place perfectly clean. The bugs found shelter with his neighbor during the cold weather. Thus it is, that the individual is often helpless in such matters so long as his neighbors refuse to take the necessary precautions.

If all the farm land were under cultivation, kept clear of trash, and plowed in the fall, we should not hear so much about insect pests. Every bit of waste land, grown up with weeds, breeds or shelters insects which may attack the crops.

Scale-insects may be usefully dealt with in the winter. In Mesilla, N. M., the San Jose scale problem was solved in a very simple way. The trees were cut back as much as was safe, and then the infested trunks were painted carefully with kerosene. This method will do very well for the Salt River Valley, where there are not many trees infested.

The winter birds destroy a great many insects. We have noticed in New Mexico how large a percentage of the larvæ of the codling moth, wintering under the bark of apple trees, are eaten by the birds. The birds, then, should be encouraged, and should not be shot or otherwise persecuted by small boys.

The Bryobia mite, which is common on almond trees in the Salt River Valley, can be treated with a spray of lime, salt and sulphur wash. The formula for this wash is:—Unslaked lime, 40 pounds; sulphur, 20 pounds; salt, 15 pounds. One-fourth of the lime is first slaked and boiled with sulphur in 20 gallons of water for two or three hours; the remainder of the lime is slaked and, together with the salt, is added to the hot mixture, and the whole boiled for half an hour or an hour longer. Water is then added to make 60 gallons of wash.

T. D. A. COCKERELL,
Visiting Entomologist.

CARE OF MILK FOR THE FACTORY.

No. 10, February 15.

A consideration of the subject of the care of milk upon the ranch is always timely. It is especially so at this time of the year. If any special provision is to be made for better methods of handling the cows and the milk during the trying summer season, now is the time to do it, before the warm weather sets in.

With the great lack of cold water upon our farms the problem of getting milk to the factory in the best of condition is not an easy one to solve. Many dairymen are careless or indifferent concerning it, and others, knowing this, argue that it is useless for them to take good care of their milk if it is to be contaminated at the factory by being mixed with the bad milk of their neighbors. And there is some reason in their argument. As a chain is no stronger than its weakest link, so a day's make of butter or cheese at the factory cannot be very much better than what would have been made from the poorest lot of milk alone. Most milk faults are contagious and milk coming to the factory sour or tainted should invariably be rejected. Any man who so disregards, not only his own interests, but those of his fellow patrons, as to deliver foul milk at the factory should suffer this penalty at least. To reject bad milk is the creameryman's only means of defending himself and his other patrons against the few wilfully careless and ignorant, and in justice to all concerned it must be done. No creameryman likes to turn away a patron, however, and no patron can afford to have his milk refused. If a few general principles concerning the handling of milk are understood and acted upon it need not be necessary.

In the first place it should be understood that the souring and other fermentations of milk are not normal changes. They take place as a result of the growth in the milk of minute forms of life called germs, or bacteria. These germs are so small that they are to be seen only by the use of a powerful microscope, but they reproduce themselves with great rapidity. Milk as it is formed in the udder of the healthy cow is free from these germs and, if it could be drawn without exposure to the air, into a closed vessel, equally germ free, it would remain in a sweet condition indefinitely.

There is one source of contamination, however, before the milk reaches the outside. That is the small quantity of milk remaining in the milk duct of the teat from one milking to another. Into this receptacle germs work their way. Here conditions for growth are so favorable that by the next milking many thousands are ready to be carried out into the milk pail by the first few streams of milk. By milking this fore milk, as it is called, into a pail reserved for that purpose and feeding it to calves or pigs at home this source of trouble may be avoided.

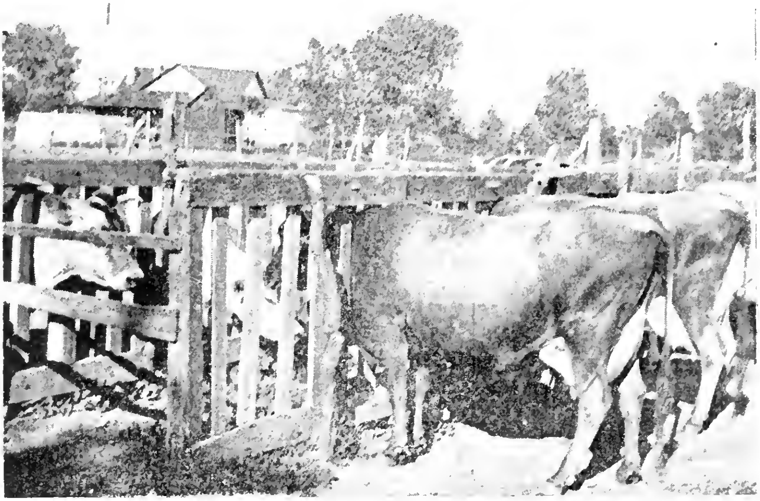


FIG. 8. Cows in stanchions.

The rest of the trouble comes from without. Every particle of dust in the air of the corral, and every hair and bit of dirt on the body of the cow and the clothing of the milker is covered with countless germs. Thousands and thousands of them find their way into the milk. In order to avoid needless contamination from these sources much care must be exercised.

In the first place the corral should be kept clean. The manure should be cleaned up and hauled away regularly and not allowed to collect, until the corral fence simply encloses one big flat manure pile with a surface of dry, powdery particles of pulverized dung rising in a cloud of dust whenever the cows are brought in to milk. In the next place, the animal should be tied during milking. The ordinary stanchions used on some of the ranches in the Salt River Valley are cheap and efficient for this purpose. By using them the cows are kept quiet and dust avoided, the animals may always have a clean place to stand, they are more easily handled and much time is saved.

The body of the cow is perhaps the most fruitful source of trouble. It should be brushed to remove the loose hair and particles of dirt, and the udder and adjacent parts dampened by the use of a moist cloth or sponge. The indifferent man will scoff at this suggestion, but experience has shown that it is a practical thing to do. In an experiment made by Dr. Russell of the Wisconsin experiment station, it was found that the contamination was nearly twenty-nine times greater when these precautions were not observed than when they were.

The milker's hands and clothing should be clean. This goes without saying. Yet too many fail to grasp the real meaning of what they know to be true. This word, *clean*, is the same word and has the same meaning as that word, *clean*, used to describe the desirable condition of a Sunday shirt.

In spite of all these precautions some germs will find their way into the milk. If they did not increase in number their presence would not be especially harmful. Milk, however, is an ideal food for them and precautions must be promptly taken to check their growth. At a temperature of from 70 degrees F. to 90 degrees F. their development is probably most rapid. At below 60 degrees F. it is comparatively slow. Dr. Russell found in a sample of milk, held for twenty-four hours at 59 degrees F. one hundred and sixty-three times as many germs as at first; while in milk held for the same length of time at 77 degrees F. he found over sixty-two thousand times as many as at first. As the temperature of the body of the cow is about 100 degrees F. the necessity of using every available means to cool the milk down to 60 degrees, or better lower, as soon after milking as possible, is very apparent. For this work the use of an aerator is indispensable. The aeration of the milk, aside from the cooling, is especially beneficial when the milk is to be used for cheese making.

Unclean utensils are another cause of bad milk. The fact that a milk pail looks clean should not be taken as evidence that it is clean. It is well to remember that the agencies directly causing the souring of milk are invisible. Belief in the cleanliness of dairy utensils should be based, then, upon faith, not sight; and no faith should be put in any method of washing which does not include the use of boiling water. No means less effective will leave them in any degree free from germ life.

The almost universal practice of returning the skim milk to the farm in the same cans used for carrying the sweet milk to the factory is a custom which, in this climate, is to be deplored, for the reason that the skim milk is almost invariably sour before it reaches home. The cans in which the milk goes to the factory should be emptied, washed, steamed and dried before they leave it and a different set used for the skim milk.

Success in dairying is dependent upon four things: good feed, good cows, good product and a good market. Good product comes, not as a result of good feed or of good cows alone, but also as a result of good care. There is a market for good product only.

G. H. TRUE,
Department of Animal Husbandry.

BLACK ALKALI.

NO. 11, MARCH 1.

Black Alkali, though a white substance, is so named because in contact with the vegetable matter of wet soil, it produces the dark appearance so well and unfavorably known to the irrigation farmer. It is the same in composition as common washing soda, which resembles the caustic principle of wood ashes extracted in common lye. It is chiefly formed by the decomposition of granitic rocks, and when the natural rainfall and drainage are not sufficient to carry it away it remains in the soil.

Southern Arizona, being semi-arid and traversed by many granite mountain ranges, contains some black alkali in the agricultural soils, though the amounts are not excessive excepting where irrigation has caused concentration of the alkaline salts.

This fortunate deficiency is probably in part due to those occasional downpours of rain characteristic of the southwest, which suddenly flood the surface of the country and which probably at such times sweep away large amounts of soluble alkaline salts. This, indeed, has been observed to be true, as shown by the changed character of the salts in solution in Salt River in time of flood.

The limit for black alkali in a soil varies with the kind of crop and the nature of the soil. Sugar beets, for instance, are more hardy than grains, and plants from arid countries usually

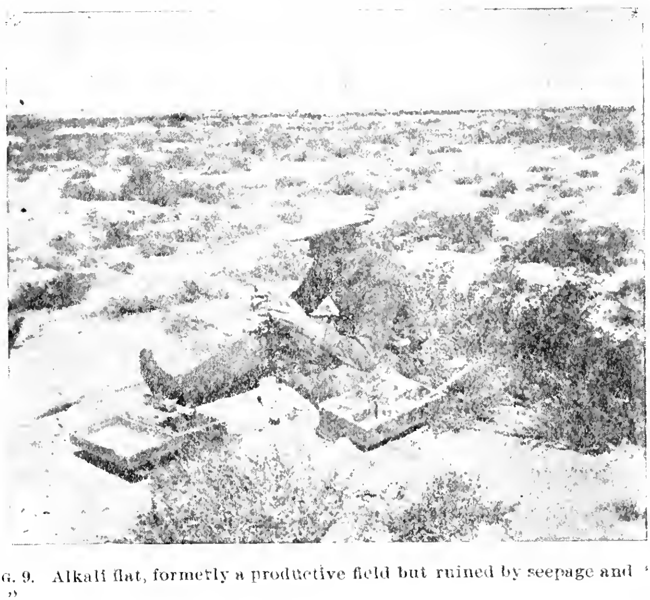


FIG. 9. Alkali flat, formerly a productive field but ruined by seepage and "rise of alkali."

endure more alkali than those from humid regions. Clay soils, more than sandy ones, are injured in tilth by black alkali. In general, 0.1 per cent of black alkali in the two top feet of soil will prove destructive to most crops.

The injurious effects of black alkali are brought about in various ways; it destroys the tilth of heavy soils, causing them to become cloddy and difficult to cultivate. Also, in presence of water, it dissolves the humus or vegetable mould in the soil and thus allows of its removal. But the worst effect is its corrosive action directly upon the plant at or near the surface of the ground where, especially in hot, dry weather after an irrigation, the alkali, as an effect of evaporation, collects in the form of a crust.

In Salt River Valley the average of twenty analyses shows only .044 per cent of black alkali, but at some of the lower levels where the ground is subirrigated by water from the canals, black alkali exists in destructive amounts, having been concentrated through the action of irrigating water.

The seepage from such localities carries black alkali in solu-, tion, as is the case in Jenkin's seepage ditch near Double Buttes, southwest of Tempe. On the other hand, Salt River has been observed to contain lime in the form of gypsum, which is an antidote for black alkali. At a time of high water this upper-river water may modify or overcome the alkaline character of seepage water. It is therefore probable that lands lying under seepage canals are at some times benefitted, apart from the addition of silt, by the application of upper-river water.

The best remedy for alkaline salts of any sort, where drainage is possible, is to flood the ground for a sufficient time, many days if necessary, to carry the salts down and entirely away into the country drainage. This is practiced in Utah and is stated to have been done near Buckeye.

In small areas of valuable lands, gypsum, in a well drained soil, can sometimes be used with economy to overcome black alkali. One ton per acre of gypsum would overcome about .036 per cent of black alkali in the surface foot of soil. Gypsum exists near Vail's station, twenty miles east of Tucson, and the chief cost would be that of transportation.

Much land is being cleared at this time of year in preparation for planting, the brush often being collected in great piles and burned. Since ashes contain black alkali in considerable amount, the site of an old brush fire may easily be marked by an alkaline spot in years to come. It would be better to drag the brush to the roadside where possible, or burn it in very small piles so as to distribute the alkaline ashes.

Ashes, also, are sometimes used here as a fertilizer. In Eastern states, where the rainfall prevents the accumulation of alkali this may be permissible; but in arid regions the alkali thus added, plus that already present, may be injurious, while the potash, for which the ashes are chiefly valuable, is already abundant in most Arizona soils.

R. H. FORBES,
Department of Chemistry.

WHITE ALKALI.

NO. 12, MARCH 15.

White Alkali, notwithstanding its fair name, is probably guilty of greater crimes against agriculture in Arizona than its "black" partner. This is because it is present in our soils in much greater total quantity, although pound for pound it does not do so much damage.

The chief constituents of white alkali are common salt, and sodium sulphate, better known as Glauber's salt. Chlorides and sulphates of calcium and magnesium sometimes also occur. All of these salts result from the weathering of certain rocks, especially those of volcanic origin, and like all forms of alkali, though soluble in water, remain in the soil because there is not sufficient drainage to carry them away. In some parts of Arizona, deposits of rock salt, and of calcium and sodium sulphates, probably formed by the evaporation of ancient salt lakes, are exposed and find their way into our rivers. Through irrigation and evaporation these dissolved salts are carried upon cultivated lands and left there. The origin and quality of our irrigation waters is therefore a matter of greatest importance.

The white character of alkaline salts in southern Arizona is shown by twenty analyses of virgin soils from Salt River Valley, which averaged about twice as much of sodium sulphate and chloride as of sodium carbonate. As far as has been observed, the same holds true of the upper Gila valley. The Salt and Gila rivers, also, at most times, carry only the white alkaline salts in their upper courses.

The quantity of these salts in a soil which may be endured by vegetation varies according to the kind of crop, the variety of soil, drainage and method of cultivation. In general from 0.1 to 0.5 per cent of alkaline salts, according to the kind, is fatal to most cultivated crops. Sulphate of soda is least harmful, common salt next, and carbonate of soda most injurious of the three.

On this point Dr. Hilgard says that for barley the largest amount of alkaline salts that can be tolerated in the soil and subsoil, under otherwise favorable conditions, and with salts consisting of not over half of carbonate of soda, lies somewhere between .150 and .203 per cent of the soil. Whitney and Means state that "The limit of excess of alkali in the soils at Billings (Montana) * * * * was found to be about .45 of one per cent. This is equivalent to about 15,000 pounds per acre one foot deep." The character of the alkali at Billings is stated to be entirely "white" thus permitting the presence of a larger percentage than if carbonate of soda were present.

As in the case of black alkali, white alkali does most of its damage near the surface of the soil. When in solution in ground or irrigating water it is carried with the water wherever it goes, until evaporation occurs, when it can no longer follow.

At the surface of the soil, therefore, where evaporation takes place, the alkali concentrates until it is locally destructive to plants. It follows that where and when evaporation is greatest this process of concentration is most rapid. In hot and windy weather, or in exposed situations the "rise of the alkali" for this reason occurs most promptly.

The most effective cure for white alkali is removal by flooding and drainage. This method of course requires abundant water and good drainage, and can by no means be applied to all situations. Some of the most alkaline districts in Arizona are very favorably situated for drainage. South of Tempe, in the Buckeye country, and on the upper Gila, water is comparatively abundant, and these lands, being underlaid in some localities by gravel and lying near the river, are admirably drained. There should be little difficulty in flooding the alkali from at least portions of all these districts.

But where water is scarce and drainage is poor, other expedients must be taken. Deep cultivation is one of these. The more deeply an alkaline crust is plowed under the longer will it take to again concentrate at the surface, and in the interval a crop of grain or alfalfa may be so established as to shade the ground and, by thus lessening evaporation, still further hinder the "rise of alkali."

It has been said that he who improves a plow so that it will go an inch deeper with the same labor, is among the greatest benefactors of mankind, and the saying applies with special significance to alkaline lands.

The temporary benefit thus gained is in a measure permanent, for every crop grown on alkaline soil absorbs and removes a portion of the injurious salts and in time will perceptibly lessen them. The successful reclamation within the past three years of certain apparently hopelessly alkaline fields south of Tempe is an admirable illustration of the merits of this method.

Another expedient against alkali is furrow planting. Sorghum, for instance, is sown in furrows and water turned on. The alkali is in this way dissolved and, for the time being, carried below while the seed makes it start. By the time that the alkali concentrates again at the surface the young plants are sufficiently established to endure its presence.

Still again, plants may be chosen which will withstand alkali. Bermuda and salt grass for instance will flourish where other grasses will quickly disappear. Alfalfa, sugar beets and sorghum will endure much more alkali than grains, and among shrubs and trees the pear, pomegranate, fig, oleander and date palm are most resistant.

R. H. FORBES,
Department of Chemistry.

SELECTING DAIRY COWS.

NO. 13, APRIL 1.

The task of selecting a dairy herd is one that should be entered upon with a great deal of thought and care. The animal that is to be fed for beef is chosen for its supposed ability to make meat and at the end of a comparatively short feeding period he goes to market; whether he has made money for his feeder or not, he goes to the block just the same. The dairy cow is selected for a long term of service and, if a good cow, should go on making milk and money for her owner for years.

As there is a wide difference in the capabilities of steers to make beef, so is there a still wider difference in the capabilities of cows to make butter. The intelligent dairyman, the business farmer, puts himself in a position to know which of his cows are being kept at a profit and which are not. The only way to do this is to determine and keep a record of the amount of milk and butter fat given during the year by each individual cow in the herd. The amount of butter fat given during the year is the first test of the value of a dairy cow. The scales and the Babcock test must be used to determine this.

The books of the creameries of Salt River Valley show that there are many dairy cows that, during the last four months at least, have not given their owners a profit; sixteen patrons of one creamery, milking one hundred and forty cows, have received but little over a dollar and a half per month per cow. Every creamery patron should at the end of the month divide the amount of his creamery check by the number of cows in milk, thus getting the gross receipts per cow for the month, then compare this with the amount he could have gotten by renting his pasture and conclude whether or not the difference has paid him the interest on his money invested in cows, the pasturage of his dry cows, and for the work of milking and delivering his milk to the factory. If the difference happens to be in favor of renting pasture, possibly the growth of the calves that are being fed on the skim milk from the factory will restore the balance to the right side of the account. If, even then, the difference in favor of the dairy cows is too small, let the man who wants to know the truth compare his profits with those of his neighbors before he concludes that dairying does not pay. He will find that some of his fellow patrons are getting handsome returns. The question is, Why the difference? The answer is, The cows.

As truly as there is a typical beef animal, broad, low, and blocky, just as truly is there a typical dairy animal, but of a different type. Sometimes we find a profitable combination of beef and butter in the same animal, but it is the exception rather than the rule. While the scales and the Babcock test should be depended upon for evidence to decide in the final judgment of a dairy cow, the eye should be trained as well to see those points of conformation that indicate a high productive capacity. In studying the form of some of the cows that have become famous for their great butter production one is struck by the fact that they look alike; in a general way they are all built after the same fashion,—Jerseys, Guernseys, Holsteins, Red Polls, or Dairy Short Horns, the type is the same. Now, how does this type differ from the beef type? Mainly in the lack of meat in the dairy animal on those parts of the body where the butcher most wants it. There are the same bright intelligent eyes with plenty of room between them and the wide muzzle and strong lower jaw that is seldom at rest. The neck is more slender and attached to light shoulders, sharp over the withers. There should be the same depth through the heart, denoting constitution, and the same big barrel, giving evidence of a large digestive capacity. Accompanying these there should be a good sized, well formed udder with four good sized, well placed teats, and, extending along the belly, prominent milk veins. The capacity of these milk veins is best determined by placing the finger in the milk wells, the holes where the veins turn through the body wall. Supporting this machinery there should be a strong framework, consisting of the high front quarters mentioned above, a prominent backbone with wide flat ribs a good distance apart, a lean loin, and wide strong hips. The hind quarters, like the front, should be light, not beefy, and wide apart. All through there should be indications of capacity. Such cows make good use of their feed; they put the fat in the pail instead of on their backs. Experienced dairymen have found that this is the type of a cow that it pays to buy and keep. Now that the price of beef is high dairymen should get rid of the other sort.

G. H. TRUE,
Department of Animal Husbandry.

THE "ADOBE HOLE."

NO. 14, APRIL 15.

In early times, when there were but few settlers, and each man was welcome to a continuous flow of water in his ditches, there was no need to store water for stock in the artificial ponds commonly known as "adobe holes" or "stock water tanks." But when increasing irrigation made it necessary to shut off the run of water from each ditch in turn, the farmers of the Salt River valley met the emergency by digging tanks large enough to hold sufficient water for their animals while their ditches were dry.

The device was cheap, and met the emergency; but there is serious question as to whether it should be permanently adopted. The adobe holes in Arizona are nearly all found in the Salt River valley. There are very few in the Buckeye country and on the upper Gila they are practically unknown. A recent count by an employee of the Experiment Station discovered 338 stock water tanks south of Salt River, and 291 to the north—a total of 629. The count was made from section lines and doubtless many were not seen. It is safe to say that there are 750 adobe holes in the whole valley. They are much more thickly placed south of the river, especially near Mesa, where the farms are small and many animals are kept. Under the Tempe canal there are very few, provision being there made for a continuous run of stock water. They are especially numerous along the principal laterals, and at the edge of cultivation where water is scarce. North of the river, where the ranches are larger and much grain and fruit are grown, they are fewer. South of Salt River, stock water tanks average 4.3 to the section on 79 sections; to the north they average 2.7 on 106 sections.

Such is the why and the where of the adobe hole; but its merits as a modern institution are seriously in question.

In the first place the quality of the water for drinking purposes, especially at flood-time, is bad. Chemical analysis, and, oftentimes, the evidence of one's own nose and eyes, show it to be full of animal and vegetable impurities swept into the water courses from the surface of the desert. Last November when the river was clear and apparently at its best, a sample taken at Point of

Rocks, near Tempe, was found by the chemists of the Station to contain excessive amounts of organic matter and ammonia, and no less than 400 times as much nitrous nitrogen as is commonly considered permissible in a drinking water. These substances are not poisonous in themselves, for both men and animals use and sometimes even prefer river water; but these impurities afford food for bacterial forms of life, some of which may cause disease.

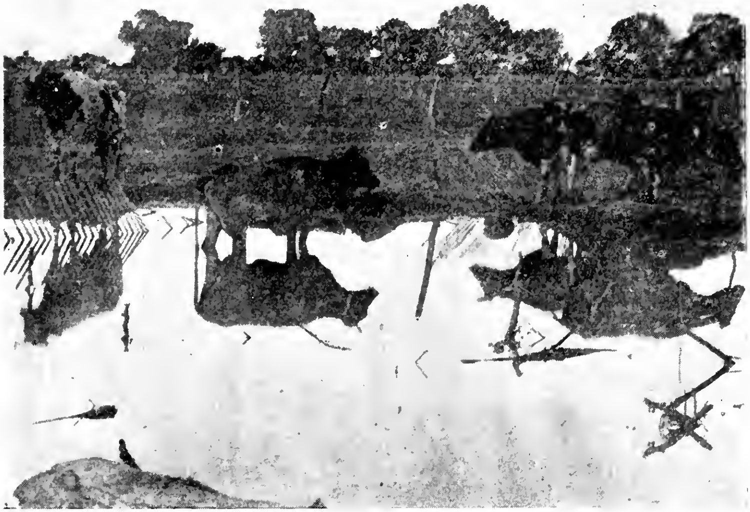


FIG. 10, An adobe hole, or stock water tank, near Phoenix, Ariz.

Especially in warm weather, where such water is allowed to stagnate in stock water tanks, these germs multiply enormously. Of course a certain disease germ may or may not be present, but such conditions invite and favor its development. There is no question that the germs of hog-cholera and black-leg, both of which have caused serious losses in Salt River valley, are propagated in the stagnant water of these tanks. The doctors state, also, that the same cause is responsible for much disease and mortality among the farming population.

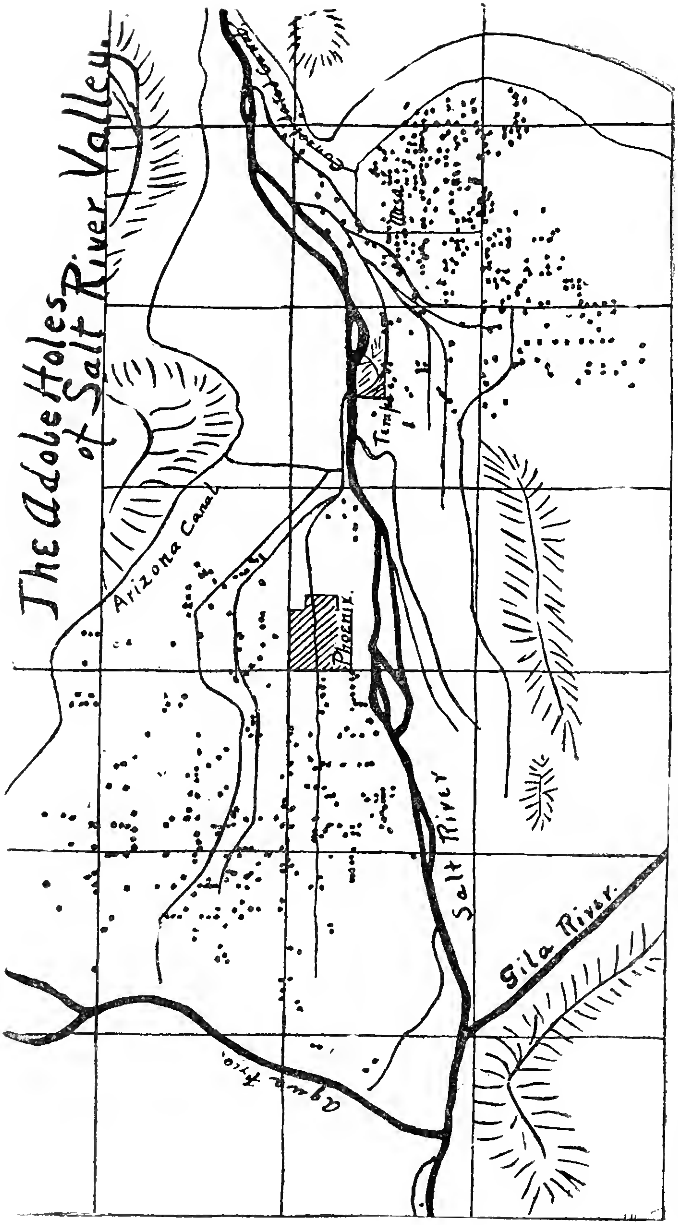


FIG. 11. Map showing location of Adobe Holes in Salt River Valley.

Again, the adobe hole is notoriously in conflict with dairying interests. When a cow wades belly deep into a filthy tank, festering in the heat, and fouled with excretions, her milk will inevitable suffer. Not only will the foul odors of the water she drinks be imparted in some measure to the milk, but millions of bacteria, adhering to her hair and udder will, when she is dried off and milked, find their way as dust into the milk pail. Quick souring of milk in warm weather and undesirable changes in butter and cheese, caused by bacteria, result.

One sample of water from an adobe hole near Phoenix was found by Dr. Tyler, cf the Station, to contain over a billion germs to the cubic inch. The possibility, indeed the certainty, of contamination from such a source is evident. A creamery manager, in defense of his own business, is manifestly justified in refusing milk from a herd using such water, and the Tempe creamery is stated to have successfully required that its patrons obtain well water for their cows.

Stock water tanks and streams are also wasteful of water. The seepage and evaporation from large canals sometimes amounts to 30 per cent of the water carried, and from tanks and small streams such as are permitted under the Tempe canal, it is undoubtedly more.

There is indeed little to be said in favor of the adobe hole, but we have not far to go for a remedy. Under our feet, for the most part within economical pumping distance, is a great storage reservoir of excellent drinking water. South of the river it is from four to fifty feet to this supply while only at the higher levels above Phoenix is it as much as one hundred feet to water.

It has been sufficiently proved by practical men, especially at the lower levels, that windmills and horse power pumps are successful and desirable for watering stock. For instance, Dr. Wilbur, of Mesa, states that with a 5,000 gallon tank and a small windmill he has never run out of water for his stock. Most of the farmers about Mesa are also familiar with the cheap and efficient horsepower devices successfully operated in that vicinity.

In a few words, therefore, it may be stated that the adobe hole promotes contagious diseases among animals, is a drawback to high class dairying, is a source of ill health to human beings, and, together with stock water streams, is extremely wasteful of irrigating water.

With nothing but false economy in its defense, and an abundant supply of well water within easy reach, it may be properly classed in many localities as a public nuisance, and its early abolition by a progressive farming community is to be earnestly hoped for.

R. H. FORBES,
Department of Chemistry.

DEHORNING CATTLE.

No. 15, MAY 1.

The thought of saying something upon this subject was suggested to the writer by seeing a promising young bull suffering the loss of his horns by what seemed to be a most barbarous method. The poor brute had been thrown and was lying with three feet tied together, his head fastened to one post and one hind foot drawn back by pulley and tackle to another. Three men and a boy were working about his head helping to saw off the horns. The dry powdery manure of the corral was used to stop the flow of blood. The operation of dehorning must cause some pain but it need not be accompanied by such rough handling as to endanger the future usefulness of the animal dehorned.

There are few men, if any, who have handled hornless cattle that do not appreciate the advantages of dehorning and who do not strongly advocate its practice. Not only is danger of injury from hooking avoided but the animals are more quiet and peaceable, giving better results in the milking corral and the feed lot. With the loss of their horns they seem to lose the desire to fight. It is no longer a question as to whether cattle shall be dehorned or not but a question of when and how to do it.

The old original method of dehorning was by use of the saw. It is still advocated by some and has the advantage of taking off the horn where other means sometimes fail. Clippers designed for the purpose are more convenient and as a rule more efficient. In the case of old animals not only do the horns themselves become very hard but the so-called pitch assumes a bony character such that it is sometimes impossible to cut them with clippers. In such cases the use of the saw must be resorted to. The mistake of sawing off the horns some distance from the head is sometimes made, the idea being that it is less painful to the animal than taking them off close. Not only is the operation no less painful but the remaining nubs detract from the appearance of the animal and sometimes grow, thus defeating the object of dehorning. Whether the saw or clippers are used the horns should come off close to the skull, always below the line where the skin grows about the base

FIG. 12. Calves dehorned by the use of caustic potash.

of the horn. There is sometimes a considerable loss of blood which may be lessened or entirely stopped by a simple method of "tying the arteries." These arteries lie mostly on the side of the horn toward the ear so that by drawing a string tightly around both horns and tying, pressure is brought to bear on the blood vessels and the flow of blood is stopped. After the string has been tied the pressure may be increased by bringing the front and back strands together over the top of the head and fastening them. In some cases cutting the horn close to the head makes an opening into a cavity of the skull. In such cases it is well to put a little medicated cotton over the opening to keep out flies and dirt. Should the animal in a day or two give evidence of pain by shaking its head an opening should be made in the cotton to allow the escape of matter which is sometimes formed inside. When a saw is used it is almost necessary to have a chute in order to properly hold the animal during the sawing operation. If clippers are used the use of a chute will save time but is not necessary. While the horns of young animals are more easily cut than those of old ones the operation is more painful and usually accompanied by a greater loss of blood on account of there being more sensitive tissue and a greater supply of blood vessels in the soft growing horn.

The best time to dehorn cattle is when they are calves, and the younger they are the better. Some will not agree with this statement, believing that animals never having horns retain their desire to fight and simply bunt instead of hook. During the first few days of the calf's life the horns to be are simply little buttons that are not attached in any way to the skull. They may then be removed by the use of a sharp knife, or by clippers made for the purpose, with very little pain to the calf and little or no loss of blood. Various chemicals and commercial dehorning fluids have been used for the destruction of the young horns. In the use of liquid preparations the greatest of care should be exercised to prevent the spread of the fluid. The use of caustic potash is perhaps the most to be recommended, it being cheap, easily applied and efficient. It comes in the form of sticks which for the protection of the fingers should be wrapped in paper when handled. A stick costing ten cents will dehorn ten or a dozen calves. The hair should be clipped from the horn and the skin immediately surrounding it, the potash dipped in water and the moistened end rubbed upon the horn. Repeat this three or four times or until the part seems sensitive. A scab forms where the caustic potash has been applied and when that comes off the horn comes with it. There is no wound made and therefore no danger of trouble from flies and screw worms. With the writer this method of dehorning has proved effective on calves up to a month old.

G. H. TRUE,
Department of Animal Husbandry.

DATE PALM CULTURE—A WORD IN TIME.

No. 16, MAY 15.

It has long been known that the date palm will live and bear fruit in the state of Sonora and adjacent portions of Mexico. There are a number of lofty palms at Hermosillo, for instance, that are probably 200 years of age, and 60,000 bearing trees exist in the single town of San Ignacio, Lower California. More recently, both by accident and design, seedling trees have been established in Southern Arizona and found to bear well.

FIG. 13. Date palms near Hermosillo, Sonora, about 175 years old.

Date Palm seedlings, however, as is usual with the seedlings from highly developed varieties of fruit trees, are likely to be inferior in quality of product, so that as yet the home grown trees of Arizona have for the most part yielded indifferent results. But in the date growing countries of the Old World the Arabs, and other races, have developed the date until in excellence and variety it corresponds with other cultivated fruits.

Knowing that the conditions, especially of climate, enable the tree to produce in Southern Arizona, it is evidently necessary to

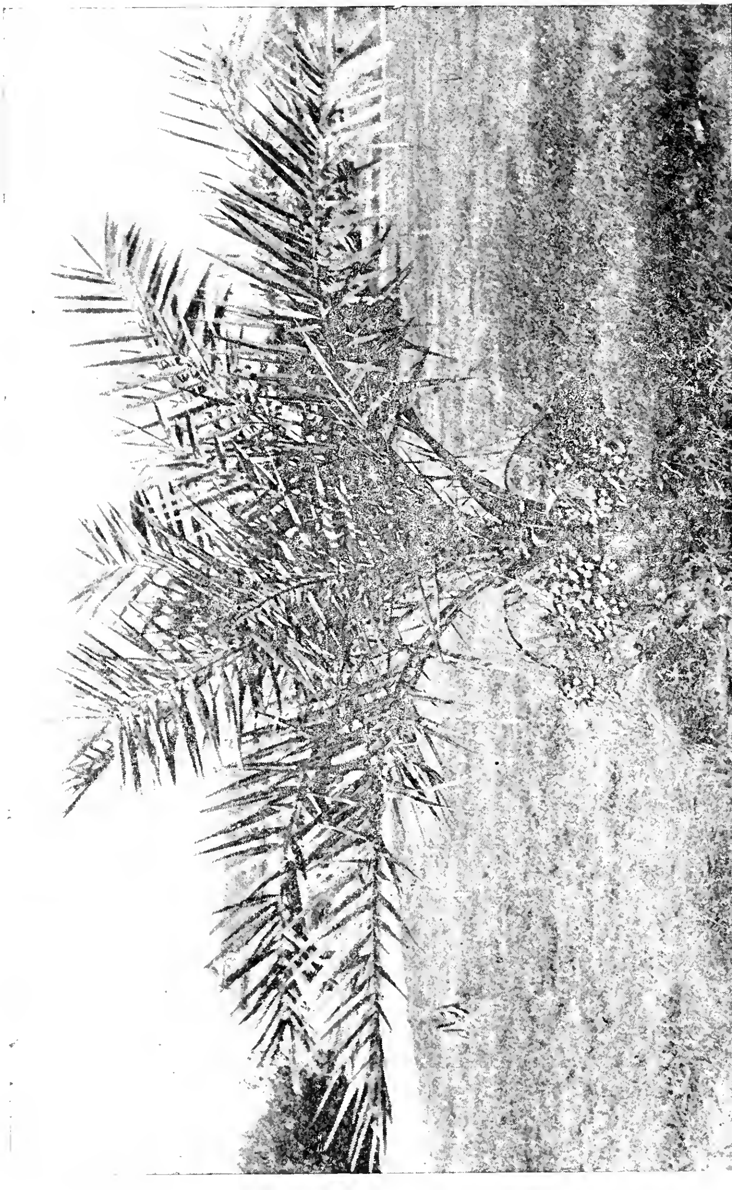


FIG. 14. Date palm on University grounds, Tucson, 4 years old, with 4 large bunches of fruit.

avail ourselves of the centuries of Old World experience, bring the best varieties from the Sahara, Egypt and Arabia, and establish them here.

This is what the Arizona Experiment Station with the help of the Department of Agriculture is now doing. One small importation, sent on to determine the best mode of shipment has been safely landed in the orchard south of Tempe and another large one is now just starting from Algiers.

The importance of quality is evident from the following examinations of 3 samples of fruit; No. 1 was purchased in Guaymas, Sonora, and came from Mexican seedling trees in Lower California; No. 2 was from the Tucson market, supposedly commercial African dates; No. 3 was a choice sample from Algiers by way of the Paris markets:

	Wt. of seeds.	Wt. of flesh.	No. per pound.	Quality.
1. Mexican seedlings.	25.0 p. ct.	75.0 p. ct.	93	Dry and poor.
2. Tucson market.	14.8 p. ct.	85.2 p. ct.	79	Indifferent.
3. Deglet Noor from Paris	9.7 p. ct.	90.3 p. ct.	53	Most excellent.

It is not surprising that the delicious large fruits of sample 3 sell for 35c in less than 1 pound boxes in the cheap markets of Washington, D. C., while Nos. 1 and 2 bring as low as 10c a pound in the dear markets of the Southwest.

It will be at least four years, however, before suckers will be available for distribution in any considerable number from the experimental orchard, and even then a transplanted sucker requires several years to come into heavy bearing. The date palm is famously slow to yield returns, indeed the Mexicans call it "El arbol del porvenir," the tree of the future, but it has corresponding advantages: 1. It will grow in the strongest alkaline soil and its roots thrive in the alkaline ground water often found at or below the surface of such soils. In any irrigated district, at the lower levels, there are usually considerable areas of alkaline lands with water near the surface, resulting from the seepage from higher levels. When once established in such a locality the date palm is independent of irrigation and is not injured by alkali. South of Tempe in the alkali strip a number of handsome palms are to be seen, some of them on ranches which have been abandoned for years and upon which most crop growth has been destroyed by the alkali. The writer followed a root of one of these trees six feet down into hard pan and 8 inches below the surface of ground water. 2. The Date Palm lives and bears to a great age—for scores and even centuries of years. 3. Conservative estimates indicate that desirable varieties should yield a very profitable crop—and this upon lands otherwise worthless unless reclaimed by expensive drainage.

Although the best varieties are at present only to be had in Eastern countries, certain preparations can be made against the time when good suckers shall be available. The date palm is dioecious, bearing male and female flowers on separate trees. Any orchard must have a suitable proportion of male trees, say one in ten, to fertilize the female blossoms which develop into fruit. It is well to establish these trees in advance of the others in order that abundance of pollen shall be available when it shall be wanted. These male trees may be raised from seed, no special variety being demanded for fertilization. Every farmer in the warmer parts of Southern Arizona, from San Carlos west and south, will do wisely to plant a handful of date seeds along his ditch banks, where constant moisture will reach them—not next year or the year after, but now.

Perhaps half the resulting trees will be males, and may be transplanted as desired into the future orchard for the fertilization of first class suckers. A small proportion of the females may produce desirable fruit, and are more likely to do so if the seed comes from good fruit. The Experiment Station has a quantity of seed from the best varieties of Algerian dates which will be sent, for the purpose named, to those desiring them.

R. H. FORBES,
Department of Chemistry.

SUMMER CULTIVATION.

NO. 17, JUNE 1.

During this season of scanty water supply it is very important that every possible means of conserving the available water be resorted to. Thorough cultivation is one means of compensating for a shortage of irrigating water. Orchards and all crops planted in rows may be made more productive during dry weather by keeping the surface of the soil well pulverized.

The effects of cultivation are three-fold—(1) the aeration of the soil, (2) the conservation of moisture, and (3) the destruction of weeds.

The aeration of the soil is very important. That the necessary biological and chemical processes may proceed properly in the soil, a constant supply of oxygen is essential. If these processes cannot continue, a crop may starve, though there be an abundance of raw material in the soil. After rains and more especially after irrigation most soils form a crust over the surface, or "bake" to some depth, and thus free access of air is prevented. Cultivation breaks up the surface and promotes the aeration of the underlying soil.

The conservation of moisture by cultivation is based on well-established principles. During a rainstorm or during irrigation, the water received by the soil moves downward. As soon as the supply from above ceases and the free water settles away, by capillary action the movement of the moisture in the soil sets in in the opposite direction, moving upward as well as downward. As the moisture reaches the surface, it passes off as vapor. Only by preventing the water reaching the surface can this evaporation be checked. The capillary action by which the water reaches the point where it evaporates can go on only in a closely packed soil furnishing the innumerable, minute, irregular tubes through which the water rises. To break up these tubes checks this upward movement. Cultivation not only breaks up the capillary tubes of the surface, but forms over the surface a mulch that prevents rapid evaporation. The moisture will then rise to the mulch, but cannot pass beyond it by capillary action, and evaporation thus proceeds much more slowly than if the moisture were permitted to follow the capillary tubes to the surface.

Samples of soil taken recently in an orchard illustrate the foregoing. The orchard in question had been irrigated last on March 5. Most of it had been thoroughly cultivated; but a portion had been left uncultivated, and had become overgrown with weeds. A determination of the per cent of water in each of the five upper feet in each area May 23 gave the following results:

	Cultivated.	Uncultivated
First foot	7.3	3.8
Second foot	12.6	8.1
Third foot	15.6	10.5
Fourth foot	15.0	11.6
Fifth foot	12.1	11.7
Totals	62.8	45.7

It will be seen that as a whole the upper five feet of soil in the cultivated area contained over a third more water than the upper five feet in the uncultivated area. But when only the available water in each is taken into consideration, the difference is much greater. Plants cannot remove all the water a soil contains. In such a soil as the above, at least five per cent would be left in it after the rootlets had removed all they had power to remove. Making this deduction, the soil in the cultivated area would be found to contain about twice as much available moisture as that in the uncultivated area. Making the statement in another form, the loss of water from the uncultivated area from March 5 to May 25 exceeded the loss from the cultivated area by the equivalent of over 2 inches of rainfall. To replace this loss from a ten-acre field would necessitate the running of a stream of 100 miner's inches for about ten hours.

In order to produce the best results the soil must be so cultivated, however, that it is not left broken up into large clods that will permit the air to reach the underlying strata. The finer and looser the surface mulch the better, and in our arid region it needs to be deeper than elsewhere.

Weeds injure growing crops by appropriating the available plant food and by removing water from the soil. While a soil may be very fertile, there seldom is present enough plant food, in the form necessary for the use of plants, to support a crop of weeds and a crop of fruit, grain, or vegetables at the same time. But weeds usually do the greatest injury by removing from about the roots of the crop the water needed by it. Not only do weeds require water for their increase in size, but water is continually evaporating from the surface of their leaves. While they may shade the surface of the soil so as to check evaporation there, the evaporation from their leaves is much more rapid than it would be from the surface of the unshaded soil, if it were properly cultivated. Thus, the destruction of weeds by cultivation not only curtails the loss of plant food and of water, but the process produces all the desirable conditions of the soil mentioned above.

A. J. McCLATCHIE,
Department of Agriculture and Horticulture.

GRAZING VERSUS IRRIGATION.

No. 18, JUNE 15.

At the present time there is much controversy in Arizona as to the disastrous effect of grazing, more particularly sheep grazing, in lessening and rendering less constant the flow of water from the mountain regions to the irrigated valleys.

It is a well known fact that the agricultural interests of Arizona depend entirely upon the amount of water available for irrigation and further, that all this available water flows from the wooded mountain regions to the valleys below where it is taken from the streams through canals and ditches to the various farms.

The development of irrigation in Arizona has raised the value of thousands of acres of land from practically nothing to a maximum value of one hundred dollars or more per acre. It has made possible the building of villages and cities in regions which without irrigation would be uninviting and uninhabitable.

Through irrigation, agriculture in Arizona has prospered until today it is the greatest and most enduring industry in the Territory and gives employment directly and indirectly to more people than all other industries combined. When we consider the great value of available water to Arizona agriculture we can readily see the necessity of giving the closest attention to its conservation and of guarding against every condition that can be overcome by man that lessens or renders more irregular its flow.

It is universally recognized the world over that soil covers, including forest, chaparral and all other vegetable growth as well as the litter and humus from this growth, are the great conservators of moisture. All growth tends to bind the scanty soil to the rocks and to hold back the rains and melting snows until they sink into the earth to appear later as perennial springs and give constant flow to the rivers from which practically all water is drawn for irrigation purposes.

The agriculturists of the Territory contend that grazing, more particularly sheep grazing, on the watersheds of the irrigating streams has gradually shortened the time of flow of the streams and rendered them more irregular.

During the past several years sheep grazing has extended over large portions of all the watersheds from which our longer streams are fed and the smaller growth is each year becoming less and less.

In recent years four forest reserves have been segregated from the public domain in Arizona. Of these reserves, two, viz: the San Francisco and the Black Mesa include portions of the highest and most valuable watersheds in Arizona. They are the feeders to the most important tributaries of the Salt River, the most valuable stream in Arizona. The ostensible purpose in segregating these reserves was to protect the watershed of the Salt River. The timber consideration was only secondary.

The question at controversy is as to whether these reserves should be thrown open to be grazed without restriction and as to whether it is advisable to graze sheep upon them at all. This is purely an economical question and should be decided upon its merits.

In a sense there are three crops which can be harvested from these reserves, viz: timber, grazing and water. Each of these has a market value and taking one year with another can be represented by a definite sum. It stands to reason that the crop from any of these forest reserves which brings to the people of the Territory the greatest annual income without lessening or destroying the possibility of continuing this income from year to year, is the crop which should be protected, and so far as the others interfere with it they should be eliminated. If it can be shown that the returns from grazing, taking one year with another, are greater than the returns from increased agricultural operations, resulting from a larger or more constant water supply arising from the non-pastured watershed, grazing should not be prohibited or restricted. But if the reverse be true a rigid restriction should be placed on every animal that grazes upon the watersheds of Arizona supplying the streams from which water is drawn for irrigation.

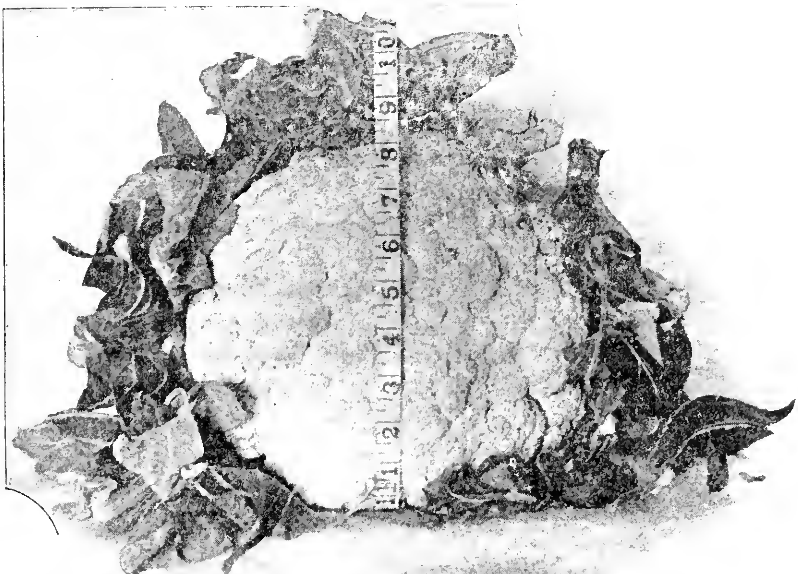
The Division of Forestry of the United States Department of Agriculture will, during the present year, make a careful investigation of sheep grazing on all the forest reserves in the United States. This investigation is now in progress in the forest reserves in Arizona. As this question is of such vast importance to the people of Arizona it is imperative that the truth be ascertained. In order that every facility be given the Government officials who are now investigating our forest reserves it is requested that all persons interested communicate with the Experiment Station, giving specific illustrations from their own experience bearing upon whichever side of the controversy they may support. It is the intention of the Station to place this material in the hands of the persons making the investigation.

J. W. TOUMEY,
Department of Botany.

University of Arizona

Agricultural Experiment Station.

Bulletin No. 35.



Burpee's Dry Weather Cauliflower.

Vegetable Growing in Southern Arizona.

By ALFRED J. McCLATCHIE.

Tucson, Arizona, August 15, 1900.

ARIZONA AGRICULTURAL EXPERIMENT STATION.

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The Bulletins of the Station are sent to all residents of Arizona applying for them.

Address:

EXPERIMENT STATION,
Tucson, Arizona.

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FIG. 2. View in vegetable garden at the Station Farm.

VEGETABLE GROWING IN SOUTHERN ARIZONA

By Alfred J. McClatchie.

INTRODUCTION.

So much relative to vegetable growing remained to be settled by careful experiments, and the requests for information have been so numerous, from visitors and by mail, that it seemed important that systematic experiments be conducted at the Station farm near Phoenix, and a bulletin embodying the results issued. Work along this line was begun during 1898, and is still in progress. The farm, situated as it is about midway between the warmer, dryer region about Yuma, and the cooler valleys of the Verde and the upper Gila, is fairly well located to give results that will be applicable to most of southern Arizona.

The data upon which this bulletin is based have been drawn not only from our own experiments, but have been obtained from market gardeners, and other vegetable growers in various parts of the Territory. In this connection, the writer, upon behalf of the Station, wishes to thank Lewis Wetzler and E. J. Gleason, Phoenix; Geo. Cobb, Glendale; T. P. Banta, Mesa; C. N. Nichols, Thatcher; F. Hubbard, Pima; M. Winsor, Yuma, and all others who have so kindly contributed data from their experience.

CLIMATIC CONDITIONS.

Our climatic conditions are so different from those of most of the remainder of the United States that the growing of vegetables by those without previous experience here is usually attended with many difficulties. However, acquaintance with our peculiar conditions usually enables one to overcome many of the difficulties encountered.

The climate of southern Arizona is essentially a desert one. The rainfall being but three to ten inches per year, the air is most of the time too dry for the growth of some plants, even if an abundance of water be supplied to the roots. There being no large body of water near to modify the temperature, the difference between summer and winter and between day and night is much greater than in the same latitude near the Coast. For some vegetables the summers are too hot and the winters too cold, only a short period between the extremes being suitable for their growth. The change from the cool weather of winter to the hot weather of summer, and from the latter to the cool weather of autumn being usually very rapid, plants that are adapted to one season are often overtaken by the conditions of the next, and their growth checked before reaching full maturity. Vegetables that can endure neither frost nor extreme heat have but a short period during which to make their growth. Another feature of our climate is the variableness of the seasons, causing what will succeed one year to fail or do poorly the next.

The peculiar conditions existing here make it important that suitable varieties of each vegetable be sown,—varieties that are adapted to these conditions. Varieties that thrive elsewhere, even in seemingly similar localities, may fail utterly here, while the proper varieties of the same vegetables will succeed.

Besides the climatic conditions mentioned, there is the ever perplexing question of the proper application, artificially, of the needed water that the clouds fail to furnish;—How much water to apply, how to apply it and when.

In undertaking vegetable growing, all of the above facts need to be taken into consideration. The wise thing to do is to make the most of the natural conditions, expect some failures, and profit by them. Continued effort will usually be rewarded with success.

Notwithstanding the difficulties mentioned, fresh vegetables may be taken from the garden throughout the year. Those not so situated that they can give regular attention to the vegetable garden will have fewer disappointments, however, and more vegetables for the table, if they depend upon the market gardener for their daily supply. But those who do not reside where they can be served by a gardener, and who for other reasons wish to attempt the growing of their own vegetables, will find it possible to provide for the table those they need, if they devote sufficient time and thought to the work. There are many pleasures connected with gardening, even under the somewhat trying conditions of southern Arizona.

CLASSES OF VEGETABLES.

In respect to their relation to temperature, vegetables may be divided into three fairly distinct classes: (1) those that thrive only during cool and moderately cool weather, and endure temperatures as low as 15 to 20 deg. F., (2) those that grow well only during moderately warm weather and do not endure temperatures below 30 deg. to 32 deg. F., and (3) those that thrive only during warm or hot weather.

To the first class belong the beet, cabbage, carrot, cauliflower, endive, kohl rabi, lettuce, parsley, parsnip, radish, salsify, spinach and turnip. It will be seen that, with the exception of cauliflower, the list includes only those vegetables of which the leaves or roots are eaten. All of these can be grown in southern Arizona during autumn, winter and early spring, but cannot be successfully grown during the heat of summer. They do best if put out during September and October, or during January and February.

The second class includes beans, peas, potatoes and tomatoes, vegetables grown during spring and during early autumn. The vegetative part of peas endures most of the low temperatures of our region, but the blossoms and young pods are quite sensitive to frost. Tomato plants usually remain alive during the heat of summer, but in the warmest parts of southern Arizona produce little or no fruit. Vegetables of this class must be planted so as to make their growth between the frosts of winter and the extreme heat of summer.

To the third class mentioned belong corn, cucumbers, egg-plant, melons, peppers, sweet potatoes, pumpkins and squashes, including, with the exception of sweet potatoes, only those vegetables of which the fruit (that is, the seed-bearing part) is used for food. These thrive during summer. Corn, however, might more appropriately be placed in the second class, since the seed producing organs are injured by the extreme heat of summer, in some parts of southern Arizona.

Besides the above vegetables, there are two—celery and onions—that require a large part of our year for their development.

WHEN TO PLANT.

Information concerning when to plant particular vegetables seems to be more in demand than any other. For convenience, the facts are tabulated below. The table will indicate approximately when each vegetable may be planted with hope of a successful outcome. The dates are intended to apply specially to the region about Phoenix, the climate of which is intermediate between that of the extreme south-western part of Arizona, and the valley to the east. At Yuma, for example, plantings could be made as a rule a few weeks earlier in the winter and spring and a few weeks later in the summer and autumn; while at Safford, on the other hand, plantings would be later in winter and spring and earlier in the summer and autumn in most cases. In a few cases, however, even the slight existing difference in climate makes it advisable to plant at quite different times than the ones mentioned. The best time to plant any particular vegetable must be determined for the locality in which one is residing:

Asparagus seed or roots—January to March; October and November.

Beets—January to March; August to November.

Beans—March and April; August and September.

Cabbage seed—August to October; upper Gila—February and June; plants—January and February; September to November; upper Gila—April and July (F. Hubbard.)

Carrots—January and February; August to October.

Cauliflower seed—August and September; plants—September and October.

Celery seed—January to March; plants—August to October.

Corn—February to April; July; cool valleys—May and June.

Cucumbers—March to May; August and September.

Egg-plant seed—January to March; plants—April to June.

Kohl Rabi—January to March; September and October.

Lettuce—January and February; August to October.

Melons—March to July.

Onion seed—September and October; sets—November to January.

Parsley—January and February; September and October.

Parsnips—January; October.

Peas—January and February; August; November and December.

Peppers—January to April.

Potatoes—January and February; August and September.

Pumpkins and *Squashes*—February to April; June.

Radishes—January to April; August to December.

Salsify—January and February; October.

Spinach—January and February; September to November.

Sweet-potatoes—April to June.

Tomato seed—January to March; plants, April.

Turnips—September to January.

With many the question will arise "What may be planted at this season of the year." The following summary will show what vegetables may be planted during any particular month:

January:—Asparagus seed and roots, beets, cabbage plants, carrots, celery seed, egg-plant seed, kohl rabi, lettuce, parsley, parsnips, peas, pepper seed, potatoes, raddishes, salsify, spinach, tomato seed, turnips.

February:—Same as above with the addition of corn, pumpkins and squashes.

March:—Beets, beans, celery seed, corn, cucumbers, egg-plant seed, melons, pepper seed, radishes, tomato seed.

April:—Beans, corn, cucumbers, egg-plants, melons, pepper plants, pumpkins and squashes, sweet-potatoes, tomato plants.

May:—Egg plants, sweet-potatoes.

June:—Pumpkins and squashes for autumn and winter use.

July:—Corn.

August:—Beets, beans, cabbage seed, carrots, cauliflower seed, celery plants, cucumbers, lettuce seed, peas, potatoes.

September:—Beets, beans, cabbage seed and plants, carrots, cauliflower seed and plants, celery plants, kohl rabi, lettuce seed and plants, onion seed, parsley, potatoes, radishes, spinach, turnips.

October:—Asparagus, beets, cabbage seed and plants, carrots, cauliflower plants, celery plants, cucumbers, lettuce, onion seed, parsley, parsnips, radishes, spinach, turnips.

November:—Asparagus, beets, cabbage plants, peas, radishes, spinach.

December:—Peas, radishes.

PREPARATION OF THE SOIL.

A very important step in gardening is the proper preparation of the soil. Much time may be saved and many failures avoided by giving due attention to this part of the work.

Most vegetables grow best in a sandy loam, but with proper care they may be successfully produced in quite a variety of soils. When a choice is practicable, a soil fairly retentive of moisture, but not inclined to bake and crack when dry should be selected for the garden spot. The majority of the soils of southern Arizona contain a good supply of all the elements required by plants, except nitrogen; but many of them do not possess the physical properties that are desirable in a garden soil. Some are too sandy or gravelly, and hence so porous that they do not retain water properly; while others consist of a fine adobe that is very adhesive when wet and very hard when dry. The sandy soil may be improved by the addition of well rotted manure and other fine material that will cause the soil to be more retentive of water, and more fertile as well. Adobe soil may be improved by applying strawy manure or other coarse material that will make the soil less adhesive when wet and less inclined to bake and crack when dry. The growth of alfalfa upon any soil improves its physical condition and adds the desired nitrogen as well. When possible, it is best to select for a garden a piece in which alfalfa has been grown. If more than one grade of soil is available, the lighter one should be used for winter vegetables. One that is heavier and more retentive of moisture will be better adapted to the growth of vegetables during summer. Having selected a garden spot and applied manure, if it is needed, the next step is to plow it deeply and harrow it thoroughly.

PREPARATION FOR IRRIGATION.

Since in our region all vegetables are irrigated at some stage of their development, the contemplated method of irrigating them must be taken into consideration when they are planted. With reference to their subsequent irrigation, vegetables may be planted in four different ways:

1. They may be planted in level soil, as they would be where irrigation is not necessary or practicable, and then furrowed for irrigation when in need of water. This method may be pursued with many vegetables planted during winter in soil fairly retentive of moisture. From the latter part of November to February, beets, parsnips, peas, potatoes, radishes, spinach and turnips may be planted in the above manner, and will need no irrigation for some time after coming up. But the soil must be thoroughly irrigated just before its preparation for seeding, in order to make this possible. If this be done, and the seed be planted before the surface of the soil becomes dry, it wiil germinate before the required moisture has left the soil surrounding it, and for some time the roots will push downward faster than the soil will dry. Most of the vegetables mentioned above make a better growth by this method than by any other. As soon as they give evidence of suffering for water, it should be applied in freshly opened furrows.

2. A second method is to make furrows the distance apart the rows of the vegetable to be planted are desired, and wet the sides of the furrow by a stream of water run for a sufficient length of time to permit it to soak over several inches from the margin. Within a few days, when the soil has become dry enough to be stirred, the seed are planted along the margin of the furrow, and not irrigated until they are up. This method is especially applicable to beans, corn, cucumbers, melons, pumpkins, squashes, and to tomatoes planted in hills where they are to remain; and may be used in planting some vegetables with smaller seeds sown in drills. Most vegetables do better if started without irrigation between planting and germination, and the aim should be to pursue this method whenever practicable.

3. A third method is to sow the seed in dry or only slightly moist soil along the margin of furrows through which water is run

soon afterwards, the object being to furnish by irrigation water for germinating the seed. This is the method pursued with most vegetables planted during the summer and early autumn, when evaporation is so rapid that the soil about the seed becomes dry very rapidly; and is necessary at other times of the year in sowing small seed. Ordinarily, unless great care is exercised, as good a stand of young plants is not secured by this method as by those previously described.

4. A fourth method, practiced by some growers, is to throw up permanent ridges along the sides of which the seed is planted and between which the irrigating water is run. This system is applicable to the growing of nearly all vegetables, and in some soils gives fair results. Little or no opportunity is afforded or cultivation, especially with a horse, thus requiring much hand labor when weeds are growing vigorously.

It will be obvious that the preparation needed for irrigation must be varied to suit the soil, the plant to be grown, the time of year the planting is being made, and the convenience of the grower.

IRRIGATION.

In southern Arizona irrigation of all vegetables is essential. No definite rules can be laid down to govern those without previous experience along this line. The amount and frequency of the application of water will depend on the soil, the condition of the weather and the vegetables being grown.

The heavier (that is, the finer) the soil, the more water and the longer time will be required to saturate it, and, as a rule, the longer it will remain moist. Coarse sandy soils are more easily and quickly saturated, and retain water a shorter time. During dry, warm, or windy days soil loses its moisture much more rapidly than during moist, cool, or quiet ones; and the need of irrigation will be hastened. But whatever the soil, the weather or the vegetables, it has been pretty well demonstrated that at each irrigation the soil should be thoroughly soaked with water. The frequency of these soakings will be determined by the above factors, but the thoroughness of the operation will not be. One thorough irrigation followed by proper cultivation will, as a rule, produce much better results than two or more light irrigations with or without intervening cultivation. In all cases, the irrigating stream should be prevented from flowing over the soil about the plants.

CULTIVATION.

The effects of the cultivation of growing vegetables are (1) the aeration of the soil, (2) the conservation of moisture, and (3) the destruction of weeds.

The aeration of the soil is very important. That the neccessary biological and chemical processes may proceed properly in the soil, a constant supply of oxygen is essential. If these processes cannot continue, a crop may starve, though there be an abundance of raw material in the soil. After rains and more especially after irrigation, most soils form a crust over the surface, or "bake" to some depth, and free acess of air is thus prevented. Cultivation breaks up the surface and promotes the aeration of the underlying soil.

The conservation of moisture by cultivation is based on well-established principles. During a rainstorm or during irrigation, the water received by the soil moves downward. As soon as the supply from above ceases and the free water settles away, by capillary action the movement of the moisture in the soil sets in in the opposite direction, moving upward as well as downward. As the moisture reaches the surface, it passes off as vapor. Only by preventing the water reaching the surface can this evaporation be checked. The capillary action by which the water reaches the point where it evaporates can go only in closely packed soil furnishing the innumerable, minute, irregular tubes through which the water rises. To break up these tubes checks this upward movement. Cultivation not only breaks up the capillary tubes of the surface, but forms over the surface a mulch that prevents rapid evaporation. The moisture will then rise to the mulch, but cannot pass beyond it by capillary action, and evaporation thus proceeds much more slowly than if the moisture were permitted to follow the capillary tubes to the surface.

In order to produce the best results the soil must be so cultivated, however, that it is not left broken up into large clods that will permit the air to reach the underlying strata. The finer and looser the surface mulch the better, and in our arid region it needs to be deeper than elsewhere.

Weeds injure growing crops by appropriating the available plant food, by removing water from the soil, and, in the case of some small vegetables, by excluding light. While a soil may be very fertile, there seldom is present enough plant food, in the form necessary for the use of plants, to support a crop of weeds and a crop of vegetables at the same time. But weeds usually do the greatest injury by removing from about the roots of the crop the water needed by it. Not only do weeds require water for their increase in size, but water is continually evaporating from the surface of their leaves. While they may shade the surface of the soil so as to check evaporation there. the evaporation from their leaves is much more rapid than it would be from the surface of the unshaded soil, if it were properly cultivated. Thus, the destruction of the weeds by cultivation not only curtails the loss of plant food and of water, but the process produces all the desirable conditions of the soil mentioned above.

CULTURAL SUGGESTIONS.

In the following pages an attempt is made to give the important facts concerning the growing of the principal vegetables raised in southern Arizona. Space does not permit of giving detailed cultural directions. The reasons for giving in a Station bulletin what growers in most states obtain from horticultural books and papers is, that conditions are unique and no published books or articles give information applicable here. Wickson's "California Vegetables," however, will be found to be very suggestive and useful.

ASPARAGUS.

Culture. Asparagus is readily grown in southern Arizona, much of the soil being well adapted to its culture. The slight amount of common salt present in most of the soils is favorable to its growth. It prefers a very rich soil, especially a well-manured one. Where the soil is not naturally saline, the addition of salt is beneficial. Asparagus may be grown by planting the seed in hills three feet apart each way, where the roots are to remain; but the usual way is to sow seed in a bed and set out the roots when a year old. Seed may be sown in rows two feet apart during early spring (January to March) or during October. The growing plants require considerable water, and should be thinned to six inches apart to prevent crowding of the roots. The next season they may be set out in well prepared, heavily manured soil, making the rows four feet apart and setting the plants two to three feet in the row. No stems should be cut until the third season. The stronger the roots become before cutting is begun, the greater will be the yield in future years. Each autumn the matured stalks should be cut away and burned, and the soil manured and thoroughly cultivated.

Varieties. Any variety will thrive, but the old standard variety Conovers Colossal is the one most generally grown here. Palmetto is also an approved variety.

BEANS.

Culture. Beans are not easily grown in our region. The bush varieties are the ones most successfully grown here, and these sometimes fail. They endure neither frost nor the dry heat of summer, and hence have but a short period of growth. They are planted during March and the early part of April and again during August and the early part of September. They may be planted in hills 15 to 20 inches apart along the side of furrows through which water has been previously run, or they may be dropped in small furrows that are subsequently filled with a small plow.

Varieties. One of the easiest varieties to grow is the Pink Bean of the southwest. Of the sorts more popular elsewhere, the Long Yellow Six Weeks gives the best results. The Pima Indians grow quite successfully on their reservation a small Lima bean of the Sieva type. They plant it during February.

BEETS.

Culture. The beet is a vegetable that is quite easily grown in our region, if a few precautions are taken. When once started beet plants endure heavy frosts and considerable heat, and consequently grow through our winters and considerable of the summer. The young seed-plants are somewhat sensitive to cold, hence it is sometimes difficult to secure a good stand during the latter part of November, during December, and the early part of January. By irrigation, a fair stand can be obtained from August to November that will result in furnishing beets for the table from December to April. From the middle of January until March is the best time to sow beets. If the soil has been previously irrigated, and is moist when the seed is sown, no irrigation will be required for some time after the beets are up. A better stand can be secured in this way at this time of the year than by sowing in dry soil and irrigating the seed up. Care must be taken not to cover the seed too deep, from three-fourths to one and one-half inches being the proper depth. It may be covered deeper during warm than during cool weather. Beets respond promptly to cultivation, which should begin as soon as they are an inch or two high.

Varieties. All varieties do well here. The most popular ones are the Blood Turnip and the Long Blood. The sugar beet is easily grown and produces a very sweet root much relished by some.

CABBAGE.

Culture. This vegetable can be grown quite easily during the cool part of the year. Seed may be sown from August to October, and the plants set during September, October and November. Seed of the early varieties may be sown later, and the plants set during January and February, but the results are not always satisfactory. The warm weather of early summer soon checks their growth. Seed sown during warm weather requires considerable water, and the young plants should be watered daily.

The cabbage grows best in a rich mellow soil. Well-rotted stable manure greatly improves the soil for cabbage, there being little danger of getting the soil too rich. They are usually set in rows two and one-half to three feet apart, and 15 to 24 inches in the row, the larger sorts being set further apart than the small ones. Cabbage require considerable water, and are benefitted by frequent cultivation. The space between the rows should be cultivated at least once after each irrigation, that the soil may be kept constantly mellow and free from weeds. Fresh cabbage may be taken from the garden from January to June, if settings have been made during successive months of the previous autumn.

Varieties. All varieties do quite well during winter, but some do not endure the heat of early fall and late spring as well as others. At the Station farm Succession has during two seasons produced the largest number of heads and the greatest number of pounds per square rod, of the eighteen varieties tested. Next in yield has been Fottler's Brunswick. All Seasons and most of the Drumhead varieties yielded well. The Flat Dutch varieties do well during cool weather. Burpee's Safe Crop and Surehead were satisfactory. For those who like a red cabbage, the Red Poland will be found to be satisfactory. For producing small early cabbages the Early Jersey Wakefield and Winningstadt are good.

CAULIFLOWER.

Culture. Cauliflower is somewhat difficult to grow here, as it requires much water, and most varieties need a damp atmosphere and do not endure as much heat at cabbage. But in a very rich soil some varieties of this vegetable may be successfully grown, if supplied with an abundance of water. The soil should receive a heavy dressing of stable manure, and should be plowed deeply and harrowed well before the furrows along which the plants are to be set are made. The seed may be sown during August and September and the plants set out during September and October. Set the plants about two feet apart in rows three feet apart. From the time of setting until maturity the soil about them should be kept constantly moist, that the plants may grow without any check. The more cultivation they receive, the better.

Varieties. The varieties that have succeeded best at the Station farm are Burpee's Dry Weather and Burpee's Best Early. The former produced large heads weighing three to ten pounds, and the latter medium-sized ones weighing two to three pounds. The California Main Market proved an almost entire failure; Henderson's Snow-ball and Early Erfurt have been grown about Phoenix with fair success. This vegetable is such an excellent one when grown properly, that it is important that a variety suitable to the region be selected for planting.

CARROTS.

Culture. Carrots are readily grown in all localities. The seed may be sown during August, September and October for winter use, and during January and February for spring growth. The seed, being small, must not be covered deep, about half an inch being the proper depth. The more rapidly they are kept growing, by giving sufficient water and cultivation, the more tender will the roots be.

Varieties. The varieties used most for garden purposes are Danver's Half-Long, the Ox-heart, and the Short-horn.

CELERY.

Culture. This is a difficult vegetable to grow in our warm, dry climate. It requires a very rich moist soil and a long season. The seed is sown from January to March and the plants set out from August to October. As the seed is small, it can be brought up best in a small bed under shade, where the soil can be kept constantly moist. When the plants are about three inches high clip off the tops, and during August, September or October clip again and set out. The soil in which they are set should have been heavily dressed with well-rotted manure and rendered mellow. Set in rows two to three feet apart, about six to eight inches in the row. Give them an abundance of water and good culture, keeping the earth away from the plants until they are ten to twelve inches high; then bank up to bleach the stems. Two to four weeks will be required for bleaching.

Varieties. The Giant Pascal is the variety most generally grown here. It seems to be a greater favorite than the White Plume which is so popular in California.

CORN.

Culture. Corn is commonly planted along the sides of previously irrigated furrows. The seed should be planted as soon after irrigation as the soil will permit, and ordinarily need not be irrigated until well up. When irrigation is necessary, water may be run down the furrows mentioned above. In the warmer valleys plantings may be made during February, March and early April for spring and early summer use, and during July and early August for fall use. In the cooler valleys corn may be planted from March to June. With the addition of irrigation, the culture of corn is much the same here as elsewhere.

Varieties. The only varieties of table corn grown with satisfaction during spring are Early Adams, Extra Early Adams and Mexican corn. The latter endures much heat and may be planted later than other varieties. The period between the frosts of March and the heat of early summer is so short that none but a very early northern variety has time to mature. None of the sweet corns give satisfaction. Either the heat prevents the formation of the kernels, or, if formed, they are eaten by larvae. The field varieties planted during July produce green corn for table use during September and October.

CUCUMBERS.

Culture. The culture of cucumbers, although attended with some difficulties, is much the same here as elsewhere. Plantings are made from March to May for summer use, and during August and September for autumn use. The dry heat during summer is trying to their foliage. Cucumbers require a rich soil, and are planted four to six feet apart along previously irrigated furrows. They require considerable water, and the soil should be kept mellow by frequent cultivation.

Varieties. The varieties generally grown are Long Green, White Spine, and Boston Pickling.

EGG-PLANT.

Culture. After the plants are once started, the egg-plant is an easily grown vegetable in our region. It is sensitive to cold, but flourishes during our hottest weather, if set in rich soil and supplied with sufficient water. The seed may be sown under cover any time from January to March. When the plants are about two inches high, they should be set about four inches apart in a box or bed of rich soil that they may become stocky and robust before being set out in the garden. When the warm weather of April comes they may be set out three to four feet apart each way. If watered and cultivated frequently, they will now grow rapidly, and will produce fruit through the summer.

Varieties. But one variety is grown extensively—the New York Improved Large Purple.

LETTUCE.

Culture. Lettuce is a very easily grown vegetable during the cool part of the year in southern Arizona, but does not endure the summer heat. It will grow in a great variety of soils, but prefers a rich, mellow one. The principal difficulty is in getting the seed to germinate. Being small, it must be covered lightly, and consequently soon dries out unless watered frequently. When the young plants are once established, they grow rapidly. For a fall crop the seed should be sown under cover, that the young plants may be protected from the heat of the sun. Sowings may begin during the latter part of July, and the young plants set out four to six inches apart during September. During the latter month seed may be sown in the open ground, and sowings may continue until February. The seed row should be placed near a furrow through which water is to run frequently. The soil between the rows should be kept mellow and free from weeds. When the plants are well established, the heading varieties should be thinned to four to six inches apart. Other varieties may be thinned by beginning their use early.

Varieties. All varieties can be grown with more or less success in our climate, but some are so much better than others that it is well to grow the best. Most persons prefer a head lettuce. The best variety of this type grown at the Station farm has been Henderson's New York. It produces very solid heads of a good size and remains in season about three months in cool weather. The earliest variety of head lettuce we have tested is the Golden Queen, but the heads are rather small and its season is short. A very popular and fairly satisfactory variety is the Improved Hanson. Other good varieties are Boston Market, Denver Market, Iceberg, Deacon, California Cream Butter, Prize Head, Salamander and Wonderful. The latter variety is much prized by some growers.

MELONS.

Culture. Southern Arizona is preeminently a melon growing region. Melons of all varieties thrive here as they do in few other places in the United States. Melons prefer a rich mellow soil, and do best in our region on land upon which alfalfa has been grown for some time. A heavy dressing of manure is also beneficial. Planting may begin as soon as danger from frost is over. This will be during March, April, or May, depending on the locality. The first care is to plant the seed in soil sufficiently moist to bring the young plants up without further irrigation. This is accomplished by making furrows (about six feet apart) through which water is run for a sufficient time to permit the sides to become wet to a distance of about a foot. As soon as the soil beside the furrows is dry enough to be stirred without causing it to bake, the seed is planted in hills six feet apart. A covering of one to two inches is best. The soil immediately above the seed should be pressed firm, and a mulch of drier soil thrown on top to prevent baking and check evaporation. This method should bring the seed up without further irrigation, but if the soil about them seems in danger of drying out before germination is completed (owing to cool, windy weather, or other causes) irrigation through the adjacent furrow must be resorted to. By supplying sufficient water and by frequent cultivation, the young plants should be kept growing without any check. When the vines have attained a length of three to four feet, it will be necessary for cultivation with a horse to stop, but they should be kept free from weeds during the entire period of their growth. If they have been planted five to eight feet apart, as they should be, the ground will soon become entirely covered, and the increasing heat from the sun will be thus moderated among them.

Varieties. All varieties do well. Three characteristics should be kept in mind by those growing for market:—earliness, size and firmness of rind. To those growing them for home use, quality is of first importance, although earliness is very desirable, since melons are most enjoyed early in the summer season. The earliest water melon we have tested at the Station farm is the Augusta. The quality also is excellent, and the size satisfactory.

It is very productive, and continues bearing longer than other early varieties tested. Fordhook First is also a good early melon. Phinney's Early and Cole's Early have been the popular early melons heretofore, but the quality of neither is satisfactory, and the renumerative season short. For a main crop Florida Favorite, Georgia Rattlesnake, Sweet Heart, and Kleckley Sweets are among the popular varieties of watermelons.

Among varieties of muskmelons the Rockyford, or Netted Gem, is probably the most popular. Other desirable varieties are Nutmeg, Hackensack, Cassaba, and Banana.

ONIONS.

Culture. The onion is grown quite successfully in our region, if planted at the right time and treated properly. It endures both low and high temperatures, if supplied with sufficient water. Since their season of growth is long, consideraale labor is involved in growing them. While they will grow in quite a variety of soils, they enjoy a fertile, loamy one, especially a soil rich in humus. The latter may be supplied by the application of an abundance of well rotted stable manure that is thoroughly mixed with the soil. They may be planted in the same soil for years, rotation not being essential as in the case of most other crops. The best time to sow the seed is from the middle of September to the middle of October. Either of two methods may be pursued:—they may be sown in rows where they are to remain, or they may be sown broadcast in beds from which they are to be transplanted. There is little difference in the amount of labor required, and the latter method has some advantages: The seed is confined to a small area that can be kept moist more easily, the soil to which they are to be transplanted can be more readily kept free from weeds during the time when it would otherwise be occupied with the young plants, and an even stand is assured. Some growers sow in single rows 18 to 24 inches apart; while others sow in double rows 6 to 10 inches apart, with a space between wide enough to permit cultivation with a horse. When the plants are a few inches high they should be thinned to four to six inches apart, if they have been sown where they are to stand; or transplanted out that distance apart, if the young plants have been grown in a bed. They will need to be irrigated frequently and should be cultivated after each irrigation. They mature during the summer, having occupied the soil a large part of the year.

Varieties. The Prize Taker is in many respects the most satisfactory variety we have tested at the Station farm. The White Portugal or Silver Skin, the Silver King, and the Australian Brown are also good varieties. The latter has the reputation of keeping well. The Barletta is a small early variety that is

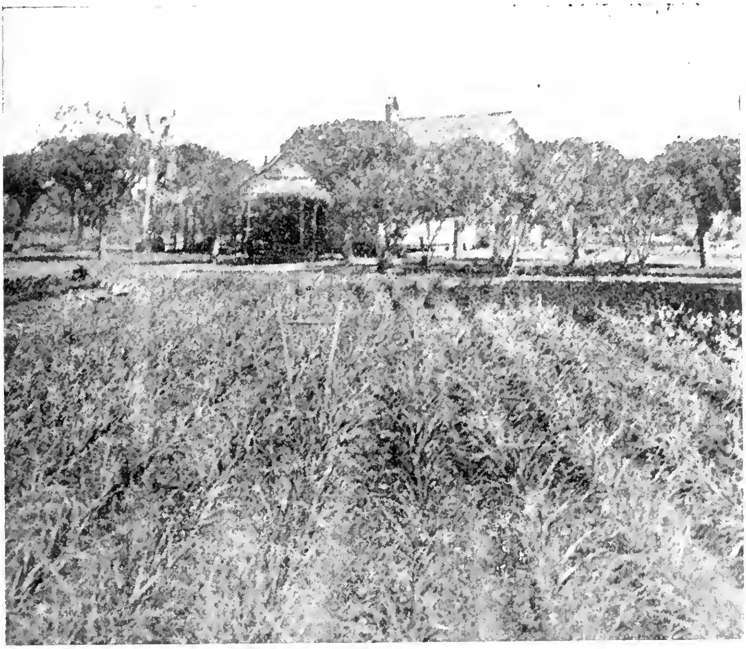


FIG. 3. Onions sown Sept. 16; side to right of cultivator growing where sown; side to the left sown in bed and set out Dec. 1; photographed April 6.

grown some. A larger and more satisfactory early onion is the New Queen. At the Station farm it has produced marketable onions before any of the other varieties did. The Prize Taker yielded about a fourth more than the New Queen, but ripened a month later. The old standard varieties, Yellow Danvers and Red Weathersfield do fairly well, but those having their origin in a climate similar to ours do best.

PARSNIPS.

Culture. As this vegetable requires a long period for growth, and does not endure much heat, it must be sown at the beginning of the cool weather of the fall, in order to be grown most successfully. Parsnips prefer a rich loamy soil, and should be sown in rows about two feet apart. After being once started they require only a moderate amount of water and cultivation. The more rapidly they are kept growing the more tender and sweet they will be.

Varieties. Two varieties are grown—the Hollow Crown, a long smooth variety, and the Turnip-rooted.

PEAS.

Culture. The pea is a vegetable that often causes the grower considerable anxiety in our region. It is not an especially difficult vegetable to grow, but is an uncertain one. With proper treatment it produces well during favorable seasons. Being a plant of which we eat the seed, the desired part cannot be produced during frosty weather, and the vegetative part cannot endure dry heat. Hence the plan resorted to here is to grow the vegetative part during the cool weather of winter, for producing pods during the temperate weather of spring; or to try to get the plant to go through all its stagesduring the temperate weather of fall. In doing the latter, growers are not always successful. The danger during the winter is that the early bloom and pods will be killed by frost. The danger during the fall is that the pods will not mature quickly enough to escape the November frosts, since it is difficult to get them to germinate early enough to reach maturity before that time. The pea is such an excellent vegetable when grown, that it is worthy of a gardeners best efforts. Peas enjoy a rich mellow soil. The seed is sown in drills about two feet apart, and irrigation furrows run along the sides, except when sown in moist soil in cool weather. Sometimes they are covered by plowing a light furrow upon the seed in the drill. This leaves a furrow for irrigation. If sown during the cool part of the winter in moist soil, they will come up without irrigation, but irrigation is always essential when sown during the early fall. They do not need a large amount of water, but should be given plenty of cultivation. Baking of the soil about the plants is very injurious.

Varieties. Green peas may be secured during April by either of two methods: Early dwarf varieties may be sown during midwinter, or larger later varieties may be sown during the previous fall. Some growers prefer one method and some the other, while still others pursue both. The best dwarf varieties for sowing from the latter part of December to the middle of February are the American Wonder, Little Gem, Nott's Excelsior, and Gradus. For sowing during late October, November, and early December, the most popular varieties are the Yorkshire Hero, Champion of England, Horsford's Market Garden, Stratagem and Telephone. For August and September sowing, to produce green peas during November, only the dwarf, early varieties, like the American Wonder and Little Gem, are suitable.

POTATOES.

Culture. The season between the frosts of early spring and the heat of early summer being short, the growing of potatoes during spring is attended with difficulties; and greater difficulty still is encountered in attempting to grow them between the heat of summer and the frosts of late autumn. But proper attention to the requirements of this important vegetable results in a fair yield during May and June, and a usually lighter one in November. The potato requires a mellow, loamy soil kept moderately moist —neither too wet nor too dry. A good percentage of humus in the soil is also highly desirable. This condition may be secured by turning under alfalfa, or by applying plenty of stable manure, followed by deep plowing and thorough harrowing.

For spring growth the best time to plant, according to our experiments at the Station farm, is from the middle of January to the middle of February, in the Salt River valley. The later they are planted here after the middle of February, the less growth they will make before the hot weather of June, which in the vicinity of Phoenix, is sure to level all potato tops to the ground. The seed pieces are commonly dropped 12 to 18 inches apart in furrows 2½ to 3 feet apart, and covered by throwing a furrow over them. If the soil is moist and the field is harrowed or rolled after the furrows are made, irrigation will not be necessary until after they are up, but in some cases it is well to have furrows left for use, in case the soil becomes too dry before they are up. It should be remembered that, unlike seeds, the early stages of germination proceed as well in dry as in moist soil. Not until the stem puts out roots is much moisture needed. The less the soil is irrigated and the more it is cultivated, the mellower it will remain. If the soil

FIG. 4. View in experimental potato plat.

becomes too dry at any time, irrigation is apt to start a new growth that will be detrimental to the crop. It is very important that the soil be prevented from baking about the roots and tubers. To this end, the irrigation stream should, by keeping the furrow midway between the rows, be kept as far away as possible. Thorough cultivation should follow each irrigation. By following these methods, the yields have been from 60 to 175 bushels per acre at the Station farm during the past two years.

For fall growth potatoes are planted during August. In some parts of southern Arizona they must be planted whole, or they rot instead of sending up stems. For this purpose small ones are used. When they are cut, the seed pieces are placed with the eye upwards, by some growers, and covered lightly that they may come up before decaying. The growth of tops is commonly slender at this time of year, instead of stocky as during spring. At best, the yield is usually light, especially in the warmer valleys.

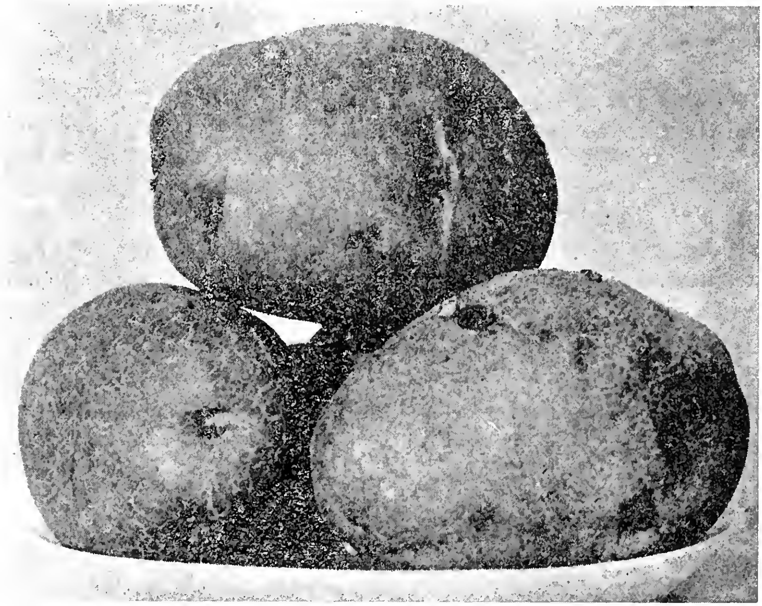


FIG. 5. Burpee's Extra Early potato; planted January 17; mature May 15; two weeks earlier than Early Rose, and equally productive; two thirds natural size.

Varieties. None but early varieties have time to make their growth during the short season that exists. The Early Rose is the one commonly planted, and at present is in the Salt River valley the only one that it is practicable to grow successfully. Burpee's Extra Early, Triumph, and Early Andes yield equally well, and are some earlier, but at present there is no suitable source of a seed supply. Early Ohio is early, but does not yield so well.

The Bovee yields well, and is as early as the Early Rose.

RADISHES.

Culture. Radishes may be had for the table six weeks from sowing at any time from October to May. The seed germinates promptly in all temperatures in our region from August to May, and the plants endure all low temperatures that ever occur here. Their cultivation is very easy, and the results quick in moderately warm weather. As tenderness and crispness are the chief qualities desired, they should be kept growing as rapidly as possible.

Varieties. All varieties grow successfully. The French Breakfast and Scarlet Turnip are early varieties. The Chartier and the Chinese varieties are popular.

SPINACH.

Culture. This vegetable is easily grown in our region during the cool part of the year, but does not endure our dry summer heat. It requires plenty of moisture, and prefers a rich soil. It is sown in rows 18 to 24 inches apart; and when an inch or two high may be thinned to 4 to 8 inches, or it may be left to be thinned by using the small plants. It may be sown along permanent furrows, or it will sometimes do best in the bottom of furrows. It should be given sufficient water to keep it growing thriftily.

Varieties. The varieties most commonly grown are the Prickly, the Long-Standing and the Round or Summer.

The New Zealand Spinach is distinct from any of the above, it being a summer variety that should be treated about as tomato plants are.

SQUASHES.

Culture. If the proper varieties are planted the squash is an easily grown vegetable in our climate. It is sensitive to frost, but endures heat. It needs a rich soil and a moderately generous supply of water. It grows most rapidly if planted after the soil has become well warmed, but may be planted, especially the bush varieties, as early as February. In the case of the large varieties, ordinarily nothing is gained by planting during cool weather.

The bush varieties should be planted 3 to 6 feet apart, and the running varieties 6 to 8 feet apart. They are planted as melons and cucumbers are, along furrows previously wet by a stream of water.

Varieties. Among early summer varieties the scalloped ones are the most popular, the Mammoth White Bush and the Mammoth Yellow Bush giving the heaviest yields at the Station farm. None of the Northern winter sorts thrive here, the Cashaw Crooked Neck Pumpkin taking its place. For fall and winter use it should be planted during June or early July.

SWEET POTATOES.

Culture. The sweet potato is grown quite successfully in southern Arizona. It may be grown in quite a variety of soils, but prefers a fairly rich sandy loam. It is very sensitive to frost, but thrives during hot weather. Planting out should not begin until danger of frost is past, and in making summer plantings, the fact that they will be killed by the first frosts of Autumn should be kept in mind. The sweet potato is grown from sprouts from tubers that are kept in a suitable condition for their development. The young plants may be started in a hotbed, or in the open air. In either case, heat from beneath is important. If grown in the open air, a trench may be dug four or five feet wide and about two feet deep and filled to within about six inches of the top with firmly packed fresh horse manure. After adding a few inches of soil and wetting the whole thoroughly, the potatoes may be placed upon the soil as close as possible and prevent them coming in contact with one another. Enough sand should be thrown in to fill in between the potatoes and two or three inches of sandy loam or sand thrown over the whole. The bed should be kept moist, and in six to eight weeks the plants will be ready for setting out. They may be removed from the tubers as they lie in the bed, or the potatoes may be uncovered, the shoots removed, and the cover replaced. Splitting the potatoes before placing them in the bed facilitates the removal of the young plants, as they will then all grow from the upper side.

The plants are commonly set about eighteen inches apart on the sides of ridges made three to five feet apart. Care should be taken to keep the plants wet from the time they are removed until set out. They should be kept moderately moist and should be given shallow cultivation until the length of the vines interferes.

Varieties. The Californian, or Shanghai, is very generally grown throughout the southwest. The southern Queen and the red and yellow Nansemond are also grown.

TOMATOES.

Culture. The tomato is not grown here with the ease that it is produced in many regions. In most of the valleys the winters are too cold and the summers somewhat too warm for the successful fruiting of this vegetable. In the cooler valleys they fruit through the summer, but in the warmer ones, the vines cease bearing during August and early September. At Yuma, by giving the plants a slight protection during the heat of summer and the cool part of winter, fruit may be gathered throughout the year. The tomato prefers a rich mellow soil. They may be planted in such a soil where they are to remain, or may be transplanted to it when warm weather arrives. In either case, the seed should be planted during January or February.

In sowing the seed in boxes, care should be taken not to get them too thick. The object to be kept in mind is to produce stocky vigorous plants. As soon as they begin to crowd one another in the seed box, they should be transplanted to boxes or beds two to four inches apart each way. Giving them plenty of light and exposing them to the outdoor atmosphere will contribute to their hardiness and vigor. During April they may be transplanted to the garden, setting them three to four feet apart each way. They will do better to be closer together than in a less dry, sunny region, as it is an advantage to have the plants shade one another. They require a moderate supply of water, and should be cultivated until well grown.

At the Station farm we have found that tomatoes planted in hills where they are to remain give good results, and require less care than when propagated in the usual way. In our dry atmosphere, some time is required for a tomato plant to recover from the shock caused by transplanting. If they are planted where they are to remain, this drawback is obviated. Plants grown from seed planted out will endure a surprising amount of frost. The seed may be planted during January, and, while the young plants grow slowly for a month or two, they eventually will be fully up with and often ahead of plants forced inside in boxes. Several seed should be dropped in a hill, and when the plants are established, all removed except the most vigorous one. In 1899 ripe tomatoes were gathered from those planted where they were to remain ten days before those planted in boxes inside a greenhouse, at the same time, produced any ripe ones. In 1900, seed was planted in hills only, and the results have been quite satisfactory.

Varieties. Of the many varieties of tomatoes extant, the Dwarf Champion is the favorite in this region. The sun is so trying, that a stocky plant with heavy foliage matures its fruit in the best condition. Other varieties having these characteristics are the Dwarf Aristocrat and the Fordhook Fancy. Of the older varieties the Trophy, the Acme, the Stone, the Favorite, the Ponderosa, the Beauty, and the Perfection are grown more or less successfully in southern Arizona.

TURNIPS.

Culture. This vegetable is grown quite successfully in our region, and during early winter is the principal one seen on vegetable wagons. Their culture is quite simple. They may be sown in drills and irrigated through furrows, or they may be sown broadcast and flooded. Plantings may be made from September to February. They require plenty of water, in order to grow rapidly and produce tender roots.

Varieties. All varieties succeed. Those commonly grown are the Purple Top, Strap-leaved, the Early White Flat Dutch, and the Early Purple-top Milan.

IMPORTANCE OF PLANTING GOOD SEED.

There is no region where it is more important that none but the best seed authentically named be planted. At best, difficulies attend the germination of seed in our climate. Hence it is a waste of time and money to plant seed of doubtful germinating power. Then, too, it is imperative, in the case of many vegetables that certain varieties be planted; and it is consequently important that correctly named seed be secured. At the Station farm, we have found seeds from the long-established seed-houses of W. Atlee Burpee & Co., Philadelphia, and Peter Henderson & Co., New York, to be always reliable. A few varieties can sometimes be procured to better advantage from one of the southern seed firms, J. Steckler Seed Co., New Orleans, N. L. Willet, Atanta, or the Germain Fruit Co., Los Angeles. Beware of buying seed kept in bulk by a local dealer. unless you have full confience in his reliability. Such a course would be likely to result in disappointment, instead of vegetables for the table. It pays to plant the very best, and none but the very best of seed.

University of Arizona

Agricultural Experiment Station.

Eleventh Annual Report.

For the Year Ending June 30, 1900.

(With subsequent items.)

Including a discussion of the work of the Station, and notes on

Grain,
Forage Crops,
Vegetables,
Eucalypts,
Winter Irrigation,
Crown Gall,
Steer Feeding,
Sheep Feeding,
Dairying,
Irrigating Waters,
Sugar Beets,
Etc.

Tucson, Arizona, Dec. 26, 1900.

UNIVERSITY OF ARIZONA.
AGRICULTURAL EXPERIMENT STATION.

STATION STAFF.

The President of the University	
R. H. Forbes, M. S.,	Director and Chemist.
A. J. McClatchie, A. M.,	Agriculturist and Horticulturist.
G. H. True, B. S.,	Animal Husbandry.
David Griffiths, Ph. D.,	Botanist.
W. W. Skinner, M. S.,	Assistant Chemist.
T. D. A. Cockerell,	Consulting Entomologist.
S. M. Woodward, A. M.,	Consulting Meteorologist.
W. O. Hayes,	Clerk.

The Bulletins of the Station are sent to all residents of Arizona applying for them.

Address:

THE EXPERIMENT STATION,

Tucson, Arizona.

LETTER OF TRANSMITTAL.

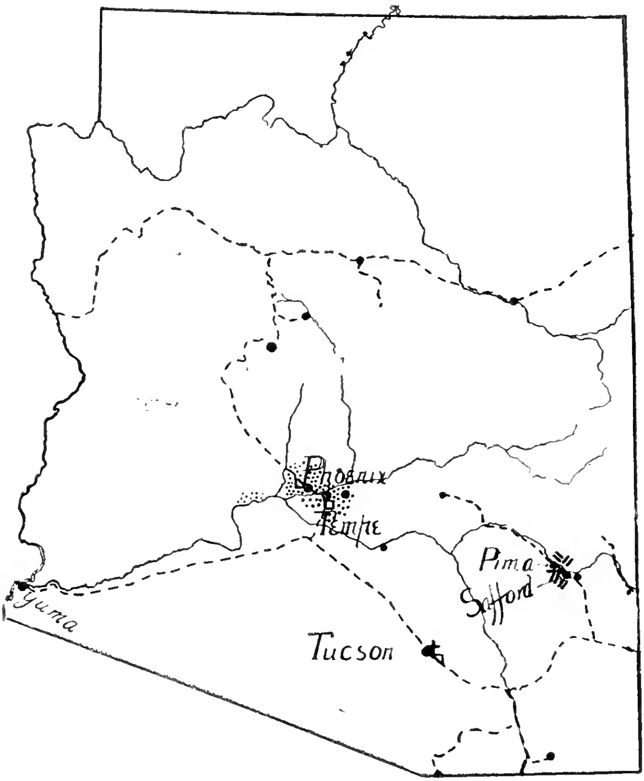
To His Excellency, N. O. Murphy, Governor of Arizona:

SIR: In accordance with the Congressional act of March 2, 1887, I submit, herewith, the Eleventh Annual Report of the Arizona Agricultural Experiment Station, for the fiscal year ending June 30, 1900.

Very respectfully,

R. H. FORBES,
Director

CONTENTS.



+ Experiment Station Office, Botanical and Chemical Laboratories, Tucson.
◁ Range Study Tract, Tucson. (Co-operative, U. S. D. A.)
◺ Experiment Station Farm, Phoenix.
☐ Date Palm Orchard, Tempe. (Co-operative, U. S. D. A.)
Soil and Alkali Survey. (Co-operative, U. S. D. A.)
ǁ Sugar Beet Experiments, Pima, Thatcher and Safford.

MAP SHOWING PRESENT ARRANGEMENT OF EXPERIMENT STATION WORK.

ELEVENTH ANNUAL REPORT.

ORGANIZATION AND WORK OF THE STATION.

During the fiscal year ending June 30, 1900, the Arizona Station has continued and strengthened its work in the agricultural, chemical and botanical departments, has established a new department of animal husbandry, has increased the usefulness of the office for the distribution of a growing number of publications, has engaged in cooperative work with the farmers of the Territory and with outside specialists which has yielded much useful information at little cost, and, all things taken together, has put in operation a plan of work which has been productive of satisfactory or promising results in a somewhat dispersed situation.

The principle on which the business of the year has been transacted is, to do each kind of work, so far as possible, in the situation most favorable to its accomplishment.

Costly experience in Arizona has demonstrated the futility of trying to make Nature recognize the motives of human expediency. The diplomat, therefore, who commands a peach tree to bloom and be fruitful on top of a frost-bitten, calichi hill, is likely to meet with an embarrassing refusal, as is also the scientist who tries to force unnatural results where, for the time being, they will satisfy sectional feeling.

According to the principle emphasized above, the various lines of experiment station work have been distributed as follows:

The director's office and the departments of botany and chemistry have continued and enlarged their operations at Tucson, in connection with the Territorial University, of which the Experiment Station is a legally constituted department. This arrangement, under proper regulation, is of advantage to both institutions. The Experiment Station profits by the buildings, the libraries, and the associations of the University, while the University is benefited from time to time by the teaching ability of Station specialists, and by the constantly increasing influence exerted through their publications.

Moreover, the present location of the offices has proved conveniently accessible to the three great agricultural districts of the Territory,—Salt River valley, Yuma, and the upper Gila—and has made it possible for the Station staff to divide their field observations equitably between these three diverse, yet in each case important districts.

The Experiment Station farm at Phoenix has been continued and strengthened for the reason mentioned above; namely, that this location, in a general way, is probably the best one in the Territory for the purpose. Salt River valley is intermediate in elevation, in precipitation, and in mean yearly temperature between the two other important farming districts of Arizona, Yuma and the upper Gila, and for this reason the agricultural and horticultural results obtained there are capable of the most general application in the Territory at large. This fact makes it possible, for instance, to study oranges, dates, and eucalypti for the benefit of the Yuma and Salt River valley districts on the same ground where peaches and sugar beets may be investigated to the advantage of the upper Gila and other cooler localities.

The date palm orchard, again, is located in a suitable situation—the alkaline district south of Tempe. According to Old World experience as well as observations in Arizona, this valuable palm will grow in exceedingly alkaline ground, and the demonstration of this fact by the Station on a commercial scale will create value for tens of thousands of acres of lands in the Southwest.

Finally, on this same principle, the Station has from time to time during the year sent its workers into various localities where needed and where the best chances for good results were to be found. In cooperation with the Division of Soils, U. S. D. A., a complete and very valuable soil and alkali survey of Salt River valley and the Buckeye country has been completed which will for the first time give definite information concerning the nature and extent of the various types of soil and the amount, kind, and distribution of alkaline salts in this region. At the invitation of the Station, also, Professor T. D. A. Cockerell spent November, 1899, in the same district looking up noxious insects in order to give warning of any existing or impending insect pests.

Also, the investigations with sugar beets were extended to the upper Gila under the personal care of Mr. Arney, of the Station. The promise held out by the more favorable climatic records of this district has, to an encouraging degree, been made good and a continuance of operations is planned for next year.

THE STATION STAFF.

The changes in the staff during the year, while serious, have, fortunately, not interfered with the usefulness of the Station. Prof. J. W. Toumey, for nine years botanist of the Station, went to the Division of Forestry, U. S. D. A., and from there to the Yale Forest School. His thorough familiarity with the Southwest and his eminent ability to grasp and work out southwestern problems, makes his loss a serious one. Dr. A. A. Tyler, for one year associate botanist, has also accepted a connection with Bellevue College, Nebraska. Dr. David Griffiths, for several years special agent of the Division of Agrostology, U. S. D. A., and having wide experience with western conditions, has assumed the duties of botanist.

Mark Walker Jr., for many years the efficient assistant chemist of the Station, has been succeeded by W. W. Skinner, M. S., formerly first assistant chemist in the Maryland Station.

The new department of animal husbandry was placed in charge of Prof. Gordon H. True who came to the Station from the dairy school of the Michigan Agricultural College.

A new and useful feature of service established during the year is the "consulting" staff. This is composed of specialists in subjects for which the Station cannot afford to employ the whole time of expert investigators. For a moderate sum, however, it is possible, as occasion may arise, to secure the services of a specialist for stated work. Technical correspondence also is turned over to these gentlemen and they are expected to contribute to the publications of the Station as circumstances shall permit.

Under this arrangement Prof. T. D. A. Cockerell of Las Vegas, New Mexico, has been appointed consulting entomologist and Prof. S. M. Woodward, of Tucson, consulting meteorologist. The appointment of a consulting irrigation engineer is under consideration.

MAILING LIST.

During the year the mailing list was increased by about 1200. It now numbers 3000 names, (not including the official list,) of which 2200 are in Arizona and the rest in other States and countries. Estimating the agricultural population of the Territory at 60,000, it appears that our publications reach about 3.7 per cent of those actively interested in them, this being a larger proportion than is reached in most of the more populous States. The very fact, therefore, of a sparse population enables the Arizona Station to reach a larger proportion of its public and should lead to a quicker general utilization of its results.

PUBLICATIONS.

During the year 210 pages of regular Station publications were issued as follows:

Tenth Annual Report, 40 pages, including notes on soils, the crown-gall disease of fruit trees, the date palm, sugar beets, green manuring crops, grains, etc., by different members of the Station staff.

Bulletin No. 31, 10 pages; Sugar Beet Experiments during 1899, by A. J. McClatchie.

Bulletin No. 32, 23 pages; Some Insect Pests of Salt River Valley and the Remedies for them, by T. D. A. Cockerell.

Bulletin No. 33, 58 pages; An Inquiry into the Cause and Nature of Crown-gall, by J. W. Toumey.

Bulletin No. 34, 51 pages; Timely Hints for Farmers (a collected edition,) by various members of the Station staff.

Bulletin No. 35, 28 pages; Vegetable Growing in Southern Arizona, by A. J. McClatchie (Printing not complete till Aug. 15, 1900.)

The series of "Timely Hints for Farmers" is a new departure for the year and marks a special effort on the part of the Station staff to reach the farmers of the Territory with needed information on living questions, presented at the time and in the manner most likely to be useful. These "Hints" have been sent not only to the newspapers, but individually to each name on our southwestern mailing list of 2500 names. The labor of doing this twice each month has been very considerable, involving an output of some 45000 pieces of mail in addition to our regular correspondence and bulletins. The many expressions of regard and appreciation, however, which have been returned to us by the farmers of the Territory have amply rewarded the labor. The subjects treated and the times when issued are as follows:

Oct. 1, 1899. Green-manuring Plants for Orchards.—By A. J. McClatchie.
Oct. 16, 1899. Planting Eucalypts in Arizona—By A. J. McClatchie.
Nov. 1, 1899. Improvement of Arizona Soils.—By R. H. Forbes.
Nov. 15, 1899. Winter Irrigation of Orchards.—By A. J. McClatchie.
Dec. 1, 1899. The Crown-Gall.—By J. W. Toumey.
Dec. 15, 1899. Desirable Varieties of Peaches.—By A. J. McClatchie.
Jan. 1, 1900. The Danger of Introducing Insects on Trees.—By T. D. A. Cockerell.
Jan. 15, 1900. What to Plant on Arbor Day.—By J. W. Toumey.
Feb. 1, 1900. Winter Remedies for Injurious Insects.—T. D. A. Cockerell.
Feb. 15, 1900. Care of Milk for the Factory.—By Gordon H. True.
Mar. 1, 1900. Black Alkali.—By R. H. Forbes.
Mar. 15, 1900. White Alkali.—By R. H. Forbes.
Apr. 1, 1900. Selecting Dairy Cows.—By Gordon H. True.
Apr. 15, 1900. The "Adobe Hole."—By R. H. Forbes.
May 1, 1900. Dehorning Cattle.—By Gordon H. True.
May 15, 1900. Date Palm Culture,—A Word in Time.—By R. H. Forbes.
June 1, 1900. Summer Cultivation.—By A. J. McClatchie.
June 15, 1900. Grazing versus Irrigation.—By J. W. Toumey.

INSTITUTE WORK.

The Station staff has organized or assisted in eight farmers' institutes during the year as follows: Tempe 1, Mesa City 2, Buckeye 1, Glendale 1. Safford 1, Thatcher 1, Pima 1. These institutes were for the most part productive of interested discussion on the part of those present and were especially valuable to the Station in improving the acquaintance of the members of the staff with the different agricultural districts in Arizona.

ADDITIONS TO THE EXPERIMENT STATION FARM.

The Experiment Station farm on Grand Ave., northwest of Phoenix, has been maintained and added to during the year.

When Professor True joined the Station staff the need of additional ground on which to conduct his work in stock-feeding became evident. Recognizing the fact that help was not to be expected from the public for this purpose, the Station undertook the matter for itself. The Renaud property of 28 acres adjoining the experimental farm was purchased and partly paid for out of a fund accumulated during the preceding two years from the occasional fees received in the chemical laboratory, from sales of greenhouse plants, and farm produce. Eight hundred and fifty dollars was paid down April 1st, at the time of purchase; the balance ($850) being advanced by the Board of Regents from the University Territorial fund. This advance is being returned to the use of the University as available money is received.

This acquisition of ground gives the animal husbandry and agricultural and horticultural departments ample room in which to conduct their operations, and the expectation is that as fast as means shall permit, the building improvements on this ground. which are at present poor, shall be made adequate for the significant and valuable work now planned or in progress

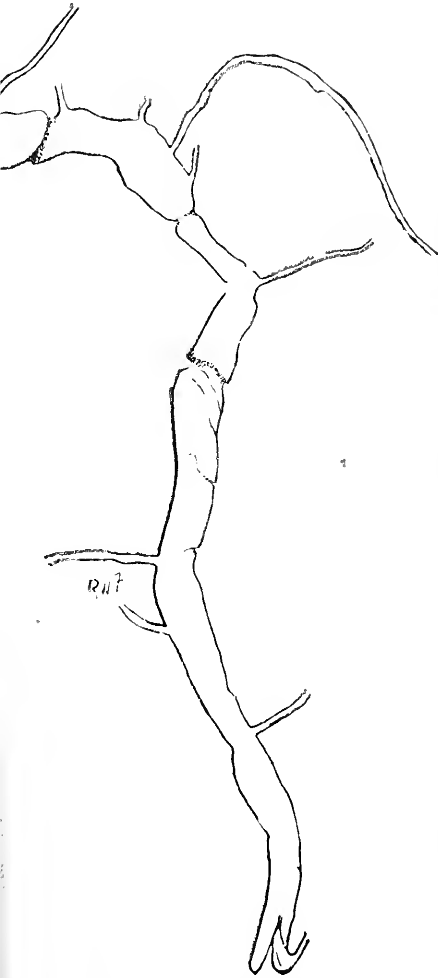
THE DATE PALM ORCHARD.

The small consignment of date palm suckers received from Algiers in 1899 has been followed by a large shipment from the same place, consisting of 447 suckers in 26 varieties.

This shipment was made June 11, 1900, through Mr. W. T. Swingle, of the Division of Botany, U. S. D. A., under the cooperative arrangement existing between the Department and the Arizona Station, whereby the expenses of purchase and transportation are borne by the Department, while fumigation, planting and care are attended to by the Station.

The consignment, which was packed in twenty-three cases, weighing about eight tons, and filling a large car, was received at Tempe July 17th, unpacked July 20th, fumigated to destroy scale July 20th to 23rd, and 391 suckers planted at Tempe July 22nd to 25th; 21 more were planted at Phoenix July 26th, and the remaining 35 shipped to the California Experiment Stations at Berkeley and Pomona.

Date Palm Orchard at Time of Planting, July 23, 1900. Straw in Pits at Bases of Suckers for Convenience in Irrigating.



Date Palm root taken from calichi hardpan 6 feet below surface of soil, growing in strongly alkaline ground-water.

On account of the dryness of the season and the scarcity of irrigating water, unusual efforts had to be made in order to save the palms at Tempe. A well was dug and a 4-in. San Jose pump put in. From this source of supply, water was carried in barrels by wagon about the orchard and the suckers were kept wet during August and September, being for the most part successfully carried through. An inspection October 2nd showed 93 per cent of the plants to be apparently safe, and some of them were beginning to grow.

From present indications, a large percentage of the suckers will live, and their prosperity in this alkaline locality is reasonably assured by the presence of several thrifty, home-grown trees in the vicinity. The vigor with which the palm takes hold of alkaline soil is shown by the accompanying figure of a living root secured by the writer six feet below the surface of the ground and eight inches below water. The soil was very strongly alkaline and the root was extracted with difficulty from the calichi hardpan into which it had wedged its way.

RANGE IMPROVEMENT WORK.

It is a matter of common knowledge that the overstocking of the range has in some districts practically destroyed the country for grazing purposes. The grasses have been killed out and the seed blown or washed away; while in many localities the bared and devastated surface has begun to wash and gully in a disastrous manner. This condition is not only ruinous to the stockman, but also to the irrigation farmer who is affected by the alternating floods and drouth caused by a bare watershed.

While the principles of forestry are well understood, those of range administration are not. But little is known in this region as to the extermination of native grasses and shrubs by cattle; we have no knowledge of the progress and completeness of the recovery of our range country under rest and wise administration; little has been ascertained of the rate of washing or of the methods of preventing it; neither has the difficult matter of putting a scheme of administration into operation among existing stock interests been dealt with.

The study of these important questions, for some time in contemplation, has, in co-operation with the Division of Agrostology, U. S. D. A., been entered upon by the Arizona Station. About 350 acres of worn out range near Tucson is now (Nov. 17, 1900), under fence, native grass seed has been secured, and the work of reclamation and range study is to proceed in this vicinity under the special attention of Dr. David Griffiths, botanist of the Station. At present much confusion necessarily results from a discussion of this subject, partly for the reason that little scientific knowledge upon it really exists, and the first step towards the solution of the questions involved is the attainment of that scientific and practical knowledge which is now in prospect.

NEEDS OF THE STATION.

Although the Station, during the past year, has enjoyed the full use of its appropriation, even this has not been entirely adequate for the reorganization and extension of its various departments. The laboratory and library equipments of the botanical and chemical departments at Tucson are sufficient for the work in hand, although both of these would greatly profit by extensions which the funds will not now permit.

The Experiment Station farm, in particular, is in need of fencing, barns. dairy sheds, tool-house, stock scales and a residence building. The maximum amount which can be expended for this purpose from the Hatch fund, in any one year, is $750, but it would require at least $2000 to replace the present old and shabby barn with a suitable structure, properly fence the farm and put up a windmill and pump house.

Besides these needed improvements, proper residence accommodations on the farm would greatly facilitate the work of those members of the staff at Phoenix. Compelled to reside at a distance of three miles from the scene of operations, much time is necessarily lost in going back and forth, and less supervision of critical work is possible.

The date palm orchard, also, needs a small building for storage of tools, and for shelter and fumigation purposes.

To economists it may be stated that there is nothing unusual in State appropriations to the experiment stations. For the year ending June 30, 1899, twenty-three experiment stations in the United States received State appropriations ranging from $390.49 to $68,000 in amount; and of the remaining twenty-nine stations, twenty-six had from other sources, from $20.02, to $19,323.56 each. Among the whole number of forty-six stations receiving the full Hatch appropriation, all but seven had a larger income from State and other sources than had the Arizona Station. In other words, the Arizona Station receives less financial attention from State and other directions than thirty-eight other stations.

In view of the peculiar need of a new and rapidly growing country for strong and efficient experiment station service, this seems hardly just to the interests involved. During the year the Station has done everything possible to help itself to needed improvements. From the proceeds of farm produce and laboratory fees, the ground was purchased for the new and important work in animal husbandry, and the strong and efficient co-operation of the U. S. D. A. has been secured in various special lines of work. But it rests with the public, especially the farming public, to take those final legislative measures which shall enable their Experiment Station to possess creditable and necessary working appliances and rank highly in usefulness and progressiveness among the stations of the country.

ACKNOWLEDGEMENTS.

The results of the year are by no means to be credited exclusively to the members of the working staff, efficient though their labors have been. To the friends of the Station, indeed, ample acknowledgement is to be given.

In the first place, it is due to the Governing Board to state that for the past eighteen months the Station, in the matter of appointments and otherwise, has been out of politics—absolutely, so far as the writer is aware. This alone is sufficient reason for increased efficiency; for an experiment station has to deal, not with matters of opinion, nor even with matters of business merely, but with matters of scientific fact. Moreover, the facts which concern its workers and the agricultural public require the studious attention of trained men appointed solely on their professional qualifications.

During the year, the Station has been secured in the full and best use of its funds, the staff having withdrawn from overmuch instruction work in the college.

The Southern Pacific, M. & P. & S. R. V., and G. V. G. & N. railroads, have been substantially assistant by granting pass and transportation facilities. The Southern Pacific road, in particular, made unusual efforts for the rapid transit of the carload of date suckers from New York City to Maricopa, which was done without charge.

More than all else, however, the kindly expressions which have often been returned from the readers of our "Timely Hints" and other publications, and to those who have assisted at institutes, have served to encourage and guide the work of the Station.

This is as it should be; for the needs of the agricultural public are the only reason for the creation and maintenance of an experiment station in Arizona, and it is largely through such expressions that the working staff finds that it has, in some measure, understood and met those needs. With a logical and successful organization, with each department favorably situated and busy with its special lines of investigation, and with growing interest and appreciation on the part of the agricultural public, it is hoped that the Arizona Station has at last reached a condition of useful stability.

R. H. FORBES, Director.

FINANCIAL STATEMENT.

For the year ending June 30th, 1900.

Cash received from the United States Treasurer....		$15,000.00
Cash paid for salaries	$6,947.73	
for labor	3,525.15	
for publications	870.32	
for postage and stationery	204.72	
for freight and express	348.08	
for heat, light and water	108.90	
for chemical supplies	127.85	
for seeds, plants, and sundry supplies	211.46	
for fertilizers	208.65	
for feeding stuffs	190.31	
for library	7.97	
for tools, implements, and machinery	708.58	
for furniture and fixtures	23.25	
for scientific apparatus	103.93	
for live stock	410.00	
for traveling expenses	599 50	
for contingent expenses	10.30	
for buildings and repairs	393.30	
		$15,000.00
Cash received from other sources:		
On hand July 1st, 1899	$ 504.70	
For farm products	157.76	
For chemical laboratory fees	295.23	
Miscellaneous	277.95	
		$ 1,235.64
Disbursed from above fund:		
For purchase of 28 acres of land for work in animal husbandry	$ 850.00	
Additional payment on same	100.00	
For special chemical work	22.94	
Balance	262.70	
		$ 1,235.64

WE, THE UNDERSIGNED, duly appointed Auditors of the Corporation, do hereby certify that we have examined the books and accounts of the University of Arizona Agricultural Experiment Station for the fiscal year ending June 30, 1900; that we have found the same well kept and classified as above, and that the receipts for the year from the Treasurer of the United States are shown to have been $15,000.00, and the corresponding disbursements $15,000.00; for all of which proper vouchers are on file and have been by us examined and found correct, thus leaving nothing unexpended.

AND WE FURTHER CERTIFY that the expenditures have been solely for the purpose set forth in the Act of Congress approved March 2, 1887.

H. B. TENNEY,
H. W. FENNER,
Auditors.

DEPARTMENT OF AGRICULTURE AND HORTICULTURE.

The past year has been devoted largely to a continuation of work begun the previous year. Experiments have been continued with grains, forage crops, green-manuring, vegetables, methods of irrigation, sugar beets and Eucalypti. Work has been begun on the relations of vegetation to extremes of temperatures.

GRAINS.

Two lines of experimentation have been followed: the testing of wheats grown for milling purposes, and the determination of the best varieties of grains for hay for horses.

WHEAT.

The work on wheat consisted chiefly of testing varieties, determining times of sowing that give the highest yields, and testing methods of irrigation. Of the fifteen varieties tested, Ruby was the only one that gave as high a yield as Sonora, the standard variety of the region; and number 1174 of the Department of Agriculture, from Turkestan, was the only one that ripened in as short a time. Several, however. showed milling qualities superior to Sonora. Winter wheats, even when sown in early autumn, gave only about two-thirds the yield of Sonora sown at the same time, or several months subsequently. White Australian, the variety that is becoming popular with the millers, gave about three-fourths the yield of Sonora sown at the same time. Three varieties of macaroni wheats were grown, each doing well and giving about four-fifths the yield of Sonora. Number 1174 from Turkestan was sown March 10, and made on excellent growth for the season of the year, ripening June 10, a few days earlier than Sonora sown at the same time. The variety is reputed to possess great heat and drouth resisting powers; but it will be necessary to test it at least another season before its merits will be established.

Sonora sown in early November gave the highest yield. The yields from sowings made during the following month were slightly less. Sonora sown as late as March 10 gave a low yield. The indications are that the earlier grain is sown after the first of November, the heavier the yield will be.

Sonora was sown to be irrigated by three different methods; by flooding, in drills to be irrigated in furrows. and broadcast to be irrigated by furrows. The last method gave the highest yield. The wheat was sown broadcast, and furrowed and covered by one operation with a machine devised for the purpose. A man and four horses could put in five to ten acres per day by this method.

HAY FROM GRAINS.

As the only members of the grass family used for hay in this region are wheat and barley, experiments with each were made. Sonora wheat sown November 10 gave a yield of 3.5 tons of hay per acre on adobe soil. Upon account of the scanty foliage of this variety, the hay from it is not as desirable as that from a more leafy variety. Feld-spar proved to be more leafy, and thus produced a better hay, the yield being equal to that of Sonora.

Three varieties of barley were tested: hulless, Fowler beardless, and bearded. The yields of hay per acre were as follows in adobe soil, from sowings made November 7: Hulless, 4.1 tons; Fowler beardless, 4.6 tons; bearded, 4.9 tons. The excess of yield of the bearded over the beardless was probably due largely to the presence of the beards on the former. The hulless and beardless varieties make more rapid growth during the cool weather of winter, and were ready to cut ten days earlier than the common bearded variety. Since they yield almost equally well, and are free from the objectionable beards, they are much preferable for hay.

FORAGE CROPS.

During 1899 four varieties of sorghum, six varieties of Indian corn, two varieties of Kaffir corn, Egyptian corn, teosinte, two varieties of millet, and three varieties of cowpeas were grown as forage crops. The club-head sorghum commonly grown in the region surpassed all in yield, the Indian corns giving the lightest yields of all. Kaffir corn was next to sorghum in yield. Teosinte gave a good yield of good fodder, but required too much water to be a desirable crop for this region. The Egyptian corn endured heat and drouth best, but gives promise of being more valuable as a source of grain than of fodder.

The shortage of water for irrigation has prevented the continuation of experiments with forage crops this season.

GREEN-MANURING PLANTS

The testing of plants suitable for green-manuring was continued throughout the year. Especial attention was given to crops to be grown in orchards for this purpose. Sowings of cowpeas were made from April to August, 1899. The best results were obtained from those sown August 10. The yield of green matter was eight tons per acre.

During the autumn sowings were made of lupins, yellow sweet-clover (Melilotus indica,) and alfalfa. The lupin seed was imported from Paris, the varieties being the ones that had succeeded best at the California Experiment Station. The seed of the yellow sweet-clover was procured at a mill from grain screenings, the local name of the plant being "sour clover." The yields were as follows:

Crop.	*Date of seeding.*	*Date of plowing under.*	*Yield per acre green.*
Clover	Sept. 9	Mar. 22	42,600 lbs.
"	" 26	" 22	43,000 "
"	Oct. 8	Apr. 10	53,100 "
"	" 19	" 7	52,700 "
"	" 29	" 10	43 560 "
Alfalfa	Sept. 9	Mar. 22	28,300 "
"	Oct. 9	Apr. 10	26.500 "
"	" 19	" 7	31,300 "
"	" 20	" 10	29,600 "
"	" 25	" 9	22,200 "
Large blue lupin	Oct. 11	Feb. 24	20,000 "
Small blue lupin	Oct. 11	Mar. 12	9,500 "

The yellow sweet-clover is plainly the best plant for the green-manuring of orchards. As was the case last year, the best results were obtained from October sowings. Earlier than October, the temperature is too high to secure a good stand; and sowings made later than this month do not have sufficient time to become established before the cool weather of winter. This year's experience teaches that the crop should be plowed under during the latter part of March, about two weeks earlier than most of the sowings were turned under. By early April the crop had become so heavy as to be nearly unmanageable. A few weeks earlier the plants were not so large, were more succulent, and would have turned under more readily and decayed more rapidly.

Alfalfa is less suitable for winter green-manuring, since the seed is more expensive, the growth is lighter, and it is more difficult to kill when spring comes than the yellow sweet-clover.

The lupins make a more rapid growth during autumn, and reach maturity sooner than alfalfa or the clover; but the comparative yield is too light for the purpose.

VEGETABLES.

Owing to the demand for information concerning the culture of vegetables, considerable attention has been given to experiments with the leading kinds. The work during the previous year was quite miscellaneous; but during the past year attention has been confined principally to experiments with cabbage, cauliflower, lettuce, melons, onions, and potatoes.

During the latter part of the year a bulletin was prepared giving dates for seeding, methods of irrigation and culture, and suitable varieties of each of the principal vegetables grown in southern Arizona. The unique climatic conditions of the region made the issuing of such a bulletin important.

CABBAGE.

A large number of varieties of cabbage were tested. Sowings of seed were made during May, August, and late September. Those sown during May were set out during August, and matured during December and January; those sown during August were set out the latter part of September, and matured during February and March; and those sown during the latter part of September were set out during November, and matured during April and May. A succession of fresh cabbage from December to June was thus secured. This represents quite accurately the possibilities in this line, in the warmer valleys of southern Arizona.

The yields from the varieties tested were as follows:

Variety.	*Date of seeding.*	*Date of setting out.*	*First heads ready.*	*Yield in lbs. per sq. rd.*
Burpee's New Cabbage from Germany	May 25	Aug. 16	Nov. 23	18
All Seasons	"	"	Dec. 5	85
Fottler's Brunswick	"	"	" 14	135
Early Jersey Wakefield	"	"	" 22	30
Large Late Drumhead	"	"	Jan. 13	100
Henderson's Late Flat Dutch	"	"	" 18	60
Red Poland	"	"	Feb. 14	80
Succession	Aug. 11	Sept 28	" 14	160
Drumhead Savoy	"	"	" 14	20
Danish Ball-head	"	"	" 26	50
Burpee's Safe-crop	"	"	Mar. 2	70
" Sure-head	"	"	" 17	80
" Drumhead	"	"	" 17	40
Acme Flat Dutch	"	"	" 17	70
Early Jersey Wakefield	Sept. 29	Nov. 21	" 26	45
New Cabbage from Germany	"	"	April 13	25
All Seasons	"	"	" 23	100
Marblehead Drumhead	"	"	" 23	70
Winningstadt	"	"	" 23	55
Early Flat Dutch	"	"	" 23	45
Fottler's Brunswick	"	"	May 14	75
Late Flat Dutch	"	"	" 14	75
Late Mammoth Drumhead	"	"	" 14	70

The best varieties of cauliflower tested were Burpee's Dry Weather and Burpee's Best Early.

LETTUCE.

The following varieties of lettuce were tested during the year, the principal sowing having been made September 25: California Cream Butter, Burpee's Hard-Head, Henderson's Boston Market, Henderson's New York, Morse, Iceberg, new lettuce from Tyrol, Salamander, White Cos, Denver Market, Golden Queen, Wonderful, San Francisco Market, Big Boston, and Hanson. Of these the earliest was Golden Queen, a small variety making good compact heads. The New York and the new variety from Tyrol produced the largest heads. Next in size were the Hanson and Wonderful. Other satisfactory varieties were Iceberg, Denver Market, and Big Boston.

WATERMELONS.

Twelve varieties of watermelons were tested this season. Of these the Augusta proved the most satisfactory. It furnished the first ripe melons, for the first three weeks of the melon season furnishing a larger number of melons and a greater weight per square rod than any other variety. Henderson's Sweet Siberian proved to be a melon of excellent quality, but was not quite as early as the Augusta, nor so large. The Russian varieties did not make as good a showing as they did the previous year.

ONIONS.

The experiments with onions covered tests of varieties and methods of culture. Seed was planted September 16. Part of it was sown in rows 20 inches apart, and part was sown broadcast in a small bed that could be watered frequently. December 2 the plants that grew in the latter were transplanted into rows adjoining the ones sown where they were to stand. They were set about six inches apart, and the others were thinned to the same distance, vacancies being filled in. The subsequent treatment was the same. The New Queen ripened June 15 to 20, and the remaining varieties July 10 to 25.

The yields in pounds per square rod were as follows:

Variety.	*Transplanted.*	*Not Transplanted.*
Australian Brown	14	19
White Portugal	29	21
Mammoth Silver King	14	23
New Queen	36	36
Prize Taker	39	45
Averages	26.4	28.8

The early ripening of the New Queen is decidedly in its favor, and only one variety surpassed it in yield. The Prize Taker, however, besides giving the heaviest yield, produced the best quality of onions. This variety and the Australian Brown kept better than the white varieties. The best way to keep them was found to be to spread them out on the ground in the shade of trees.

The results of this season's experiment indicate that the yields will not differ greatly, whether the onions be transplanted or be sown where they are to remain. However, but for the filling in of vacancies, the yields of the plats sown where they were to remain would undoubtedly have been lower than the others.

POTATOES.

The aim of the experiments with potatoes was to determine whether any variety could be profitably grown in the place of the one commonly planted—Early Rose, to test the effect of times of planting, of distance in rows, and of the application of Chili saltpetre. About an acre and a half was devoted to the experiment. The land had been previously dressed with about fifteen loads of stable manure per acre. Seed of the Early Rose came from California, of the Sunrise from the upper Gila valley, and of the remainder of the varieties from the northeastern states. The yields were as follows:

Variety.	*Date of planting.*	*Date of ripening.*	*Yield per acre.*
Early Rose	Jan. 17	May 30	4130 lbs.
Burpee's Early	"	" 20	4160 lbs.
Sunrise	"	" 25	2625 lbs.
Early Rose	Feb. 7	June 1	3025 lbs.
Early Ohio	"	May 25	1975 lbs.
Early Andes	"	" 30	3250 lbs.
Bovee	"	" 30	3150 lbs.
Sunrise	"	" 30	2500 lbs.
Triumph	"	" 25	3525 lbs.

It will be observed that Early Rose planted January 17 gave over a third higher yield than those planted February 7, the three weeks start evidently proving of great advantage. Of the January 7 planting Burpee's Early matured first and gave a yield equal to that of Early Rose. Tubers form on this former variety very early in its growth. As early as April 18, the yield of a measured area was at the rate of 3440 pounds per acre, against a yield of 1650 pounds for Early Rose. May 5 Burpee's gave a yield of 3840 pounds per acre, and Early Rose 2670 pounds. Seed of the former variety sprouted so freely early in the winter that it was not deemed best to hold any of it for the later planting.

Of the February 7 planting, Triumph gave the best results. It matured as early as Ohio and gave a much higher yield. It also forms tubers early in its growth. April 18 it gave a yield of 2550 pounds per acre, against 660 pounds for Early Rose planted at the same time. May 5 the yield was 3180 pounds, against 2275 pounds for Early Rose. Burpee's Early and Triumph are promising varieties for the region. At present, however, there is no available supply of seed. Raising seed in the vicinity of Phoenix is impracticable. An attempt is being made to get the varieties introduced into the cooler valleys along the railroad to the north of Phoenix. To this end, seed from those grown at the farm was sent early in June to a grower near Kirkland, upon condition that he save for seed the tubers grown from it. It would be a distinct advantage to the valley if a source of supply of seed potatoes could be established in the cooler valleys to the north.

Part of the Early Rose plat was treated with Chili saltpetre (sodium nitrate) at the rate of 500 pounds per acre. The unfertilized portion gave a yield of 3025 pounds per acre, and the fertilized portion a yield of 3695 pounds per acre, a gain of 670 pounds, worth about $12. The nitrate applied per acre was worth nearly this amount.

A test of the effect of dropping seed different distances apart in the rows gave the following results: 18 inches apart, 2810 pounds per acre; 15 inches apart, 3280 pounds per acre; 9 inches apart, 4370 pounds per acre, a gain of over 1500 pounds, worth about $30, over the plat planted 18 inches apart. The difference in cost of seed would be $10 to $12.

WINTER IRRIGATION OF ORCHARDS.

The test of the effectiveness of the thorough irrigation of orchards during winter, when irrigating water is comparatively abundant during ordinary seasons, was repeated during the past year. During autumn a "Timely Hint" was issued advising orchardists to irrigate as thoroughly as possible during winter, advice that many followed, much to their advantage.

Water was withheld from the small orchard (irrigated thoroughly the previous winter and only once the previous summer) from June to December, 1899. During the latter month irrigation was resumed, and continued until March, the last irrigation being March 5. As soon as dry enough, the orchard was plowed each way, harrowed thoroughly, and left for the summer. After each of two April showers, it was cultivated to break up the crust that formed over the surface. Though having passed through the dryest hot period of which there is a record in the valley, the trees are now (July) in the best of condition. The apricot trees have made a young growth of three to six feet, and the peach trees a growth of about four feet. The apricot trees all matured a good crop of fruit, and many of the peach trees are unusually heavily loaded.

An adjacent vineyard was treated similarly, and with an irrigation June 5, has remained in prime condition and is bearing a heavy crop of excellent fruit.

Another peach and apricot orchard was sown to clover during October, and from then until April was irrigated sufficiently to keep the crop growing well. Samples of soil from each of the upper 33 feet, taken during April, showed that the soil had been wet to as great depth as in the orchard in which nothing had been sown. The present (July) condition of the orchard, not having been irrigated since April 6, corroborates the determinations made from the soil samples. This proves that green-manuring and winter irrigation may go hand in hand to excellent advantage.

SUGAR BEETS.

Experiments were conducted with sugar beets this year, mainly for the purpose of testing methods of irrigation, other points in their culture having been pretty well settled by previous experiments. A sowing was made September 12 in a gravelly loam, and irrigated at once, as is necessary at this time of year. The winter being quite mild, a fair growth was made. Samples taken April 2 gave the following results: Average weight of beets dug, 12.0 ounces; yield per acre, 11.5 tons; sugar in beets, 14.7 per cent; purity co-efficient, 83.3 per cent. These are probably as good results as could ordinarily be expected from seed sown on the earliest practicable autumn date.

At the close of the year 1899 bulletin 31 was issued giving the result of the year's work. The averages from ten plats sown during January and February, 1899, were as follows: Yield per acre, 9.75 tons; per cent sugar in beets, 15.0; purity, 77.7; available sugar per acre, 2010 pounds. The most important of the conclusions from the work of the year was that winter-sown beets are not benefited, and may be injured, by early irrigation, provided the soil has been thoroughly irrigated previous to seeding. The indications were that the most advantageous time to begin irrigating is when the beets are two to three months old.

A plat sown December 26 and first irrigated April 1 gave the following results:

	Sugar in beets.	*Purity.*
June 15	15.0	88.1
July 1	16.4	88.4
July 11	16.4	86.0
July 30	16.9	85.4

The yield upon the latter date was 14.5 tons per acre, giving an approximate yield of available sugar per acre of 4050 pounds, the highest yield yet obtained from any of the experimental plats during the past four years. This yield of sugar per acre evidently remained about constant during all of June and July, the increase in the percentage of sugar being just about counterbalanced by a decrease in the purity coefficient. Only a tenth of an inch of rain fell upon the plat from the time of seeding until the first irrigation over three months later, during which period they made an excellent growth. This result was accomplished by a thorough irrigation of the soil previous to seeding.

A plat sown January 23 and first irrigated April 3 gave the following results:

	Sugar in beets.	Purity.
June 15	13.6	83.2
July 30	13.7	83.0

The yield upon the latter date was 10.4 tons per acre, giving an approximate yield of sugar per acre of 2165 pounds. This plat, and others sown later, suffered for want of water during the latter part of their growth, owing to the drouth and consequent shortage of irrigating water during the past season.

EUCALYPTS.

Experiments with and observations upon these trees have been continued throughout the year. Their great value as a fuel and timber tree, as well as their usefulness for shade and for wind-breaks, makes the introduction of the species that will grow here important. It is now thoroughly demonstrated that the Blue Gum (E. globulus) will not endure the summers of the warmest parts of Arizona; but it endured both the summer and winter climate of Safford during the past year.

Of those set during the spring of 1899 and reported on last year, only the following endured both the heat of summer and the frosts of the following winter: E. corynocalyx (sugar-gum), E. cornuta, E. leucoxylon, E. melliodora, E. occidentalis, E. polyanthema, E. rostrata (red gum), E. rudis, E. siderophloia, and E. stuartiana.

For the purpose of testing the feasibility of late summer and early fall planting, several species were set during last August and September. All made a good start, and the following endured the ensuing winter and are still in good condition: E. occidentalis, E. robusta, E. sideroxylon, and E. tereticornis.

The species that had failed to survive the previous summer were reset last April. As a result of the two seasons experiments with young seedlings, it is pretty well established that the following will not endure the heat of our summers, or make such slow growth that it is not advisable to set them: E. acmenoides, E. amygdalina, F. calophylla, E. diversicolor, E. engenioides, E. ficifolia, E. globulus, E. gomphocephala, E. gunnii, E. longifolia,

E. obliqua, E. resinifera, E. robusta, E. siderophloia, and E. stuartiana.

Since the past season, upon account of its dryness and the heat of June and July, has been a very trying one, it is of interest to note the species that have best survived these conditions. They are E. corynocalyx, E. cornuta, E. hemiphloia, E. leucoxylon, E. melliodora, E. occidentalis, E. polyanthema, E. rostrata, E. rudis, and E. tereticornis. All of these are valuable timber trees, some of them being among the most veluable ones in Australia. E, corynocalyx is very useful for fence posts, for fuel, for wagon-making, and as a source of honey. E. cornuta is a very valuable source of material for agricultural implements. E. hemiphloia is useful for fence posts, for agricultural implements, and for wagon-making. E. leucoxylon is useful for fuel, for fence posts, for bridge-building, and for wagon-making. E. melliodora is useful for fuel, for wagon-making, and as a source of an excellent grade of honey. E. polyanthema is useful for posts, for wagon-making, and as a source of honey. E. rostrata is, according to Australian authorities, one of the most valuable trees of that continent, being used principally for lumber, posts, railway ties, bridge-building, wagon-making, and for fuel. E. tereticornis furnishes a similar timber, being especially durable underground.

A. J. MCCLATCHIE,
Agriculturist and Horticulturist.

DEPARTMENT OF BOTANY.

CROWN-GALL.

The results accomplished in the investigations that have been under way during the past year have been of a very satisfactory nature. The year has been marked by the appearance of Prof. Toumey's bulletin containing the complete report of his investigations upon the crown-gall, so destructive to fruit trees in Arizona. This subject has been under consideration for several years and the ultimate disposition of it as related and illustrated in Bulletin No. 33 of this Station is matter for congratulation to fruit growers throughout the United States.

A brief account of the observations made upon the crown-gall was published in the annual report of a year ago, including greenhouse experiments upon seedlings grown in sterile soil and inoculated with the disease, and upon seedlings springing up spontaneously in an almond orchard at Glendale. These experiments proved conclusively the communicability of the disease by contagion and the effectiveness of Bordeaux mixture in checking or preventing it when properly applied. But the discovery of the true cause of the disease was reserved for the investigations of the past winter and the results obtained have been gratifying in the extreme. It was found that the meristematic cells of the gall are filled with the substance of a very delicate parasitic organism, extremely difficult of detection owing to its great similarity, when in the active stage, to the natural protoplasm of the host plant. Organic bodies of this character are known as plasmodia and are not usually parasitic, the only other well authenticated case being that of *Plasmodiophora* which produces the club-root of cabbage and other Cruciferous plants. Prof. Toumey has been able to follow the organism throughout its life-history, to observe the formation of the fruit, the production of the spores and to demonstrate their inoculating power. It has thus been shown what extreme care is essential to the prevention of the introduction and spread of the disease by the use of nursery stock obtained from questionable sources and by neglect to completely destroy all trees that have succumbed to the disease, as well as knots trimmed from those which it is hoped may be saved by treatment. All Arizona fruit-growers will do well to observe the warnings and instructions urged upon them in this bulletin for the sake of checking the ravages of a disease that is becoming so destructively prevalent.

Three of the series of "timely hints" published during the year have also come from the pen of the botanist; namely, No. 5, The Crown-Gall; No. 8, What to Plant on Arbor Day; No. 18, Grazing vs. Irrigation.

ALFALFA ROOT-ROT.

Investigations have also been in progress upon the root-rot of alfalfa concerning which complaints and inquiries have been received from time to time from various sources in arable parts of the Territory. A plat was staked off in October, 1899, on the ranch of Mr. A. V. Grossetta near Tucson where this disease has gained a footing. The area marked off includes one of the typical circular spots of dead plants and those weakened by the destruction of the tap-root by the rot, as well as unaffected portions of the field. This area has been divided into sub-plats, eight within and eight bordering upon the affected spot. The sub-plats have been treated with several approved fungicides used in the normal strength as applied to soils, one plat within and one bordering upon the spot being similarly treated. The fungicides used were copperas, blue-stone, Bordeaux-mixture, ammoniacal copper carbonate, corrosive sublimate, sodium carbonate and creolin. Plats numbered 8 and 8a were reserved and treated as a check. The plats within the spot were reseeded to determine whether the disease would again become active upon an area already traversed by it. About one side of the spot, also, a trench was dug forty feet in length and increasing from one to three feet in depth at a distance of seven and a half feet from the border, in order to make possible observations upon trenching as a means of preventing the spread of the disease.

With a view to determining the relative resisting power of various varieties of alfalfa, seeds have been obtained from various parts of the United States, from Chile, Argentine, Europe and Turkestan, and these will be fully tested.

ECONOMIC CACTI.

The progress made in the cultivation of cacti, especially those of economic importance is worthy of note. The plants in the cactus garden in front of the main University building at Tucson have been named, listed and labeled and a plan of the garden made for the accurate location of a plant of any species growing in the garden. It has been found to contain nearly one hundred species of cacti about half of which are of the genus *Opuntia*.

The beginnings of a new garden in which economic investigations are to be made upon the Opuntias have been made in one corner of the University grounds and one hundred and fifty plants are now growing there representing a large number of species. A number of these are plants consigned to the Station by the Department of Agriculture at Washington and were obtained from Sicily, Algeria and South America where they have been cultivated as forage and fruit-producing plants. It is not unlikely that a number of these may sometime be profitably introduced into many parts of Arizona, making it possible to turn to account large areas of desert and otherwise nearly worthless land.

MISCELLANEOUS.

Inquiry has been made concerning the great prevalence of smut upon sorghum in the region about Concho and it has been recommended that the seed be freed from smut-spores by the use of the hot water method before planting. This method has been found effective as the spores must be in contact with the seed at germination in order to produce the disease in the plant. The method employed is to mix the seed, not more than a bushel at a time, in water at ordinary temperature and skim off those that float as they are frequently filled with spores that would fail to be destroyed in hot water. Next, the seed is placed in a loose sack and two large vessels are prepared containing water heated to 135°F. as tested by the thermometer. Place the sack containing the seed in the first vessel and keep it moving up and down in order to mix the water thoroughly with the seed and raise the mass to the temperature of the water. This will lower the temperature of the water somewhat and the sack should now be transferred to the second vessel where it should be kept in motion for fifteen minutes, the temperature of 135° being constantly maintained. The careful following out of these instructions will free the seed from smut-spores and prevent the ruining of the crop from this cause.

Complaints have been received from time to time during the spring months concerning the poisoning of cattle by weeds which they may have eaten. In no case have the materials sent as supposedly poisonous represented plants which are known to be so. In no part of the country is the knowledge of this subject at all exhaustive and this is particularly true of so new a country as Arizona where the plants are less thoroughly known than in a region less recently settled. It offers a wide and important field for investigation which it is hoped may be taken up in the early future.

A. A. TYLER,
Associate Botanist.

DEPARTMENT OF ANIMAL HUSBANDRY.

FEEDING STEERS.

It is a generally accepted fact that while cattle fatten readily on alfalfa they do not, upon that feed alone, assume that degree of finish which commands the best market prices in competition with grain fed animals. Under present conditions in Salt River valley the feeding of grain to fattening cattle is considered out of the question, barley, practically the only grain feed raised, commanding a price putting it out of reach of cattle feeders. The theory has been advanced that the feeding of sorghum in connection with alfalfa will, in a measure, have the desired effect of hardening or finishing the cattle. This method of feeding has been tried here and there by feeders who report good results but who are unable to offer any definite figures in comparison with those for feeding alfalfa only.

A comparison of the chemical composition of alfalfa with the rations recommended by scientists, and fed by the intelligent feeders of the grain producing and cattle feeding states shows that this forage crop supplies what would be called a narrow ration, one in which there is a higher per cent of nitrogenous material than is called for in what is accepted as a standard ration for fattening cattle. In this standard ration the proportion of the protein, or nitrogenous material, to the carbonaceous material is about as one is to six, while in alfalfa this relation is approximately as one is to three and a half. In the districts where cattle are most fed the portein is the expensive part of the ration; here where alfalfa grows so luxuriantly the reverse is the case. In supplying an excess of portein the cattleman of Salt River valley is not using an expensive element where a cheaper one would give as good or better results, as would be the case with a corn-belt feeder using the same feed. The fact remains, however, that alfalfa alone does not produce a finished beef. The questions remain, can better

Steers used in Feeding Trials, 1900.

results be obtained by feeding some other forage in connection with alfalfa?, and, to what extent will it pay to try to raise grain for the purpose of finishing alfalfa-fed stock? It is the aim of the work of this department to throw light upon these propositions.

Upon taking up the work here in the fall of '99 the writer found available for experimental use a small area of sorghum and some plots of corn, Kaffir corn, and teosinte. There was some alfalfa hay that had been damaged by rain and no alfalfa pasture.

It was determined to feed small lots of steers with a view to getting some indication as to the value of alfalfa fed alone and alfalfa fed in combination with the other forages at hand. Eight steers from ten to fourteen months old were purchased for this purpose and divided into two lots as nearly as possible equal in age, weight and apparent thrift. Four of the lot were from white-face dams and the rest gave evidence of shorthorn blood. Two had been skim-milk calves and though in good thrifty condition were not so fat as the remainder of the bunch.

ALFALFA HAY VS. ALFALFA HAY AND CORN FODDER.

For the first five weeks of the experiment Lot I was fed corn fodder in addition to alfalfa hay; Lot II received the alfalfa hay only. The hay fed both lots was of rather poor quality and gave evidence of having been damaged by rain. The fodder corn had been cured in the field, was very dry and much bleached. The corn had been planted close together and practically no ears had formed though there were occasional nubbins.

During this period Lot I ate 1512 lb. of hay and 1247 lb. of corn fodder and gained 195 lb. in weight or 1.39 pounds a day per head.

Lot II ate 2929 lb. of alfalfa hay and gained 145 lb. in weight, or 1.03 pounds a day per head.

ALFALFA HAY VS. ALFALFA HAY AND KAFFIR CORN.

During the next period of five weeks Kaffir corn was substituted for fodder corn in the feed of Lot I. Like the corn fodder the Kaffir corn was field cured and dry. Seed had not formed abundantly and most of what had formed had been taken by the blackbirds. After two weeks of this period the alfalfa hay fed was of good quality.

Lot I ate 1575 lb. of hay and 1333 lb. of Kaffir corn and gained 236 lb. or 1.68 pounds a day per head.

Lot II ate 2853 lb. of alfalfa hay and gained 230 lb. in weight or 1.65 pounds a day per head.

ALFALFA HAY VS. ALFALFA HAY AND SORGHUM.

The last period of the trial covered six weeks during which Lot II had sorghum in addition to alfalfa.

Lot I ate 1890 lb. of hay and 1814 lb. of sorghum and gained 277 lb. in weight or 1.65 pounds a day per head.

Lot II ate 2898 lb. of alfalfa hay and gained 280 lb. in weight or 1.67 pounds a day per head.

During the entire trial of sixteen weeks Lot I ate 4977 lb. of alfalfa hay and 4394 lb. of other forage and gained 711 lb. in weight; Lot II ate 8680 lb. of alfalfa hay and gained 652 lb. in weight. There is therefore a difference of 59 lb. gain in favor of the lot receiving fodder in addition to alfalfa, a difference of about fifteen pounds per head in sixteen weeks, a difference hardly decided enough upon which to base conclusions in favor of the use of a supplementary feed or otherwise, especially when the fact is taken into consideration that practically all of this excess of gain was made during the first period when the alfalfa hay fed was not of the first quality.

In the spring a piece of land adjoining the Station farm was purchased and pasture land thus became available for our use.

On May 11th the steers used in the foregoing trials were redivided, two of each lot being transferred, so as to offset any possible influence of previous feeding, and put upon pasture. Each lot of four had two acres of good alfalfa pasture in addition to which one lot had sorghum and the other alfalfa hay.

During the eight weeks of this trial the lot receiving alfalfa hay gained 364 lb. or 1.63 pounds a day per head while the lot getting sorghum gained 348 lb. or 1.55 pounds a day per head. The difference of sixteen pounds gain on four steers in eight weeks in favor of alfalfa hay over sorghum would not seem to indicate that there is much difference in the feeding value of these two feeds when fed to these steers, on abundant summer pasture.

The results of the foregoing trials are collected in the following table:

Trial.	Lot.	Feed.	Steer.	Weight at beginning.	Pounds gain.
First five weeks.	I.	Alfalfa hay, 1512 lb. Corn fodder, 1247 lb.	2	685	55
			3	616	50
			5	785	53
			6	614	37
					195 total.
	II.	Alfalfa hay, 2929 lb	1	626	37
			4	683	40
			7	597	39
			8	571	29
					145 total.
Second five weeks.	I.	Alfalfa hay, 1575 lb. Kaffir corn, 1333 lb.	2	740	62
			3	666	62
			5	838	60
			6	651	52
					236 total.
	II.	Alfalfa hay, 2853 lb.	1	863	54
			4	723	62
			7	636	58
			8	600	56
					230 total.
Third six weeks.	I.	Alfalfa hay, 1890 lb. Sorghum, 1814 lb.	2	802	68
			3	728	74
			5	898	67
			6	703	71
					280 total.
	II.	Alfalfa hay, 2898 lb.	1	917	67
			4	785	65
			7	694	74
			8	656	71
					277 total.
On pasture eight weeks.	I.	Pasture and sorghum.	2	870	94
			4	850	78
			5	965	97
			8	727	79
					348 total.
	II.	Pasture and alfalfa hay.	1	984	100
			3	802	74
			6	774	110
			7	768	80
					364 total.

SHEEP FEEDING.

On Feb. 15th forty head of yearling range wethers were purchased: they were of mixed breeding and weighed a trifle under 62 lb. per head; they had been running on short alfalfa pasture and had been recently shorn.

The sheep were divided for experimental feeding into five lots, each containing eight of apparently equal thrift, and were fed in small yards without shade or shelter. Before the feeding trial they were fed alfalfa hay and cured second crop Kaffir corn with practically no seed, two lots getting sugar beets in addition, it being found necessary to teach them to like beets.

The feeding trial lasted four weeks, from March 5th to April 2nd, during which time the different lots were fed as follows:

Lot I was given 40 lb. of sugar beets, chopped and fed in shallow troughs, and 20 lb. of alfalfa hay daily. There was some waste of hay but it was not weighed back.

Lot II was given 40 lb. of sugar beets and 20 lb. of sorghum daily and the sorghum stalks not eaten were weighed back.

Lot III had 40 lb. of alfalfa hay daily.

Lot IV was fed 40 lb. of sorghum and the wasted sorghum weighed back.

Lot V was fed 10 lb. of alfalfa hay per day and 30 lb. of sorghum, the sorghum not eaten being weighed back.

The following table shows the amounts of feed eaten by the different lots and the gains made:

Lot.	*Feed.*	*Pounds of gain.*	*Pounds gain per head per day.*
I.	Alfalfa hay, 560 lb. Sugar beets, 1120 lb.	58	.259
II.	Sorghum, 387 lb. Sugar beets, 1120 lb.	64	.286
III.	Alfalfa hay, 1120 lb.	42	.187
IV.	Sorghum, 944 lb.	28	.125
V.	Alfalfa hay, 280 lb. Sorghum, 704 lb.	52	.232

While one should refrain from drawing conclusions from the results of such a limited experiment, the above figures may offer some significant suggestions:

The greater gains made by Lots I and II getting sugar beets as a part of their ration point to the undoubted advantage of succulent feed in a ration.

The fact that Lot II made but a meager gain on a feed of sorghum only was to have been expected on account of the one-sidedness of the ration; for the same reason it would seem that Lot I should have made better gains than Lot II, but such was not the case. This contradiction of results seems to point to the important fact that the physical condition of feed must be reckoned with as well as its chemical composition in estimating its feeding value.

The relative gains made by Lots III, IV, and V are about what the orthodox feeder would expect, Lot III on alfalfa hay doing much better than Lot IV on sorghum, and Lot V on a combination of the two, doing better than either.

One conclusion the writer has reached, which may or may not be drawn from the figures above, is that one should not attempt to feed sheep in Salt River valley without shelter. There was but one severe storm during this trial but during the week of that storm the sheep made practically no gain and one wether in Lot I died. The sun, however, was worse than the rain. March was an unusually hot March, there being many days that the mercury went above 90° in the shade during the heat of the day. On such days the sheep suffered perceptibly and it seemed that the gain of several days melted away under the hot rays of a single day's sun.

At the end of the trial the sheep were not in condition for market. They were then turned on a three acre field of ripe and partially dry burr clover and fed alfalfa and barley hay in addition. Later, they had a run on alfalfa and were fed wheat hay on the side. There were no losses from bloat.

On June 5th the bunch was sold to a local butcher at four cents per pound, that being a little better than the prevailing market price. When sold, 39 sheep weighed 3400 lb. This made an average gain of .32 pounds per day from the time of their purchase to their sale.

FEEDING DAIRY COWS.

On June 17th six two year old heifers were purchased. They were selected from a herd of thirty with an eye to their future usefulness as dairy cows. A complete record of their milk and butter production is being kept. At present this herd is being used in a trial intended to show the comparative efficiency of feeding green alfalfa by pasturing and soiling. Incidental to the experimental feeding work with dairy cows, experiments in methods of handling milk are being carried on.

COMPARATIVE PROFITS IN DAIRYING.

Between three and four hundred ranchmen in Salt River valley milk cows and sell the product at a creamery. The product thus disposed of is weighed and tested in such a way that the cash returns per cow may be exactly calculated. This is to the advantage of the dairymen, but few of them appreciate this opportunity to calculate gains and, what is more important, compare results. This condition of affairs is illustrated by the fact that in some cases the monthly checks hardly cover the cost of feeding the cows. That the available facts concerning the comparative profits in dairying, as carried on under conditions existing in Salt River valley, may be gotten together and presented in such form as to be of instructional value, the writer is, by the help of the creamery managers, keeping a record of the number of cows milked, the pounds of milk and butter fat produced, and the cash received for the same each month, by all the patrons of the three leading creameries of the valley.

TESTING INDIVIDUAL COWS.

When the writer took up his work in connection with the Experiment Station there was no herd of dairy cows at his command for experimental use. Upon investigation it was found that no ranchman in the valley, so far as could be learned, was keeping a record of the amount of milk and butter fat given by the different cows of his herd. It seemed expedient, therefore, to enter upon a line of work that would demonstrate the importance of every farmer keeping such a record, as by this means only is one able to determine the comparative value of the different cows in the herd.

Two dairymen were found who agreed to weigh and take samples of the milk of each cow of their herds for a year, the writer to furnish sample cans and blanks for bi-weekly reports, to test the milk and keep the records. The work was started Nov. 1st and the year's record will be an illustration of what every intelligent dairyman should do for himself.

Single tests covering periods of two weeks have been made of other herds.

THE USE OF HAND SEPARATORS.

The writer has been called upon at different times to test the efficiency of hand separators that the owners did or did not suspect were doing poor work.

In one case the operator was dissatisfied with his test at the creamery but did not suspect his separator of being inefficient. The skim milk was found to contain .4 of one per cent of butter fat which indicated a loss of about $15 per month to its owner. Upon examination the upper bearing was found to be loose and in need of a new packing ring. Upon renewal of the packing ring the machine worked well.

Two other machines were tested and found to be inefficient on account of poor construction. They have never given satisfaction, are still a source of trouble and financial loss, and their owners are unable to get any satisfaction from the manufacturers. Other machines have been found to be doing good work.

The above incidents indicate: first, that the centrifugal milk separator, on account of the exactness of its construction should be thoroughly understood by its operator; and second, that it does not pay to purchase such machines of unreliable manufacturers because they are cheap. The unsuspected loss in one case cited shows the short-sightedness of using a poor machine at any cost.

It is the intention of the writer to make a systematic test of the hand separators in use in the valley for the sake of comparison with one another, with the gravity system of gathering cream, and with creamery operations.

DEHORNING CALVES.

The writer having been called upon to recommend a method of dehorning calves thought best to give a demonstration.

On Nov. 29th two calves belonging to F. D. Steel of Phoenix, one a month old and the other but a few days, were treated with caustic potash, as directed in Timely Hint No. 15. The calves suffered but little pain at the time of and apparently none after the application of caustic potash. In both cases the horns were completely killed and today the heads present a smooth poll.

GORDON H. TRUE,
Department of Animal Husbandry.

DEPARTMENT OF CHEMISTRY.

The main work of the chemists for the year has been with the irrigating waters of the Territory. Daily samples have been secured for nearly a year from the Consolidated canal at Mesa City, representing the Salt river supply; for several weeks or months, respectively, from the Gila river at Buckeye, and at Florence; and also for a number of months from the Colorado river at Yuma. The examination of these numerous samples, involving much technical work, is yet incomplete.

RIVER WATERS.

Representative samples from a flow of one week, both high and low water, from the Colorado at Yuma, the Gila at Florence, and the Salt at Mesa City; also the Buckeye canal supply from the lower Gila, show the following composition:

PARTIAL ANALYSES OF IRRIGATING WATERS.

	Salt river at Mesa City.		*Gila river at Florence.*	*Colorado river at Yuma.*		*Gila river at Buckeye.*
	April 4 to April 11, 1900; medium flow.	*July 28 to Aug. 4, 1900; very low water.*	*Jan. 11–18, 1900; medium flow.*	*Jan. 22–28, 1900; low water.*	*April 25 to May 1, 1900; medium flow.*	*May 31 to June 7, 1900; low water.*
Silt by volume	.22%	.08%	.12%	.17	.392%	.04
Silt by weight..	.029%	.014%	.036%	.058	.115%	.004
Parts in 100,000						
Total soluble solids	87.6	156.6	118.0	100.2	54.8	199.2
Sodium chloride (common salt)	62.6	116.4	67.53	37.0	17.6	133.8
Permanent hardness stated as calcium sulphate	2.99	16.04	9.52	16.59	14.14	36.72
Parts in 1,000 000						
Total nitrogen ..	1.50	1.13	1.88	1.29	1.96	1.13
Nitrogen as nitrates.........	.46	.67	.52	1.30	.86	.82

These representative, partial analyses show certain facts bearing upon irrigation:

The three great rivers of the Territory are seen to be of quite variable character for irrigating purposes, containing in the instances mentioned, from 50 to 200 parts of soluble salts in 100,000, in round numbers. The quantity of soluble salts is influenced by the stage of water and by seepage from irrigated districts. The nature of these salts is influenced by the same causes. The Colorado river is less saline the year around than either the Salt or the Gila. In summer, when its waters rise under the influence of the melting snows in Colorado and Utah, the total soluble solids were observed to average as low as 25 parts in 100,000 for months at a time.

Flood waters in all cases not only carry less salts but more silt, including nitrogenous fertilizing materials. Barring the inconvenience of excessively muddy water, therefore, flood waters are in every way preferable for irrigating purposes.

In winter the Colorado water, and in summer the Salt and Gila waters, averaging low and therefore leaching and flowing more slowly through the country drained, carry larger amounts of soluble salts and less silt. During the exceedingly dry summer of 1900, the solubles in Salt river rose to 156.6 parts, a concentration which in some soils and with tender plants would possibly cause injury if long continued.

At the foot of irrigated districts both on the upper Gila and in the Buckeye district the soluble salts increase in quantity, largely through the effects of seepage water from irrigated districts above. In its slow passage through the soil, for instance, as shown in the table, the soluble content of the Buckeye supply has increased 27, 69 and 127 per cent over that of the Salt and Gila rivers above, from which it is derived. This increase of soluble solids is a fact which, together with such matters as the original alkalinity of the soil, the natural drainage, and the crops to be raised, should be duly considered by prospective settlers in a given locality.

199.2 parts to the 100,000 of water is equal to 5423 pounds of salts per acre for one acre foot of water. For four acre feet, the amount used per year in mixed farming in some parts of southern Arizona, the total would be 21692 pounds of salts added to the soil in one year.

Now, since 20,000 pounds per acre of soluble salts in the surface four feet,—more or less according to soil, drainage, the nature of the salts and kind of crop grown, is about the average limit for ordinary crops, it follows that if this soluble matter should all remain in the soil its effects would be soon felt.

Fortunately the districts watered with seepage are narrow in proportion to their length and have excellent natural drainage. Moreover, the occasional flood waters which come down from above will undoubtedly in future prove a means of flooding alkali lands and leaching out their excessive salts.

In the table these waters are all observed to contain "permanent hardness," which consists in part of the sulphate of lime. This compound, in moist, well-aerated soil, is an antidote for black alkali, which is found in some parts of the irrigated districts. The application of these waters to irrigated lands may therefore, in some cases, actually improve them so far as this most injurious form of alkali is concerned.

The silt is of interest as affecting the fertility of irrigated lands and as being, also, a possible menace to the life of water storage reservoirs. The fertilizing value of irrigation silts the world over is well known; although excessive amounts are an inconvenience in irrigation.

The average amount of silts in the Salt river supply from Aug. 1, 1899, to Aug. 4, 1900, by weight and by volume, was, by weight .1 of the water; by volume .3 . This amount of silt is unquestionably less than the average on account of the unusually low water prevailing during most of the time of sampling. The Salt river, however, is undoubtedly far less silty than the Gila, and this element of doubt in connection with the life of reservoirs correspondingly less.

The figures for total nitrogen and nitrogen as nitrates are also of special interest, our soils being usually deficient in nitrogen. The average total nitrogen in the Salt river supply for one year was found to be 3.25 parts in 1,000,000 of water, including that which was contained in the silt. Of this amount 1.04 parts per million existed in the form of nitrates. Differently stated, this means that, in the course of one year, four acre feet of average quality water applied to land in Salt River valley would contain 35.39

pounds of nitrogen, mostly in the silt, but 11.32 pounds being dissolved as nitrates in the water. If 40 per cent of this latter portion were lost in the seepage water, there would be left a net addition of 30.87 pounds of nitrogen to an acre of sufficiently irrigated land in one year.

Now, a crop of four tons of barley hay requires about 117 pounds of nitrogen, 50 bushels of wheat require not far from 59 pounds, and a crop of 10 tons of sugar beets about 57 pounds. It is thus evident that the irrigating water of this representative region contributes materially to the nitrogen requirements of typical crops. This fact, doubtless, accounts in large measure for the fertility of irrigated desert soils, even when first put under cultivation.

ARTESIAN WATERS.

The artesian water supply which has been so vigorously developed on the eastern slope of Graham mountain above Safford, Thatcher, and Pima, and also the artesian wells in the San Pedro valley south of Benson, have been under observation during the year.

The examinations of these waters with reference to their usefulness for irrigating purposes reveal certain important facts regarding them. In the table of analyses it will be observed that, although the total soluble salts are, with exception, not excessive, carbonate of soda, or "black alkali," is uniformly present. The Mud Spring well, for instance, with 19.6 parts per 100,000 of sodium carbonate, contains 533.6 pounds of this ingredient in one acre foot of water. Calculating on three acre feet of water a year, this would mean a total of 1600.8 pounds added, which in the upper three feet of soil would amount to .0134% of the soil. But .1% of black alkali is the maximum amount allowable in the soil in ordinary farming; therefore, if all the black alkali in this water remained in the top three feet, its effect would be severely felt in about eight years. If sensitive crops were grown, the time would tend to be less; with good drainage, bad effects would be delayed. Fortunately the waters of this district as a rule contain much less of sodium carbonate, but in any case its presence in an irrigating water is a matter for watchfulness.

An analysis of an alkali crust from Hildreth's ranch near Safford showed it to consist in part of calcium sulphate, or gypsum, which is an antidote for black alkali in moist, well-aerated ground. Should the soils of this region prove to contain calcium sulphate generally, the alkalinity of the artesian wells will, at least for a time, be rendered harmless thereby.

ARTESIAN WATERS OF SOUTHERN ARIZONA.

(*Parts in 100,000.*)

No. of sample.	*Location and description.*	*Depth in feet.*	*Total soluble solids.*	*Chlorine as common salt.*	*Carbonate of soda. "Black alkali."*	*Lime.*	*Magnesia.*	*Sulphates.*
2272	Hildreth's well above Safford	80	57.8	22.3	3.4	Slight	Trace	Strong
2374	J. W. Lee's well above Safford		46.2	18.0	1.91	0.66	0.22	9.21 (SO3)
2271	Chlarson's well above Thatcher	307	79.6	44.8	2.4	Slight	Trace	Very strong
2270	Mud Spring we l above Thatcher	310	99.6	51.7	19.6	None	Trace	Very strong
2511	M. A. Cluff's well above Pima	312	110.6	62.0	5.51	2.33	0.36	21.01 (SO3)
2512	M. A. Cluff's well above Pima	627	211.6	130.0	7.20	9.32	0.24	37.07 (SO3)
2146	Cadwell & Swatling, Willcox	270	32.8	5.5	16.5	None		Strong
2212	O. F. Ashburn, St. David	450	16.0	1.1	7.5	Faint		Very slight
2214	H. M. Eckerman St. David		25.2	1.2	6.1	Strong	None	Faint

SUGAR BEETS ON THE UPPER GILA.

Climatic conditions having seemed favorable to beet culture on the upper Gila, the Station undertook to extend its work in this line to this district. In order that the experiment might be conclusive as possible, Mr. C. G. Arney, trained to this work on the experimental farm, was put in charge of the plots. The ground and part of the labor was furnished by various public spirited citizens of Safford, Thatcher and Pima. Various types of soil were chosen, and plantings were made from Feb. 23d until late summer. The seven main plots were of sufficient size to afford acreage tests from time to time, some of the results being stated below. The work suffered in several instances from the unusual scarcity of irrigating water this year, and the yields may be considered less than the average probability for this region.

Of these plots, Nos. 3 and 8 were the only ones which did not suffer seriously for lack of water, and the total sugar per acre contained (2267 and 3361 lb., respectively) is a fair result, taken in connection with the percentages of sugar (15.9 and 13.7) and the purities (84.5 and 83). Owing to the adversity of the season, it is thought that better results may be secured by a continuance of the work for the ensuing year.

UPPER GILA BEET PLOTS; PLANTED FEB. 28 TO MAR. 19, 1900.

Name of plot.	Kind of soil.	*Results July 2-6, 1900.* Sugar in beets; per cent.	Purity.	Tons per acre.	Sugar per acre.	*Results Aug. 3-13, 1900.* Sugar in beets; per cent.	Purity.	Tons per acre.	Sugar per acre.	Available sugar per acre.
1. Morris, Layton	Sandy loam	9.9	75.2	5.9	1174	10.4	72.4	7.3	1521	940
2. Brinkerhoff, Thatcher	Adobe	12.0	82.5	4.86	1169	1[illegible].6	81.6	7.38	2006	1554
3. Hubbard, Pima	Heavy adobe	12.2	81.8	4.43	1077	15.9	84.5	7.13	2267	1852
4. Hoopes, Thatcher	Sandy	13.8	79.5	3.34	924					
5. Zundle, Thatcher	Sandy	14.8	84.6	2.9	859	13.0	85.4	5.74	1491	1237
7. Mrs. Layton, Thatcher	Sandy	10.55	80.2	4.7	989	12.3	79.5			
8. Marshall, Pima	Silty loam	11.0	78.1	8.6	1892	1[illegible]	83.0	12.3	3361	2679

Note;—The "Sugar per acre" in the above table is, total sugar per acre contained in the beets. "Available sugar per acre" is approximately that which can be recovered in the process of manufacture.

MISCELLANEOUS WORK.

Miscellaneous samples of soil, silt, feeding stuffs, fruits, and canaigre, to the number of about seventy, have also been analyzed during the past year, in addition to the main lines of work undertaken.

Requests for analytical work for private parties are received occasionally, which are attended to as time permits. When the results are of public interest and we are permitted to publish them, no charge is made; otherwise, compensation is received for such work, the proceeds being expended for the benefit of the Station.

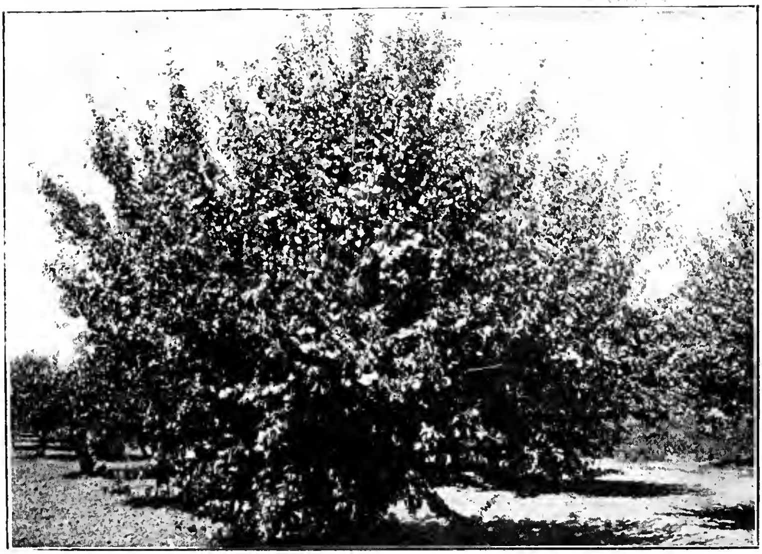
R. H. FORBES,
Chemist.

W. W. SKINNER,
Assistant Chemist.

University of Arizona

Agricultural Experimental Station.

Bulletin No. 37.



October Condition of Apricot Trees Irrigated During Winter Only.

Winter Irrigation of Deciduous Orchards.

BY ALFRED J. McCLATCHIE.

Tucson, Arizona, May 25, 1901.

UNIVERSITY OF ARIZONA
AGRICULTURAL EXPERIMENT STATION

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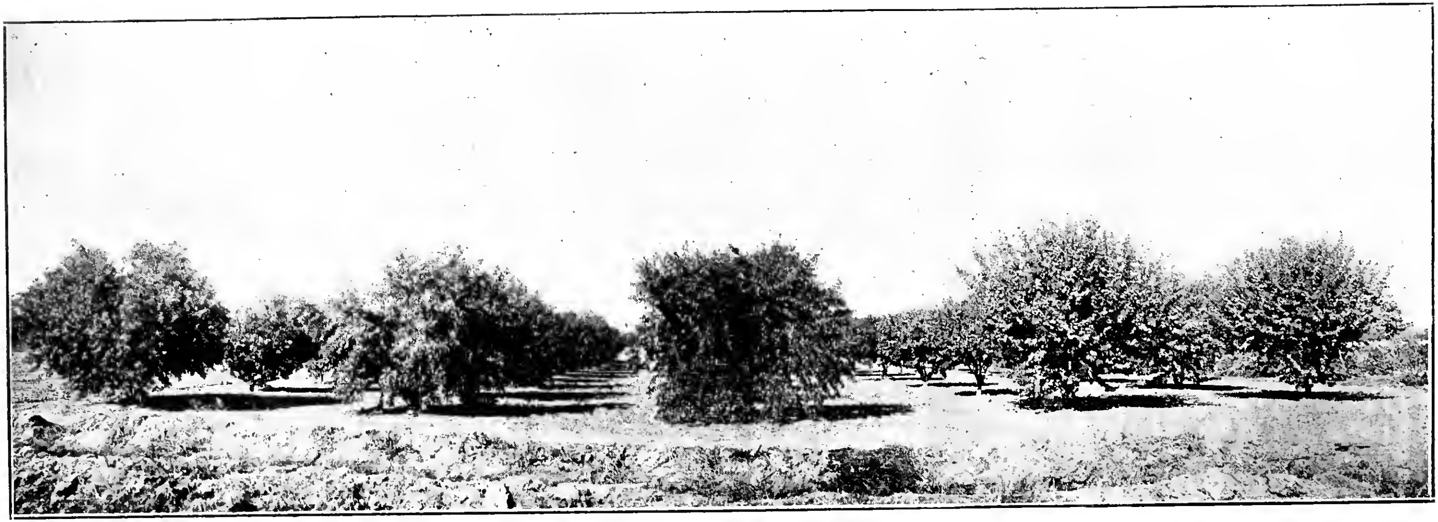

Fig. 1. Orchard used in making winter-irrigation experiments. Three rows on left side, peaches; the two rows on right side, apricots. Above photograph taken October 6th, 1900, seven months after last irrigation of the winter, and at the end of the most trying season of which there is a record at the Phoenix Weather Bureau.

WINTER IRRIGATION OF DECIDUOUS ORCHARDS.

By A. J. McClatchie.

INTRODUCTION.

During December, 1898, experiments were begun at the Station farm near Phoenix to test the effects of the irrigation of deciduous fruit trees during the winter months. The difference in opinion among orchardists as to the value of winter irrigation suggested the making of carefully conducted experiments along this line. The question as to how best to maintain orchards in a thrifty state under the somewhat trying conditions existing in the valleys of Arizona was one of much importance to the fruit interests of the territory. That those not familiar with the region may understand the bearing that the experiments outlined in this bulletin have upon our problems of orchard culture, some statements concerning the climatic conditions and the water supply of southern Arizona follow.

CLIMATIC CONDITIONS OF SOUTHERN ARIZONA.

Precipitation.

In the valleys the rainfall is usually so light that little of it reaches the roots of orchard trees. The soil is seldom wet to a depth of more than eight inches by one storm; and usually the rains are so infrequent that the soil becomes dried out between storms. Hence, in growing fruits, orchardists rely wholly upon irrigation, the supply for this purpose coming from the higher elevations.

In the mountains the precipitation is much greater, the fall of rain and snow being sufficient during a part of most years to cause a subsequent heavy flow in the streams that furnish water for irrigation. A large part of the water that falls in the mountains in the form of rain flows away within a few days or weeks. The remainder slowly percolates through the soil and rocks to the stream beds, thus maintaining a flow which, even though continuous, is not sufficient to supply with water the lands needing it. The water that falls as snow comes down to the valleys below more gradually, furnishing an increased supply for irrigation for one or two months.

While precipitation may occur at any time of the year, in most of southern Arizona, there are two seasons during which the fall is heavier than during the remainder of the year, and the consequent supply of irrigating water much greater. The greatest precipitation occurs from July to September, inclusive, the other rainy season occurring from December to February, inclusive. The rain and snow falling in the mountains during the latter period usually furnish an increased supply of irrigating water until the end of March. From the latter month until July the rainfall is light and the supply of water usually gradually diminishes, becoming very low during June. The summer rains swell the streams and increase the supply of irrigating water temporarily. Then follow about three months during which the supply is again usually less than the demand, in many valleys of the territory. The following monthly averages of the rainfall recorded at the thirty-eight stations situated in the valleys of southern Arizona and in the watersheds furnishing them water for irrigation, and having a record of five or more years, will indicate how the rains are distributed throughout the year:

Jan.	*Feb.*	*Mar.*	*Apr.*	*May*	*June*	*July*	*Aug.*	*Sept.*	*Oct.*	*Nov.*	*Dec.*	*Total.*
1.14	0.74	0.64	0.35	0.26	0.21	1.83	2.22	1.05	0.73	0.72	1.13	10.98

Temperature and Relative Humidity.

The coolest months in southern Arizona are December and January, during which heavy frosts are frequent in most of the valleys. During February the weather becomes warm enough to start the buds of some deciduous trees, and by the end of March all are partially or wholly leaved out. The principal part of the growth is made during the three months that follow. During these three months the weather becomes increasingly warm, the maximum temperatures, by the latter part of June, ranging from 100° to 115° F. in the shade in most of the cultivated valleys. The relative humidity of the atmosphere decreases as the season advances and the temperatures rise, evaporation consequently becoming very rapid. During July, August and September the weather is as warm as, or warmer than, during June; but the humidity is temporarily increased from time to time by rains, and the weather is consequently less trying upon vegetation. From September to December the weather grows gradually cooler, and the relative humidity usually gradually increases.

The following averages of the monthly mean temperature and mean relative humidity at Phoenix for each month of the past five years will indicate the changes in the weather from season to season of the year, in the largest agricultural valley of the territory:

Monthly averages 1896-1900.	*Jan.*	*Feb.*	*Mar.*	*Apr.*	*May*	*June*	*July*	*Aug.*	*Sept.*	*Oct.*	*Nov.*	*Dec.*
Mean temperatures.	52	55	60	67	75	85	90	88	83	70	60	52
Mean relative humidity	53	42	38	33	26	24	37	40	39	40	43	45

SUPPLY OF IRRIGATING WATER IN SALT RIVER VALLEY.

The variation in the supply of irrigating water from month to month of the year, in the Salt River valley, will be indicated by the following monthly averages of the flow of the Salt River during the past twelve years, based on available records.

The numbers express the flow in thousands of acre feet:

Jan.	*Feb.*	*Mar.*	*Apr.*	*May*	*June*	*July*	*Aug.*	*Sept.*	*Oct.*	*Nov.*	*Dec.*	*Monthly mean*
171	306	175	92	55	27	37	65	52	65	60	104	101

The average rainfall at the six stations in the watershed of the Salt and its tributaries is, according to available records, as follows:

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1.84	1.46	1.57	0.81	0.64	0.30	2.27	2.57	1.20	0.95	1.08	1.90

It will be seen that although the rainfall is heavier during the summer than during the winter, the flow of the river is much greater during the latter season. The parched condition of the watershed and the rapidity of evaporation during the hot summer months are undoubtedly responsible for the failure of most of the rainfall of that season to reach the valleys below. The precipitation during July, August and September is one-sixth greater than that of December, January and February, yet during these three summer months the flow of the river is less than one-third what it is during the three winter months. Hence, during the months of December, January and February, an average of over three times as much water is available for irrigation as during the summer period of most abundant supply.

PREVALENT METHODS OF ORCHARDISTS.

The practice among orchardists, before the experiments were begun at the Station farm, had been (and to a considerable extent is yet in many parts of the Territory) to begin the irrigation of their orchards during February or March, about the time the development of the buds began, and irrigate about once a month until October, or as often as water could be obtained. During considerable of this period the amount of water available was usually inadequate to the demands of the trees, and orchards frequently suffered from drought. The methods of applying the water and the subsequent treatment of the orchards, varied very much. Some fruit-growers applied the water through temporary furrows about three feet apart, some through permanent ditches made between the rows of trees, and some by flooding the entire surface of the soil. In some cases an irrigation was followed by cultivation, as soon as the soil had dried sufficiently. In many cases orchards were seldom or never cultivated, some growers believing that the growth of weeds during summer was essential to the welfare of the trees, since they kept the soil cool and thus supposedly checked evaporation.

PURPOSE AND SCOPE OF THE EXPERIMENTS.

Previous to beginning the experiments, there existed considerable difference of opinion among fruit-growers as to whether, under the trying climatic conditions of southern Arizona, the irrigation of an orchard during winter, when the trees were dormant, would materially lessen the amount of water that would need to be applied during the succeeding summer. It was thought by the writer that the question might be pretty definitely settled by experiments covering two or three years.

It is believed that sufficient data have been accumulated to warrant publishing the results in bulletin form. Besides keeping notes on the above-ground operations and conditions in the orchard, investigations have been made underground. The moisture content of the soil has been determined from time to time, and the changes caused by the application and by the withholding of water ascertained. Each phase of the subject, the above-ground and the underground, will be taken up chronologically.

ABOVE-GROUND OPERATIONS AND RESULTS.

DURING 1898–99.

The orchards upon the Station farm had been irrigated about once a month through the summer of 1898, water having been last applied about the middle of September. During the following winter all were irrigated more or less thoroughly, but one isolated orchard of about three-fourths of an acre was chosen for special treatment and observation. The orchard consists of three rows of peach trees and two rows of apricot trees, set 24 feet apart. It had been planted in 1892, and the trees had, therefore, been growing in their present situations seven seasons. The soil is a clayey loam.

Water was withheld from this small experimental orchard from September until January 9, when the frequent application of water began. The orchard was irrigated by the furrow system eight times, fresh furrows having been made with a turning plow twice during the winter. The last irrigation occurred March 29th to 31st.

As soon as the soil had dried sufficiently, it was harrowed crosswise the furrows to check evaporation from them. It was subsequently plowed deeply and harrowed thoroughly. During the two following months it was cultivated twice. It received no

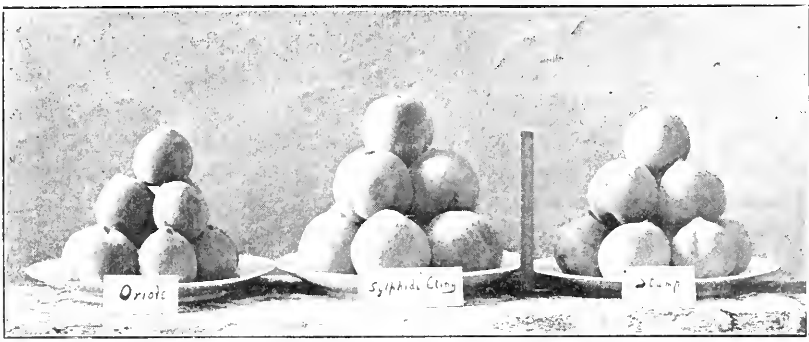

Fig. 2. Peaches grown in winter-irrigated orchard; harvested August 24, 1899, from heavily loaded trees.

irrigating water until June 24th, and no rain fell in the meantime. It was cultivated as soon after irrigation as the soil was sufficiently dry, and was cultivated once more during the summer.

The orchard remained in excellent condition throughout the season. The trees grew thriftily and maintained a vigorous appearance all summer. The young shoots on the peach trees were three to five feet long, and those on the apricot trees four to six feet long. The trees were well loaded with fruit that was larger than and of superior quality to that borne the previous year, when the orchard was irrigated frequently during the summer. The results of the season's experiment were satisfactory in every way.

The following monthly averages indicate the nature of the weather through the year 1899. The temperatures were recorded

Fig 3. Winter-irrigated orchard as it appeared October 8, 1899.

at the farm, and the relative humidity determinations were made at the Phoenix Weather Bureau, two miles distant:

Temperature and humidity, 1899.	*Jan.*	*Feb.*	*Mar.*	*Apr.*	*May.*	*June*	*July*	*Aug.*	*Sept.*	*Oct.*	*Nov.*	*Dec.*
Mean minimum.	33	34	41	48	51	64	78	69	67	51	42	33
Mean maximum.	63	69	76	86	88	101	105	102	101	83	74	67
Mean rel. humidity	49	40	32	28	22	32	40	38	31	40	46	38

DURING 1899–1900.

The winter irrigation this season was begun December 16th. Water was applied about as rapidly as the soil would absorb it.

Fig 4. Winter irrigated vineyard and orchard, July, 1900.

until three feet in depth had been given the orchard. The last irrigation of the winter occurred March 5th.

As soon as the soil was dry enough, the orchard was plowed each way about a foot deep, harrowed thoroughly and left for the summer. After summer showers, a cultivator was run over the surface to break up the crust that formed. In this way an earth mulch six to eight inches deep was maintained. No water was applied for over eight months, during which period the rainfall was but two and one-half inches, divided among five rains.

As during the previous season, the trees remained in excellent condition throughout the summer. During May and June occurred the dryest hot period of which there is a record in the valley. At the end of it the orchard showed no signs of drought whatever, the peach trees having made a growth of about four feet, and the apricot trees a growth of three to six feet. During the dry, hot period mentioned above, the apricot trees matured a good crop of excellent fruit. Many of the peach trees remained unusually heavily loaded with fruit that matured during July and August, the quality being fully up to that of the previous year.

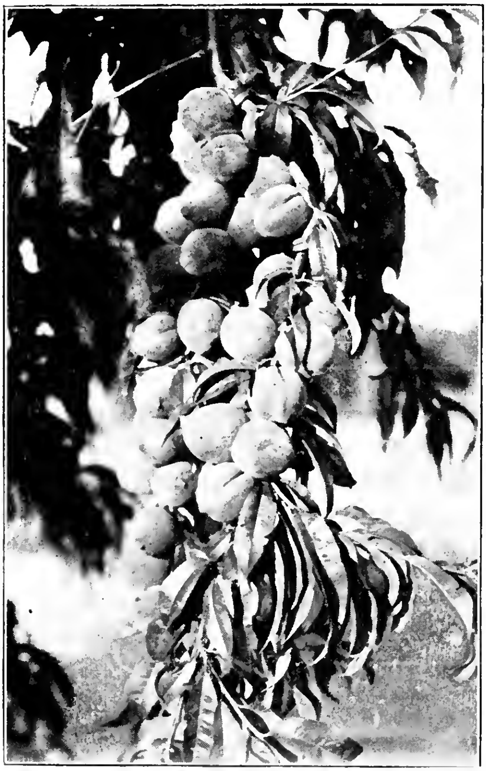

Fig. 5. Branch on peach tree, showing how heavily loaded some of the trees were July, 1900, in orchard irrigated during winter only.

Though the summer continued unusually dry (the mean relative humidity being the lowest recorded at the Weather Bureau at Phoenix), the trees maintained a vigorous appearance until November. Though having received no irrigating water for eight months, at the end of a season during which many orchards died, no thriftier or more vigorous orchard existed in the valley.

The following monthly averages will indicate the nature of the weather of 1900, the temperatures being those of the farm, and the relative humidity percentages those of the Weather Bureau:

Temperature and humidity, 1900.	*Jan.*	*Feb.*	*Mar.*	*Apr.*	*May*	*Jun.*	*July*	*Aug.*	*Sept.*	*Oct.*	*Nov.*	*Dec.*
Mean minimum.....	36	35	44	46	56	63	72	67	60	52	43	32
Mean maximum.....	70	68	82	77	95	104	105	102	100	85	76	70
Mean rel. humidity	41	29	38	44	26	16	25	26	30	36	41	42

DURING 1900–1901.

During the two previous years a green-manuring crop was grown in the other two orchards on the farm. Since it was found that the soil in these orchards would not only produce a heavy winter crop, but became thoroughly moistened to as great a depth as in the smaller orchard, the soil of which had been left bare, the latter was sown to clover (*Melilotus indica*) November 6. The seeding was followed by an irrigation, and water was applied frequently enough until March 29 to keep the crop growing well. During this period water to the depth of four feet was applied. The green-manuring crop was turned under April 6. As shown by the accompanying illustration, the clover was twenty to thirty inches high, and very thick upon the ground. Judging by the amount applied the previous winter, the clover consumed, during the four months of its growth, about one foot more water than evaporated from the surface of the bare soil from December 16 to March 5, 1899.

DISCUSSION OF PRINCIPLES INVOLVED.

Reasons for Favorable Results.

The favorable results from the experiments outlined above were due to several factors. At first thought, it seems marvelous that trees not only could endure such dry, hot weather, but grow thriftily for eight months without their roots receiving any additional water in the meantime. But their ability to do this was simply the outcome of following natural laws.

Fig. 6. Green-manuring crop of clover, showing growth reaching into limbs of trees of winter-irrigated orchard, April 2, 1900.

The chief aim of irrigation by any method should be to get the maximum amount of the water applied back through the crop being grown, and let the minimum amount escape downward or directly from the soil into the atmosphere. Only the water passing *through* a tree, for example, benefits it. That which is taken up by the roots and exhaled from the leaves is of service to the tree. The water that does not take this course does not benefit it. Another important point to be kept in mind in irrigating is that the entrance of air into the soil should not be interfered with while the plant is growing. The proper aeration of soil is very important. That the necessary biological and chemical processes may proceed properly in the soil, a constant supply of oxygen is essential. The method of irrigating trees that interferes least with the soil aeration is the desirable one. A consideration of the winter irrigation system, as outlined in the foregoing pages, will disclose that it answers the two above requirements.

During the winter the lower temperatures and the higher relative humidity cause evaporation to be much slower than during the remainder of the year. In applying water, therefore, comparatively little escapes into the atmosphere. The supply of water being greatest at that time of the year makes it possible to apply large amounts at short intervals, thus avoiding the loss that occurs if small amounts are applied at greater intervals. Then, too, the trees are dormant and the roots need little air; hence, no injury is done them by keeping the soil supermoistened, or by letting the surface bake to some extent. Consequently, cultivation after each irrigation is not necessary, much time thus being saved.

When the soil is of the proper character, the roots of orchard trees penetrate to great depths, enabling the trees to thrive, though the surface stratum be quite dry. In making the underground investigations in this orchard, roots were found in abundance at a depth of 12 to 16 feet, and many penetrated to a depth of more than 20 feet. This characteristic is what makes it possible to store in the soil, during winter, much, if not all of the water needed during the summer.

Trees make use of, and consequently need water much earlier than is commonly supposed. An examination made February

20th, 1900, revealed that at the depth of ten to sixteen feet, even, young roots three to six inches long had already grown. At this date there were few above-ground indications of growth, and it would not have been supposed by making a casual observation that the trees would make use of any water that might be applied. While the air above-ground is still too cool to start the development of the buds, the roots far beneath the surface are making a growth that prepares the tree for the demand for water that the leaves will make later. Thus, if the trees have an abundance of water during the winter, the early root growth that will be made will enable them to make a rapid growth as soon as the air above-ground is warm enough to permit it. These facts account for the rapid and vigorous growth that the winter-irrigated orchard made in early spring, compared with those that had not been thus irrigated.

Effects of Summer Irrigations.

During the summer the climatic conditions and the demands of the trees are quite the reverse of those of the winter. The high temperatures and the low relative humidity cause such rapid evaporation that much of the water applied quickly escapes into the atmosphere. The supply of water for irrigation being very low, it is not ordinarily possible to apply sufficient quantities of water to reach the deeply-seated roots of the tree. In summer a large percentage of the water applied escapes directly from the soil without passing through the trees. This is the case whether its surface is cultivated (as should be done) and the upper few inches loses all its moisture as a result; or the soil is left to bake (as should not be done) and not only the surface becomes dry and hard, but a large amount passes up from below through the baked soil.

Summer irrigations are ordinarily surface irrigations. Only a comparatively small percentage of the water applied becomes available to the trees. While the surface may be wet, the roots below may be in comparatively dry soil. Furthermore, from the time that water is applied until a cultivation can take place, the soil is practically sealed air-tight. This exclusion of air, for the reasons stated above, retards the growth of the trees. Most of the cultivation that must follow each irrigation, in order to check evaporation and admit air, is obviated by applying the water during the winter, instead of during the summer.

Reasons for Cultivation and Weed Destruction.

After each summer shower the surface of the soil should be cultivated to break up the crust that forms, and thus check evaporation and permit the entrance of air. The conservation of moisture by cultivation is based on well-established principles. During a rainstorm or during irrigation, the water received by the soil moves downward. As soon as the supply from above ceases and the free water settles away, by capillary action the movement of the moisture in the soil sets in in the opposite direction, moving upward as well as downward. As the moisture reaches the surface, it passes off as vapor. Only by preventing the water reaching the surface can this evaporation be checked. The capillary action by which the water reaches the point where it evaporates can go on only in a closely packed soil furnishing the innumerable, minute, irregular tubes through which the water rises. To break up these tubes checks this upward movement. Cultivation not only breaks up the capillary tubes of the surface, but forms over the surface a mulch that prevents rapid evaporation. The moisture will then rise to the mulch, but cannot pass beyond it by capillary action, and evaporation thus proceeds much more slowly than if the moisture were permitted to follow the capillary tubes to the surface.

Samples of soil taken in an orchard during the summer of 1900 illustrate the foregoing. Most of the orchard had been thoroughly cultivated; but a portion had been left uncultivated, and had become overgrown with weeds. A determination of the per cent of water in each of the five upper feet in each area May 23d showed that as a whole the upper five feet of soil in the cultivated area contained over a third more water than the upper five feet in the uncultivated area. But when only the available water in each is taken into consideration, the difference is much greater. Plants cannot remove all the water a soil contains. In such a soil as the above, at least five per cent would be left in it after the rootlets had removed all they had power to remove. Making this deduction, the soil in the cultivated area would be found to contain about twice as much available moisture as that in the uncultivated area. Or to make the statement in another form, the loss of water from the uncultivated area from March 5 to May 23 exceeded the loss from the cultivated area by the equivalent of over two inches of rainfall; and the loss during the entire summer would probably be about three times this amount. To replace this loss from a ten-acre field would necessitate the running of a stream of $2\frac{1}{2}$ second feet (100 miner's inches) for about 30 hours.

In order to produce the best results the soil must be so cultivated, however, that it is not left broken up into large clods, that will permit the air to reach the underlying strata. The finer and looser the surface mulch the better, and in our arid region it needs to be deeper than elsewhere.

Weeds injure growing crops by appropriating the available plant food and by removing water from the soil. While a soil may be very fertile, there seldom is present enough plant food, in the form necessary for the use of plants, to support a crop of weeds and a crop of fruit. But weeds usually do the greatest injury by removing water from the soil. Not only do weeds require water for their increase in size, but water is continually evaporating from the surface of their leaves. While they may shade the surface of the soil so as to check evaporation there, the evaporation from their leaves is much more rapid than it would be from the surface of the unshaded soil, if it were properly cultivated.

One Summer Irrigation Considered Advisable.

If about the middle of the summer, water is available in abundance, it would probably be wise to give the orchard a thorough irrigation in as short a time as possible, and then follow the irrigation with a thorough plowing, as in the spring after the winter-irrigation ceases. But frequent summer irrigations are decidedly not advisable under our conditions, where the soil is fairly deep and retentive of moisture.

UNDERGROUND INVESTIGATIONS.

DURING 1899.

Ten days after the last irrigation, samples of each foot of the soil from the surface to ground-water were taken for the purpose of determining the moisture content. By that time the surface applications had settled away, but as will be seen from the results of the determinations, the water of the entire soil had not yet had time to come to an equilibrium.

The upper five feet proved to be a clayey loam, the next foot a mixture of loam and gravel, the seventh to the thirteenth, inclusive, gravel of varying coarseness, the fourteenth foot gravel and clay, the fifteenth foot gravel, the sixteenth foot gravel and clay, the seventeenth to the thirty-first, inclusive, fine clay, and the three feet below this a mixture of clay and gravel. Free water was encountered at a depth of 34 feet.

In the upper loam stratum soil samples could be bored out with an auger, but it was not found practicable to bore through the gravel below the loam. Hence it was necessary to excavate to a depth of 16 feet, and take the samples of the gravel from the side of the excavation. Through the remainder of the distance the samples were obtained by boring with a two-inch auger. The boring was stopped at the 34th foot by the gravel encountered.

In taking the samples, roots were encountered in abundance at a depth of 14 to 16 feet, and one peach root was followed into the 20th foot, showing that water to this depth at least would be available to the trees. The 20-foot root went down almost perpendicularly, starting 18 feet from the base of the tree.

June 18th, samples of each foot of the soil to a depth of 34 feet were again taken. Samples were also taken September 30th and December 10th.

DURING 1900.

March 12th of this year, a week after the last irrigation of the orchard, samples of each foot of the soil were taken from the surface to a depth of 33 feet for the purpose of determining the moisture content, as during the previous year. For the purpose of determining how much moisture would be lost during the summer, by evaporation of water from the surface of the soil without passing through the trees, the space surrounded by four trees was covered with roofing tin.

No samples of the soil were taken until October 9th. At this time it was found that, with the exception of the upper six inches, the soil under the roofing tin was as dry as in the uncovered area. Rootlets had formed in great numbers in the surface foot, from which they were almost entirely absent in the uncovered portion of the orchard.

TABLE I: RESULTS OF MOISTURE CONTENT DETERMINATIONS.

The accompanying table gives the results of the determinations from the soil samples taken during the summers of 1899 and 1900.

The "weight per cubic foot" is the weight of the soil completely dry. In order to ascertain the degree to which the soil was saturated, it was necessary to determine the "maximum water capacity" given in the second column of the table. The percentages of moisture in the samples were determined by the usual method of weighing them before and after being completely dried in an oven kept at a temperature of 230° F.

Number of foot.	Character of Soil.	Weight per cubic foot.	Maximum water capacity.	April, '99. Water content.	April, '99. Degree of saturation.	June, '99. Water content.	June, '99. Degree of saturation.	Sept. '99. Water content.	Sept. '99. Degree of saturation.	Dec. '99. Water content.	Dec. '99. Degree of saturation.	March, '00. Water content.	March, '00. Degree of saturation.	Oct. '00. Water content.	Oct. '00. Degree of saturation.	Number of foot.
		lbs.	%	%	%	%	%	%	%	%	%	%	%	%	%	
1	Clayey loam......	76.4	37.8	15.1	40.0	4.2	11.1	3.2	8.4	3.2	8.4	15.0	40.0	4.0	10.5	1
2	" "	78.2	37.6	17.6	46.7	6.3	16.7	4.0	11.0	4.0	11.0	17.0	45.2	5.0	13.2	2
3	" "	77.5	37.5	17.4	46.4	8.4	22.4	5.6	14.8	4.5	12.0	16.5	43.8	7.3	19.4	3
4	" "	73.3	36.5	20.1	55.0	10.0	27.4	7.4	20.3	7.0	19.1	20.0	54.8	7.4	20.2	4
5	" "	75.5	38.0	20.0	52.6	11.0	28.9	8.2	21.5	7.5	19.7	20.0	52.6	6.8	17.8	5
6	Loam and gravel..	83.0	19.9	9.7	48.7	6.2	31.1	5.0	25.0	2.4	12.0	10.0	50.0	2.8	11.0	6
7	Coarse gravel.....	111.0	12.5	6.3	50.4	1.6	12.8	1.5	12.0	1.5	12.0	6.4	51.2	2.0	16.0	7
8	Gravel...........	96.5	18.9	8.4	44.4	3.0	15.8	2.6	13.6	2.5	13.1	8.5	44.7	2.8	14.7	8
9	"	96.0	20.0	7.4	37.0	3.4	17.0	3.2	16.0	2.8	14.0	7.3	36.5	3.6	18.0	9
10	"	97.0	16.6	4.5	27.1	3.4	20.4	3.3	20.0	2.2	13.2	5.0	30.7	2.9	17.8	10
11	"	96.8	17.2	6.8	39.4	3.4	19.9	3.2	18.6	3.0	17.4	7.0	40.7	3.6	20.9	11
12	"	98.0	21.2	4.7	22.1	3.0	14.1	3.0	14.1	2.8	13.2	5.0	23.6	3.0	13.9	12
13	"	102.4	22.6	4.7	21.0	2.7	11.9	2.6	11.5	2.8	12.5	5.0	22.1	3.0	13.2	13
14	Clay and gravel..	87.4	30.0	17.3	57.6	16.0	53.3	15.0	50.0	14.0	46.6	17.6	58.6	15.0	50.0	14
15	Gravel...........	97.3	24.5	8.6	35.1	5.1	20.8	4.2	17.1	3.1	12.6	8.6	35.1	3.0	12.2	15
16	Gravel and clay...	80.8	42.1	30.1	71.4	22.2	52.7	20.0	47.5	20.0	47.5	30.0	73.6	20.8	49.5	16
17	Clay............	74.0	60.8	36.8	60.5	30.1	49.5	27.5	45.4	27.9	46.1	37.0	60.8	29.2	48.1	17
18	"	73.3	54.5	30.4	55.7	23.3	42.7	23.0	42.1	25.0	45.8	31.2	57.2	26.1	48.0	18
19	"	77.0	48.4	26.8	55.7	22.0	45.4	21.1	41.6	21.8	45.2	21.2	56.2	22.7	47.0	19
20	"	74.5	52.2	24.5	46.9	21.7	41.5	21.0	40.2	21.8	41.7	24.6	47.1	24.2	46.5	20
21	"	76.0	50.0	19.3	38.6	18.9	37.8	20.0	40.0	20.6	41.2	23.3	46.6	22.0	44.0	21
22	"	76.5	49.6	17.6	35.5	19.4	37.0	20.0	40.3	20.4	41.1	21.8	43.9	21.6	43.5	22
23	"	75.8	51.1	17.3	33.6	20.3	36.0	21.0	40.0	20.9	41.0	22.1	43.2	21.6	42.2	23
24	"	78.0	45.1	14.4	31.9	15.5	34.3	17.5	38.8	17.5	38.6	19.5	43.2	19.0	42.2	24
25	"	78.4	41.1	11.3	27.5	12.3	29.9	13.8	33.6	12.8	31.1	17.5	42.6	17.1	41.8	25
26	"	76.0	45.1	15.6	34.5	13.8	30.5	14.5	32.1	14.6	32.4	19.1	42.3	18.7	41.5	26
27	"	75.2	47.0	19.0	40.4	16.8	35.7	16.9	35.9	17.0	36.1	19.1	40.6	19.6	41.4	27
28	"	75.0	44.6	22.1	49.5	16.8	37.6	20.0	42.5	20.0	44.8	22.4	50.3	22.0	49.3	28
29	"	73.2	45.0	23.4	52.0	19.7	43.7	21.0	46.6	21.0	46.6	24.0	53.3	23.8	52.9	29
30	"	75.8	45.4	25.2	55.5	22.3	49.1	22.5	49.5	22.1	48.9	24.6	54.2	24.1	53.0	30
31	"	74.0	45.2	26.2	57.9	25.1	55.5	25.1	55.2	25.0	55.3	25.2	55.7	25.0	55.3	31
32	Clay and gravel...	81.5	37.0	24.3	65.6	23.5	63.5	23.3	63.0	22.3	62.7	23.4	63.2	23.0	62.9	32
33	" "	79.0	41.1	30.6	74.4	28.5	69.3	28.4	69.1	28.0	68.1	28.4	69.8	28.0	68.1	33
34	" "	80.0	40.0	35.2	88.0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	34

DISCUSSION OF MOISTURE DETERMINATIONS.

Conditions found April 12, 1899.

Since the capacity of a soil to hold water depends upon its fineness, the maximum water capacity will, other things being equal, vary inversely as with the size of the soil particles. Also, the coarser a soil, the heavier a given dry quantity of it is, as a rule. Hence, as is to be expected, it will be observed that the maximum water capacity percentages vary inversely as the weights per cubic foot, in most cases. For example, the foot composed of the coarsest matter—the seventh—was the heaviest, and was capable of holding the least water; while the higher percentages of water capacity are found in the soils that are the lightest when dry.

That the ability of a soil to retain water depends upon its fineness also, is well illustrated by the determinations given in Table I. During even the two weeks intervening between the last irrigation of the winter, in 1899, and the taking of the samples March 12th, the gravel had evidently lost a much greater percentage of the water it was capable of holding than the finer soil above and below it. The absence of water in gravel lying next to fine clay is especially noticeable. In the case of the stratum of gravel between the 14th and 16th foot, the degree of saturation was very different from that of the strata on either side, causing the turns in the moisture lines in Figs. 7 and 8, as will be seen, to be very abrupt. It would seem that the finer soils acted like a sponge in absorbing the moisture from the coarser ones. The determinations given could not be explained on the ground of percolation alone, for if only the latter were taking place, in the samples taken March 12th, the gravel just above the clayey 14th foot for example, would be moister than that farther above.

When the fine soil below the 15th foot is reached the changes in moisture from foot to foot are more gradual and regular. The clay just below the stratum of gravel was very wet at the time of taking the first set of samples, April 12th, 1899, due evidently to the fact that it had received water from the gravel above more

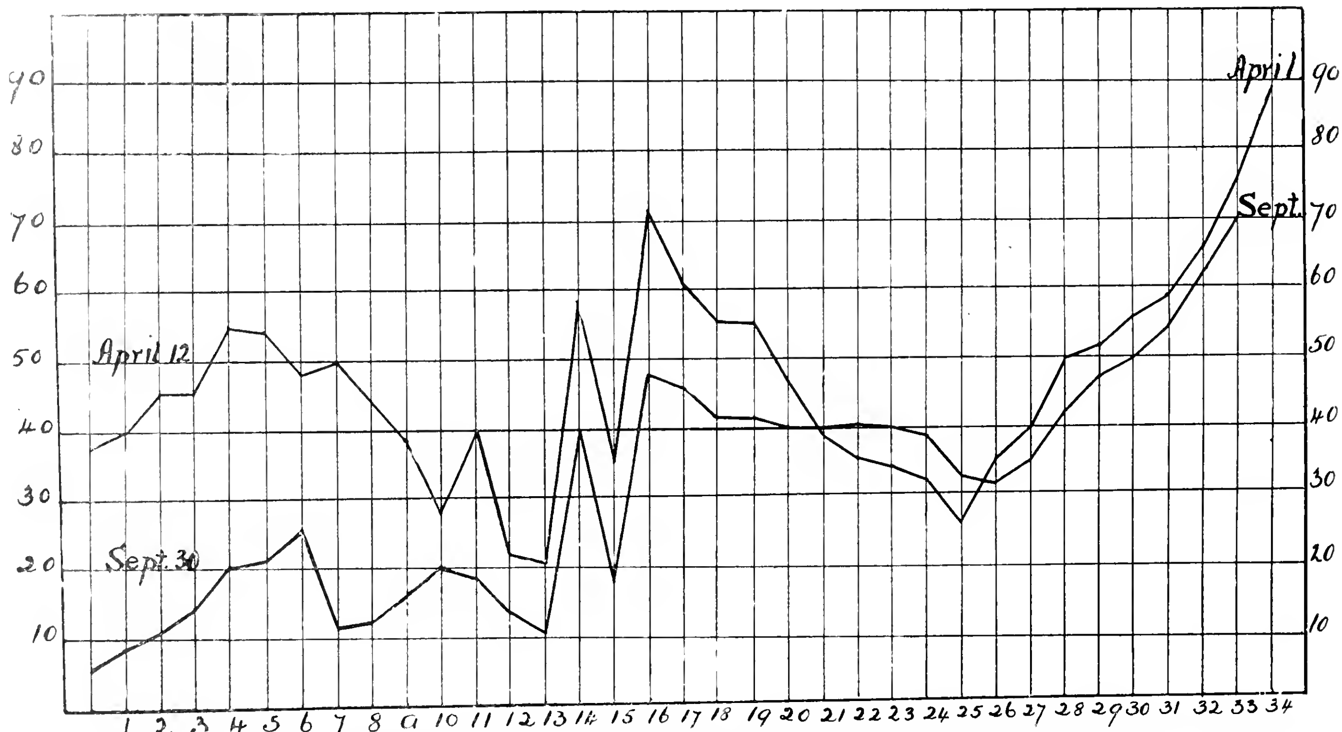

Fig. 7. Diagram showing moisture content of soil in the winter-irrigated orchard, at the beginning and at end of summer of 1899. Numbers at sides express percentages of saturation, and those at the bottom give the depth of the respective feet.

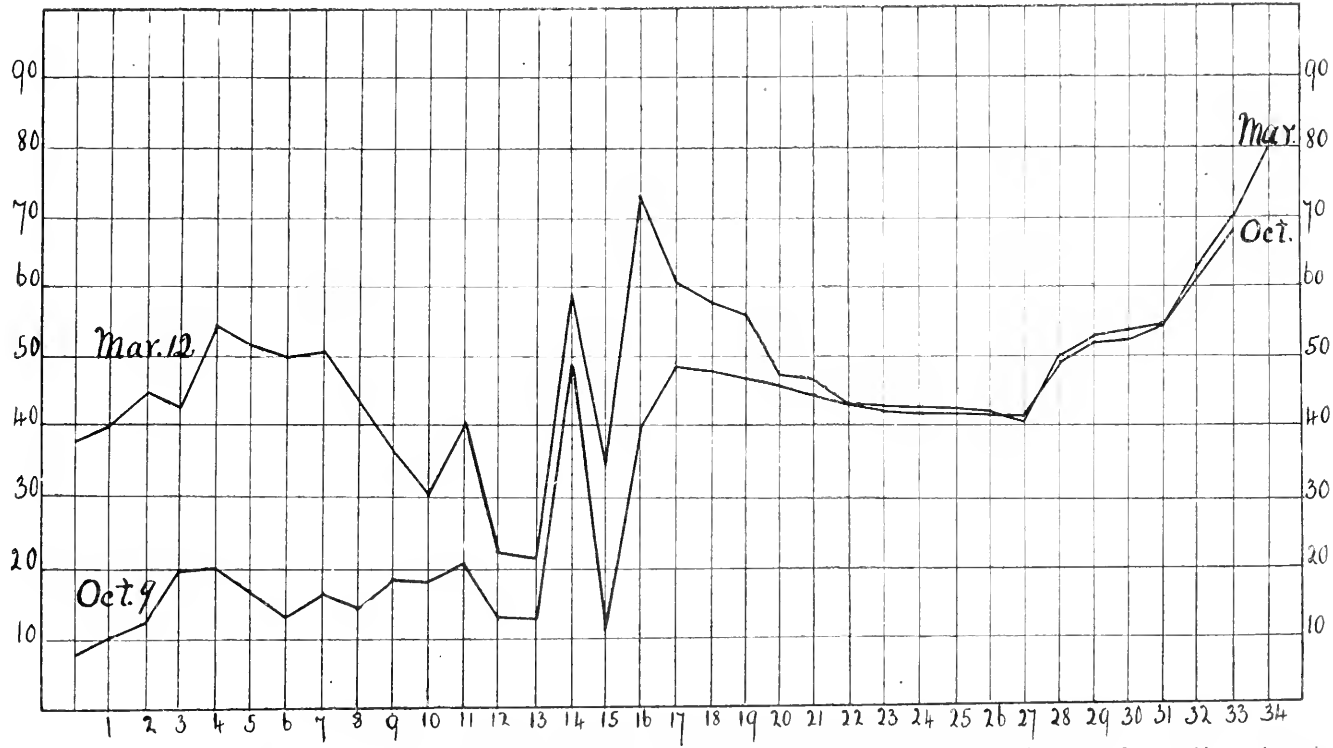

Fig 8. Diagram showing moisture content of soil in orchard irrigated only during winter, at beginning and at end of summer of 1900. Side numbers give percentages of saturation, and those at the bottom the depth.

rapidly than it could percolate downward. From the 16th to the 25th foot the percentage of moisture gradually decreased. The fact that the 25th foot contained the least water of any foot of the clay soil indicates that the soil down to just above that region had been reached by the irrigating water, the latter having percolated through the gravel into the first eight feet of clay.

Below the 25th foot the moisture content was apparently affected by the ground water nine feet below. It will be observed that the increase in the degree of saturation is quite gradual, however, and that in passing downward wet soil is not encountered suddenly, as is commonly supposed. The increase in wetness is, to be sure, more marked in the last three feet above ground water. The degree of saturation of the 34th foot is given as 88 per cent. This, it will be understood, applies to the mixed sample of soil taken from between a plane lying 33 feet below the surface, and a plane lying 34 feet below. At 34 feet from the surface the soil was saturated with water, and the degree of saturation would be expressed by 100 per cent. The regularity of the changes in the degree of saturation compared with the changes in the actual moisture content, in passing downward, is quite noticeable, illustrating the importance of determining the former, in making soil investigations.

Table of Losses and Gains.

For the purpose of showing the loss or gain in the moisture content of the respective feet, and the total loss from the orchard, Table II was computed from Table I. As it seemed evident that only or principally the upper 25 feet were affected by surface operations and conditions, the computations are given for only that depth. The percentages given in Table II are the differences between corresponding percentages of moisture for the two dates being compared; and the pounds are the products of the respective weights per cubic foot and the above differences.

TABLE II.

Losses and gains in the moisture content of each of the upper 25 feet, between dates of taking soil samples, from April, 1899, to April, 1901:

Number of foot	April 12 to June 18.		Jun. 18 to Sept. 30.		April 12 to Dec. 10.		Dec. 10 to March 12.		March 12 to Oct. 9.		Oct. 9 to April 12.		Number of foot
	Loss per cubic foot		*Loss per cubic foot*		*Loss per cubic foot*		*Gain per cubic foot*		*Loss per cubic foot*		*Gain per cubic foot*		
	%	lbs	%	lbs	%	lbs	%	lbs	%	lbs	%	lbs	
1	10.9	8.0	1.0	0.7	11.9	9.1	11.8	9.0	11.0	8.4	8.4	6.4	1
2	11.3	8.7	2.3	1.8	13.6	10.6	13.0	10.2	12.0	9.4	14.7	11.5	2
3	9.0	6.9	2.8	2.2	12.9	10.0	12.0	9.3	9.2	7.1	10.8	8.3	3
4	10.1	7.3	2.6	1.8	13.1	9.6	13.0	9.5	12.6	9.1	10.5	7.8	4
5	9.0	6.7	2.8	2.1	12.5	9.4	12.5	9.4	13.2	10.0	11.7	8.8	5
6	3.5	2.9	1.2	0.9	7.3	6.0	7.6	6.3	7.2	5.9	7.2	5.9	6
7	4.7	5.2	0.1	0.1	4.8	5.3	4.9	5.4	4.4	4.9	4.4	4.9	7
8	5.4	5.3	0.4	0.4	5.9	5.7	6.0	5.8	5.7	5.5	5.7	5.5	8
9	4.0	3.8	0.2	0.2	4.6	4.4	4.5	4.3	3.7	3.5	3.7	3.5	9
10	1.1	1.1	0.1	0.1	2.3	2.2	2.8	2.7	2.1	2.0	2.1	2.0	10
11	3.4	3.3	0.1	0.1	3.8	3.9	4.0	3.9	3.4	3.3	3.4	3.3	11
12	1.7	1.7	0.0	0.0	1.9	1.9	2.2	2.2	2.0	2.0	2.0	2.0	12
13	2.0	2.0	0.1	0.1	1.9	1.9	2.2	2.2	2.0	2.0	2.0	2.0	13
14	1.3	1.1	1.0	0.9	3.3	2.9	3.6	3.2	2.6	2.2	2.8	2.4	14
15	3.5	3.4	0.9	0.8	5.5	5.3	5.5	5.3	5.6	5.4	5.8	5.6	15
16	7.9	6.4	2.2	1.7	10.1	8.0	10.0	8.8	9.2	9.3	11.3	9.8	16
17	6.7	4.9	2.6	2.0	8.9	6.6	9.1	6.8	7.8	5.8	6.2	4.6	17
18	4.1	3.0	3.3	2.5	5.4	4.0	5.8	4.5	5.1	3.7	7.4	5.5	18
19	4.8	3.7	1.4	1.2	5.0	3.9	6.0	4.7	4.5	3.5	3.5	2.8	19
20	2.8	2.1	0.7	0.5	2.7	2.0	2.8	2.1	0.4	0.3	0.8	0.6	20
	Total loss	87.5	*Total loss*	20.1	*Total loss*	112.8							
	Gain per cubic foot		*Gain per cubic foot*		*Gain per cubic foot*								
21	0.6	0.5	0.1	0.1	1.3	1.0	2.5	1.9	1.3	1.0	2.0	1.5	21
22	1.8	1.3	0.6	0.4	2.8	2.1	1.4	1.0	2.0	1.5	1.3	1.0	22
23	3.0	2.1	0.0	0.0	3.6	2.7	1.2	0.9	0.5	0.4	1.3	1.0	23
24	1.1	0.9	2.0	1.8	3.1	2.4	2.0	1.8	0.5	0.4	1.0	0.9	24
25	1.0	0.8	1.5	1.2	1.5	1.2	4.7	3.8	0.4	0.3	0.8	0.9	25
	Total gain	5.6	*Total gain*	3.5	*Total gain*	9.4							
	Net loss	**81.9**	*Net loss*	**16.6**	*Net loss*	**103.4**	*Total gain*	**125.0**	*Total loss*	**108.8**	*Total gain*	**108.4**	

Changes from April 12 to June 18.

The set of samples taken June 18, 1899, showed that marked changes had taken place in the moisture content of the respective feet of the different soil strata. The greatest change was in the upper five feet, this part of the soil having lost over half of the water it contained April 12. This great change was due, evidently, to several factors—evaporation, percolation, and the use of water by the trees. The stratum above the gravel is the only one that could lose water by capillary action and evaporation. There was probably no great amount of percolation from this stratum after taking the first set of samples, April 12, as two weeks had already intervened since irrigation ceased. The greatest loss of water was undoubtedly from its use by the trees, as the surface mulch was intended to, and probably did, prevent the rapid loss of water from below the first foot. The four feet lying between the first and the sixth foot contain a much larger number of roots and rootlets than any stratum below, and the withdrawal of water by the trees would be much more rapid from this stratum than from any other. Furthermore, the trees made nearly all their growth between April 12th and June 18th. Hence it is not surprising that during this period the upper five feet lost over half the water contained upon the former date.

The next greatest change occurred in the upper two feet of the clay below the gravel, the water that had been received from the gravel above more rapidly than it could percolate downward, having had time to settle. Where part of it went will be indicated by a reference to the tables and to Fig. 7, which show that between the 20th and the 26th foot the moisture content actually increased during the summer. By Table II it will be seen that the net loss of water from each column of 25 feet, from April 12 to June 18, was approximately 82 pounds—equal to a layer of water a little over 15 inches deep. Of this amount the upper five feet lost over 50 pounds, or nearly two-thirds of the total.

Changes from June to September.

During the three and one-third months that intervened between the taking of the samples June 18 and September 30, the loss of water was comparatively—at first thought surprisingly—small. The total loss from the 25 feet was but a little over a fifth of what it was during the previous two and one-fifth months, or an equivalent of only about three inches in depth. The irrigating water applied June 24 did not affect the above results, as only three-fifths of the orchard was irrigated at that date, and the samples were taken from the unirrigated portion. Neither could the 4.76 inches of rain that fell in the interval affect the moisture content below the upper six inches, as it fell in twelve different showers, less than an inch falling during any one day. The only effect of these summer showers upon the soil, in the vicinity of Phoenix, is to wet a few inches of the surface that dries out within a few hours or days. There is thus formed a crust that not only promotes capillary action and the consequent loss of water that was already present, but excludes air from the subsoil. Even the part of the orchard irrigated received little benefit from the water applied, as the soil was wet to a depth of only about 15 to 18 inches, and was as dry as before irrigation within three weeks thereafter.

When Trees Use the Most Water.

The great comparative loss of water during the months of spring and early summer indicate that this is the period when orchard trees naturally use, and consequently need, the major part of their water supply. During this period of rapid growth, therefore, water should be available in abundance. But by reference to the data given in the introduction, it will be seen that during this period the supply of irrigating water is usually low. The above facts, disclosed by the moisture determinations, emphasize very strongly the importance of filling the subsoil with water during the winter, when the supply is comparatively abundant.

Losses of Water During Entire Season.

From September 30 to December 10 there was little change in the moisture content, the total loss from the 25-foot column of soil being but about five pounds. As the trees remained in excellent condition until they shed their leaves in November, all the water they needed was evidently available. The total loss during the season equaled a depth of about 20 inches of water over the orchard, of which about 80 per cent was lost during the first three months, about 16 per cent the next three months, and only about 4 per cent the last three months.

It seems to be a warrantable conclusion from the facts discussed above that the loss of water from the leaves of orchard trees is comparatively light after the trees have made their growth, the amount exhaled (and consequently the amount needed) gradually diminishing as the summer season advances. As indicated by the investigation of underground conditions (mentioned on page 219) deciduous orchard trees in our climate begin using water early in February. From this date until about the end of June the amount used evidently gradually increases, and after the latter date evidently gradually diminishes. These facts indicate plainly that much of the water should be applied as soon after the first of January as possible.

Effects of Changes in Level of Ground Water.

It will be observed by referring to Table I that during the summer of 1899 the stratum below the 25th foot lost considerable moisture, notwithstanding the fact that the 5-foot stratum above gained moisture during the same period. This was evidently due to the lowering of the level of the ground water, as the water in all of the wells of the region fell during this season. The comparatively light rainfall both in the valleys and in the mountains during the preceding one and one-half years was undoubtedly the cause of this fall in the level of the ground water. On account of the coarse gravel encountered in the 34th foot, it was impracticable to bore to ground water after June, 1899. But if this could have been done, it would probably have been ascertained that at the same distance from the water level the conditions would have been practically the same at the end of the season as at the beginning, the water of the stratum above having simply settled and adjusted itself to the changing position of the ground water. During the winter of 1899–0 the lower eight feet gained a little in moisture as the water level raised slightly, and lost a little again during the succeeding summer, as the wa-

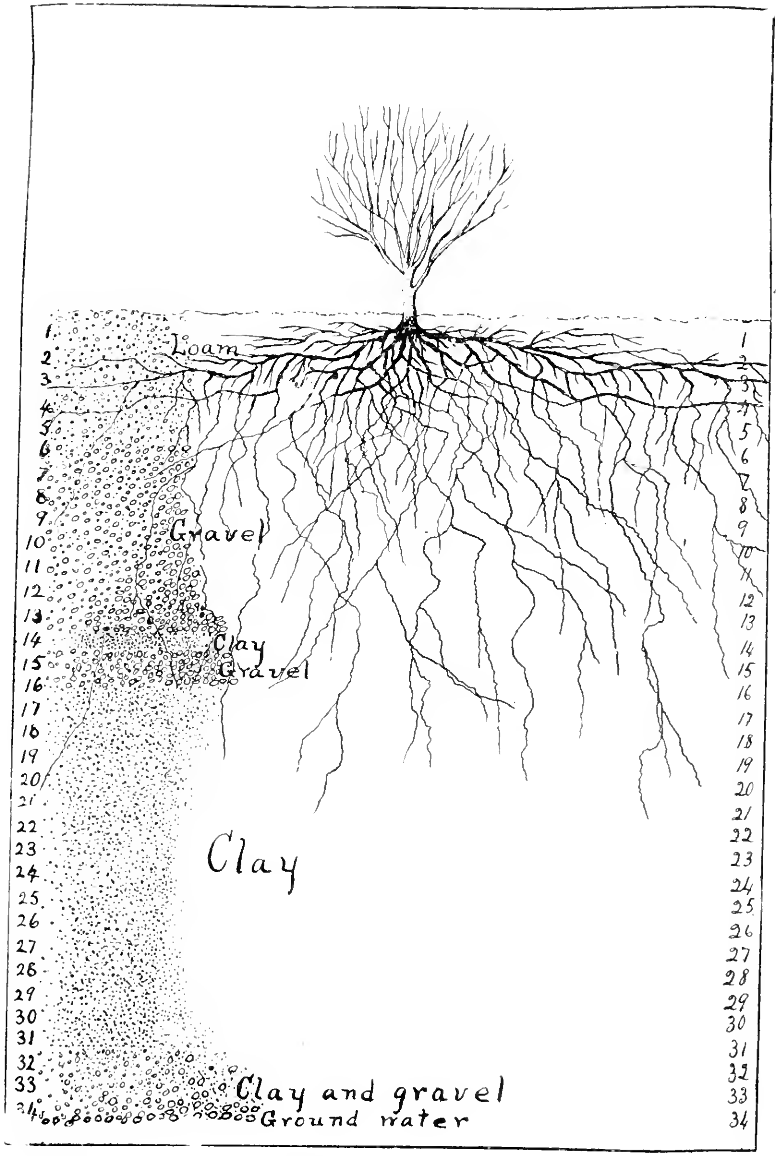

Fig. 9. Showing diagramatically the different soil strata from the surface to ground water in the winter irrigated orchard, and the root system of one of the trees. Scale, one inch to eight feet.

ter level fell. Thus, it seems that the upper stratum to a depth of about 25 feet was influenced by above-ground operations and conditions, while the soil below was influenced only or principally by the changes in the ground water level. Investigations after the heavier precipitation of the past winter will throw additional light on this subject.

Gain in Water During Winter 1899–1900.

During the winter of 1899-1900 each 25-foot column gained 125 pounds, or an equivalent of two feet of water. The gain being greater than the loss during the preceding summer, the soil at the end of the irrigating season, March 12th, was moister than at the same time the previous spring. This gain is one foot less than the depth given on a preceding page as to the amount applied. This does not mean that a foot of the water applied was lost by evaporation and percolation during the winter. For it is to be remembered that it was ascertained during the winter of 1899 that the growth of rootlets begins early in February. The production of these rootlets, the rise of sap in the tree, the swelling of the flower and leaf buds, and the putting forth of bloom and early leaves (as had some of these trees when the samples were taken) all mean the withdrawal of water from the soil.

Loss of Water During Summer of 1900.

It will be observed that the total loss of moisture between March 9th and October 8th was a little greater than that given for the previous summer. This was undoubtedly due to the fact that the samples were taken earlier in the growing season than they were the previous spring. Experiments were planned and inaugurated during the spring of 1900 to ascertain how much of the total loss of moisture would be due to withdrawal by the trees, and how much would escape directly from the soil. But it developed that the methods pursued were not adequate. As has been stated, one space between four trees was covered with an air-tight sheet of metal bordered with four-inch strips that were sunk into the soil. The purpose of this was to prevent the escape of moisture directly from the soil in that section. It happened, also, that a few of the trees near the center of the orchard had died when young, leaving a vacant space for the center of which it was thought no moisture would be withdrawn by the trees.

When the samples were taken from the covered area October 9th it proved, as has been stated previously, that the surrounding trees had put out additional rootlets and caused all the soil, with the exception of a few surface inches, to be as dry as that of the adjacent uncovered area. While the soil samples from the vacant space showed the presence of considerably more moisture than in the part occupied by trees, a little reflection resulted in the conclusion that no definite calculations could be based on the results, as it was not known during what part of the summer any particular portion of the losses occurred, in either section. It seemed evident that the comparative losses should have been determined, from week to week, since moisture that trees (had they been present) might have withdrawn from the upper five or six feet early in the season, would be lost from the vacant area, by capillary action and evaporation, during a later part of the summer. Samples should have been taken also from the covered area at least once a month, in order to determine the comparative changes that were occurring. It is hoped that experiments now under way in this orchard will bring results that will throw some light at least upon this problem as to how much water orchard trees use under the conditions existing in the vicinity of Phoenix.

Moisture Content Changes of 1899 Compared with those of 1900.

By reference to Tables I and II, and to Figs. 8 and 9, it will be seen that each foot of the 25-foot column lost moisture during the summer of 1900, instead of the stratum between the 20th and the 26th foot, gaining, as was the case the previous year. As Fig. 8 shows diagrammatically, the decrease in moisture content was quite regular from the 16th to the 26th foot. This difference between what occurred during the summer of 1899 and what occurred during the summer of 1900 was undoubtedly due to the fact that the comparatively dry stratum encountered between the 20th and the 26th foot, April 1899, had become about as moist as it could remain. In other words, this stratum was, at the beginning of the summer of 1900, so moist that it could retain no additional water permanently. Its degree of saturation was about the same as that of the surface stratum of loam. If any water escaped the tree roots of the 16th, 17th, 18th and 19th feet (where the soil was so moist at the beginning of the season) and percolated downwards, it had evidently passed on through this formerly dry stratum into the soil below. Continued heavy irrigation of this orchard during the winter may finally so fill all the soil with moisture from the 15th foot to ground water that at the end of succeeding summers the increase in the degree of saturation will be regular from the 15th foot downward. The line on a diagram representing this condition would then be an inclined one, approximately, straight, instead of curved or angular as are the lines representing the past conditions.

Amount of Water Needed by an Orchard.

The set of samples taken April 12, 1901, showed that (as will be seen by referring to Table II) the gain during the past winter was just about the same as the loss during the previous summer—between 108 and 109 pounds per 25-foot column, or an equivalent of approximately 21 inches of water over the orchard. This evidently indicates about how much water should be left deposited, henceforth, at the end of each winter, in this underground bank, that the individuals depending upon the deposit for a living may not suffer during the summer.

The difference between the amount applied during the winter (48 inches) and the gain in soil moisture (21 inches) represents the evaporation from the soil, the amount used and exhaled by the trees, and the amount used and exhaled by the clover grown in the orchard for a green-manuring crop. The latter, judging by the amount needed to grow similar crops during the winter, probably withdrew from the soil fully 20 inches of water. The amount lost by evaporation from the soil surface was probably slight, as the soil was covered with the growth of clover most of the period.

The above amount (four feet) probably represents quite accurately the amount that need be applied to deciduous orchards in the warm valleys of southern Arizona to grow a heavy green-manuring crop, and at the same time store enough water in the soil to carry the orchard through the hottest and dryest summers. Judging by observations, and by consultation with orchardists, this amount is frequently applied during the summer to maintain the orchard alone, with no better results than were secured last summer by winter irrigation alone.

SUMMARY AND CONCLUSIONS.

1. Fruits can be grown in the valleys of southern Arizona only by irrigation, the supply of water for which coming from the higher elevations where precipitation is much heavier.

2. The heaviest rainfall is during mid-summer, but the largest supply of irrigating water is during the winter, the supply during the latter period being over three times what it is during the former.

3. The general practice previous to beginning the experiments was to irrigate orchards once or twice a month, from February or March until October, the belief being quite general that under the trying summer conditions of the region winter irrigation was of little value, or at least entirely inadequate.

4. The purpose of the experiments was to determine how much summer irrigation might be rendered unnecessary by the liberal application of water during winter when the supply was comparatively abundant.

5. During the first year of the experiment the orchard was irrigated eight times from January 9 to March 30, 1899, followed by thorough plowing and summer cultivation. The only water applied during the summer was a small amount to three-fifths of the orchard June 24.

6. The climatic conditions of the growing season of 1899 were somewhat more unfavorable than usual, the rainfall being about normal, the relative humidity some below normal, and the temperature above normal.

7. The orchard remained in excellent condition throughout the summer of 1899, making a vigorous growth and bearing a heavy crop of fruit of superior quality.

8. During the second year of the experiment the orchard received three feet of water from December 16 to March 5, 1900. Following the irrigation, the orchard was plowed about a foot deep; by thorough cultivation, a mulch of 6 to 8 inches of loose soil was maintained throughout the summer.

9. The weather of the eight months following March 5, 1900, during which the orchard received no water, was very trying upon all vegetation, the rainfall being considerably below the average, the relative humidity below (part of the time very much below) the normal, and the temperature above the normal.

10. The condition of the orchard at the end of this trying season of 1900 was most excellent, the trees having made a vigorous growth, and at no time having shown the effects of the drought.

11. During the third year of the experiment a green-manuring crop of clover was grown in the experimental orchard (as had been done in the other orchards of the farm for two previous years), and four feet of water applied from November 6 to March 29. A heavy crop of clover was turned under April 6, 1901.

12. The excellent condition of the winter-irrigated and summer-cultivated orchard at the end of trying seasons was due to the fact that by this treatment a maximum amount of the irrigating water is stored in the soil and returns through the trees, due to the more abundant supply of water during winter, to comparatively slow evaporation while the water is being applied, and to efficacy of the surface earth-mulch that can be maintained throughout the summer.

13. The water of summer irrigations, upon account of the insufficient supply and rapid evaporation, does not ordinarily reach deep-seated roots and return through the trees, but irrigations cause a baking of the surface and a growth of weeds that make extra cultivation necessary.

14. The surface earth-mulch (which can be secured only by cultivation) conserves the moisture stored in soil by checking capillary action, and by preventing evaporation from all the soil except the mulch itself; and it also permits air to enter the subsoil freely.

15. The results of the underground investigations illustrated, among other things, the superior ability of fine soils to absorb and retain moisture, and the inability of coarse soils lying next to fine soil to long retain much water.

16. The moisture content of the upper 25 feet of soil was effected appreciably by above-ground operations and local climatic conditions.

17. The ground water evidently affects the moisture content of clay eight or ten feet above it, the per cent of water in the respective feet of that stratum decreasing as the water level falls, and increasing as the water level rises.

18. Growth of rootlets begins on deciduous trees, in our climate, about a month before there are indications of growth above-ground.

19. The set of samples taken June, 1899, showed that about 15 inches of water had been lost from the upper 25 feet (of which the upper five feet lost about eight inches), and that from the 16th and 17th feet considerable water had percolated into the drier soil below.

20. From June 18 to September 30 there was a loss of but a little over three inches of water from the upper 25 feet, of which the upper five feet lost a little over two inches.

21. The total loss of water from the upper 25 feet, during the spring, summer and autumn of 1899 was about 20 inches, of which about 80 per cent was lost the first three months, about 16 per cent the next three, and only about 4 per cent the last three months.

22. Deciduous orchards use and need the major part of the water supply during spring and early summer, which need can best be supplied in most of southern Arizona by filling the subsoil with water during winter.

23. The amount of water needed by a deciduous orchard to keep it in good condition in southern Arizona from March to November is about 21 inches, which can be stored in the soil by the application of about three feet during winter.

24. The amount that need be applied to grow a green-manuring crop and store enough water in the soil to carry a deciduous orchard through the summer is about four feet.

25. Deep winter irrigation followed by thorough summer cultivation is better for deciduous orchards in southern Arizona than the frequent application of small amounts of water during the growing season.

University of Arizona

Agricultural Experiment Station.

Bulletin No. 38.

Timely Hints for Farmers.

Collected, Edited and Illustrated.

Separately distributed from October 1, 1900, to July 1, 1901.

Tucson, Arizona, July 20, 1901.

UNIVERSITY OF ARIZONA
AGRICULTURAL EXPERIMENT STATION

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Tucson, Arizona.

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Amhat palm, on the Experiment Station farm, 10 years old, with 300 pounds of fruit, October, 1900 (see page 267).

TIMELY HINTS FOR FARMERS.

THE FARMER'S READING COURSE.

SEQUEL TO NO. 19, OCTOBER 1.

Appreciating, in connection with the agriculture of a new and but partly developed Territory, the unusual value to the Arizona farmer of scientific information regarding the land of his adoption, the Station, last October, offered a small but carefully selected library for the winter's reading at cost price to those who desired.

As was suggested in the invitation to join the Reading Course, though Nature bestows her blessings with liberal hand upon the Arizona farmer, yet the perplexities which confront him are many. With the problems of irrigation, culture, behavior of plants and animals under new climatic conditions, the management of drouth and alkali, excessive heat and treacherous frosts, each day is likely to afford new food for reflection.

In this region, indeed, it is more than usually true that the farmer should understand those forces of Nature which are at work all around him, and should grasp those principles of the high art of farming which may be made to serve his welfare in a thousand ways.

In accordance with this plan, the following library was collected and issued to some sixteen subscribers to the course:

Principles of Agriculture, by L. H. Bailey.

The Soil, by F. H. King.

A Handful of Soil, by R. S. Tarr, in Cornell Nature-Study Quarterly No. 2.

Nature, Value and Utilization of Alkali Lands, California Experiment Station Bulletin 128, by E. W. Hilgard.

Salt River Valley Soils, Arizona Experiment Station Bulletin 28.

Balanced Rations for Stock, Cornell Reading Lesson No. 1.

A Farmer's View of Balanced Rations, Cornell Reading Lesson No. 8, by S. W. Fletcher.

Sample Rations for Milch Cows, Cornell Reading Lesson No. 9, by Leroy Anderson.

Milk and Its Products, by H. H. Wing.

The Feeding of Farm Animals, U. S. D. A. Farmer's Bulletin 22, by E. W. Allen.

The Dairy Herd, U. S. D. A. Farmer's Bulletin 22, by Henry E. Alvord.

Breeds of Dairy Cattle, U. S. D. A. Farmer's Bulletin 106, by Henry E. Alvord.

The total cost of this library, including postage was $2.91.

As will be seen from the titles, the collection affords information for various classes of farmers, while special emphasis is laid on certain matters of more than usual interest in Arizona.

Although the number of responses was small, this fact is not discouraging, and the experience in handling reading course work gained last year, will increase its usefulness in time to come.

Appreciation and profit, however, on the part of our readers has not been wanting. Writes one: "I am glad to say that the books you sent me last winter have opened up my eyes to a great many things that I should have been familiar with before;" and what is true of this one should be true of many hundreds of others.

It is intended, therefore, that this experiment with the farmer himself, shall continue, and next year, as last, with an improved collection of books to offer, we will renew this educational effort for his benefit.

R. H. FORBES,
Director.

STINKING SMUT OF WHEAT AND ITS PREVENTION.

NO. 20, OCTOBER 15.

While walking through a stubble field in the vicinity of Tucson about a month ago, the writer chanced to pluck a few heads of wheat which had escaped the sickle. On attempting to thresh out the grain every kernel was found to be destroyed by what is popularly known as "stinking smut." Further examination of the straw lying upon the ground revealed but few unsmutted heads. The foreman of the ranch reported that about one-third of the grain hay raised in this field had been smutted with this fungus for the past two years, the seed each season having been obtained from Indian sources. He reported still further that the seed sown had a very bad fetid odor, indicating, without much doubt, the presence of this disease.

After making inquiries of several responsible individuals regarding the prevalence of smutty wheat, a circular letter was addressed to the millers of the Territory, asking them for certain information upon the subject. Returns from these letters indicate that more or less smut is offered for sale at all the mills heard from, and that the quantity varies from 2 to 20 per cent of the total amount purchased. In one instance fully one-half of the flour ground is reported to be dark with smut. One correspondent reports wheat to be injured to the extent of 50 per cent of its value for milling purposes, while another speaks of wheat offered for sale which he refuses to buy at any price. The returns show still further that all but one of the Indian tribes in the Territory invariably raise smutty wheat. Our own observations regarding crops raised from seed bought of them, indicate that there are some cases in which their crops are in a very deplorable condition indeed.

Smut is caused by a parasitic fungus, the spores of which may be found in the hairy ends of the kernels of smutty wheat. These spores germinate at the same time as the wheat, and send small tubes into the young plants. These develop and grow apace with the wheat the entire season, but cannot be seen, except by the aid of a microscope, until the berry begins to form, when the fungus distorts the kernel and fills it with a smutty mass of spores covered with a thin shell. When this shell is broken by threshing, the spores are set free and cling to the hairy ends of the healthy berries, where they are again ready to produce another crop of smut the next season.

There are many plant diseases, some of them occurring in Arizona, which have baffled every attempt of the investigator to subdue. Some have received but little attention, and it is hoped future investigation may bring them under control. These facts, however, do not apply to the stinking smut of wheat, for it has been demonstrated repeatedly *that certain treatment will destroy the fungus which causes this disease.* There is, therefore, no good reason why the farmer should go on raising smutty wheat year after year, when a little time and patience will increase his crops and furnish him more marketable returns for his labors.

The remedy is simple and easily applied. Any farmer can, by the expenditure of a very small amount of money, treat his seed wheat in a manner that will insure his crop against an attack of this fungus. He needs for this operation, four things: bluestone or copper sulphate, a good quality of lime, some large vessels which will hold water, such as tubs or barrels, and a place to spread his wheat out to dry when he is through treating it. The operation is as follows: One pound of copper sulphate is dissolved in 24 gallons of water. The seed is soaked in this solution for 12 hours, after which the liquid is drained off and the seed again soaked for 10 minutes in limewater, made by slaking one pound of lime in 10 gallons of water. After drying, the wheat can be sown at any time without any danger from the effect of smut.

The process tabulated is as follows:

1. Soak seed for 12 hours in copper sulphate solution.
2. Soak seed for 5 to 10 minutes in lime-water.
3. Dry the seed.
4. Sow the seed.

The only object in drying is to facilitate the scattering of the wheat. Where the acreage is small and the sowing done by hand, the drying can be dispensed with.

Enough of both copper sulphate and lime solutions should be used to thoroughly wet the grain. Piling the wheat on a barn floor and sprinkling it with the solutions will not give the desired results. It is better to fill a barrel two-thirds or three-fourths full of wheat and then pour in enough of the solution to more than cover the seed. The barrels can be arranged with a plug near the bottom, by means of which the liquids can be drawn off at the proper time and used again in the treatment of another batch of wheat.

This method of treatment with copper sulphate and lime solutions is the one commonly practiced and usually recommended for the prevention of stinking smut. If handled according to the directions given above, there need be no fear of this disease. In this work, as in all others, the farmer should be thoughtful and clean in his operations. After the wheat is treated, it should not be put back in smutty sacks, nor in bins which have had smutty wheat in them, without first destroying the smut. This can be done by treating both sacks and bin with a copper sulphate solution of twice the strength quoted above, or by thoroughly soaking with boiling water. The seeder should also be thoroughly cleaned and the box and cups treated with either boiling water or a strong solution of copper sulphate.

It must be constantly borne in mind that copper sulphate is a poison. Care should therefore be taken that chickens and stock be not allowed to eat the treated wheat.

There is practically no danger in planting in ground which produced a smutty crop the previous year. If clean seed is planted, no smut will be raised.

There are many other species of smut, and doubtless some of them do considerable damage in Arizona; but this "Hint" is intended to cover the question of stinking smut only. Indeed, botanists recognise two species of stinking smut, but the treatment given above will destroy both.

DAVID GRIFFITHS,
Department of Botany.

THE USE OF CHEMICAL PRESERVATIVES IN MILK.

NO. 21, NOVEMBER 1.

Late in the month of September, while the weather was yet warm, one creamery patron was heard to say to another, "What's that thing for?" indicating by a motion of his hand, a milk cooler standing near. Upon being told that it was a milk cooler, and that both morning and evening milk was cooled by its use every day before sending to the factory, the first speaker replied: "What's the use of all that trouble? Get a little Preservaline, that will keep your milk all right and isn't half so much work," and in his reply expressed, I am sorry to say, the sentiment of many creamery patrons.

The use of preservatives in milk is the lazy man's substitute for cleanliness. The fact that it is deemed necessary to add something to the milk to keep it sweet until it reaches the factory is evidence of unclean or careless handling, while the fact that preservatives are added is evidence of criminal ignorance on the part of the persons using them.

It is possible to make good butter or cheese only when the souring of the cream or milk is under control of the manufacturer. If, then, milk comes to the factory so adulterated by the use of chemicals that it will not sour, it is impossible to make good butter or cheese from it. In butter making large losses of fat in the buttermilk have been traced to this cause, and we have known the entire make of a cheese factory for several days to be an absolute loss because a single patron used Preservaline in his milk.

But more important than these financial losses is the fact that the use of the preservatives renders the milk unwholesome and deleterious to health. The liquid preservatives most commonly used depend for their preserving power upon the presence of formic aldehyde of which they are in part composed. Concerning this disinfectant, A. S. Mitchell, chemist for the Wisconsin Dairy and Food Commission, made the following statement in Hoard's Dairyman in 1898: "During the last year a new and most powerful disinfectant has been foisted upon the market as being harmless. * * * * This substance is formic aldehyde, a substance in general use as a disinfectant and for preserving and hardening dead tissues. Doctors have been obliged to abandon its use as an antiseptic, in a very dilute form, for preserving ear washes and similar solutions, as continued contact in dilutions as high as 1 to 10,000 causes the skin to die and peel off."

The fact that a solution is strong enough to stop the development of bacteria in the milk should be sufficient to deter any intelligent man with a conscience from adding it to that which he sells for human food. Because some of the readers of this article have used Preservaline or Freezene in their milk during the past summer without, to their knowledge, having killed, or injured the health of any of the creamery's customers, is no argument for the continuance of its use. It should not be necessary to prove that the substance will cause direct injury in the doses in which milk is used in order to establish the fact that it is harmful. Many cases of sickness and death have been indirectly traced to the presence of chemical preservatives in milk.

The laws of twenty-six of our states make this adulteration of milk a crime punishable by fine and imprisonment. Unfortunately our Territory has no law providing for the punishment of this crime. All creamery men should, then, be laws unto themselves and, standing together, unrelentingly refuse any milk suspected of having been treated with chemical preservatives or any other form of adulteration.

The use of chemical preservatives is the unscrupulous man's substitute for care and cleanliness, for by proper handling, milk may be kept sweet until delivered to the factory, even in an Arizona climate. A former Timely Hint dwelt somewhat at length upon the necessity of cleanliness in handling milk and we would now like to emphasize more strongly and specifically the necessity of paying proper attention to cooling the milk.

One morning in July the writer stood at the weigh can of a creamery and took the temperature and tested the acidity of each lot of night's and mixed night's and morning's milk delivered. If these lots of milk had all been handled with equal care as to cleanliness, the temperature at which they had stood through the night, as indicated by that taken at the creamery in the morning, might be reasonably considered as responsible for their acid condition at that time. The temperatures of the night's milk varied from 78 to 93° F., and while the variations in acidity did not conform exactly with those of temperature, generally speaking, the warmer the milk, the worse its condition. It is needless to say that the milk at 93 degrees was sour; it was so sour that particles of clabber stuck to the sides of the weigh can as the milk was drawn off, and yet, the driver insisted that the milk was sweet and became profanely abusive when the weigher politely told him that milk in that condition would thereafter be refused. Other lots of milk with a temperature as low as 84 degrees were sour, indicating that lack of cleanliness had contributed to their souring.

As stated before, this condition of affairs is absolutely unnecessary. In our experience at the Experiment Station farm we have observed that by the use of the ordinary tin-drum milk-cooler filled with well water, which with us has a temperature of from 70 to 73 degrees, milk may be reduced in temperature ten degrees; that by running it over the cooler a second time the temperature may be brought down five degrees more; and that by wrapping the cans in which the milk stands over night in wet burlap or gunny sacks the temperature may be still further reduced to that of the atmosphere or lower. During the first fifteen days in July, including the hottest days and nights of the season and the hottest twenty-four hour period recorded since the establishment of the weather bureau in Phoenix, the average temperature of the night's milk in the morning, under this treatment, was 71 degrees, which was less than the average minimum temperature of the atmosphere for that period. On very warm nights the temperature of the milk went several degrees below that of the surrounding air. Under this treatment the increase of acid in the milk during the night was very slight. The average per cent of acid in the milk immediately after milking, during the first ten days after July, was .165 per cent, while the same milk on the following morning showed a presence of only .17 per cent of acid. Milk seldom smells or tastes sour when containing less than .3 per cent of acid.

With these facts to base conclusions upon we feel safe in stating that, with the exercise of reasonable cleanliness in milking and in the care of utensils, and by taking proper care in cooling, milk may be delivered at the factory in good condition, and that there is no excuse based on reason for what we deem the criminal adulteration of milk by the use of chemical preservatives.

GORDON H. TRUE,
Department of Animal Husbandry.

THE OPEN RANGE AND THE IRRIGATION FARMER.

No. 22, NOVEMBER 15. (Condensed.)

There is one aspect of the irrigating water problem, not often discussed and upon which, indeed, very little accurate knowledge exists, which is, nevertheless, of great importance in connection with Arizona agriculture.

This is, the relation between the open, grassy, range country and the water supply available to the irrigation farmer. For many years in the United States, and for a much longer time in Europe, the connection between forest soil-covers and the amount and regularity of the flow of streams has been observed and studied; but it may be stated with some confidence that the interests of irrigation in Southern Arizona and some other regions of like character, are affected more by the grassy, open range, than by forested districts. The peculiarities of this range country, therefore, as affecting the run-off of water and the flow of streams are to be critically considered, and any change which is being brought about in the ranges by the operations of stockmen, is of interest to the irrigation farmer in Southern Arizona. It is true that exact knowledge upon the past and present condition of the ranges is scarcely to be had; yet historical evidence and existing facts are such as to enable us to offer a fair judgment as to what is transpiring about us.

Especially instructive in this connection is the history of the cattle industry on the Gila watershed, with the associated changes in the grazing country. The Gila watershed above the Salt river junction, and including that portion in New Mexico, is some 25,000 square miles in extent. For the most part, this great area consists of grassy plains, intersected from north to south by mountain ranges covered with forests on their higher slopes. Considerable areas of the plains themselves, also, are here and there sparsely covered with mesquite and other brushy growth. Taking this great drainage area as a whole, however, the prevailing vegetation is, or once was, grass, probably 90 per cent of the total area being mainly of this character. The watersheds of the Salt and Verde rivers, 12,250 square miles in extent, have a larger proportion of forest, but also contain great areas of grassy country.

In their original condition, these grassy plains are said by those who first came to Arizona, to have been rarely beautiful to the eye, and even yet, in remote districts, comparatively unchanged by the operations of cattlemen, evidence of the truth of these statements is to be found. In the swales and valleys of this country, and wherever water was more abundant, the great bunch grasses

Fig. 1. Swale in the San Simon valley showing a heavy growth of galleta grass which will obstruct the flow of flood water and prevent formation of gullies.

grew luxuriantly. Sacaton and the galleta covered the ground thickly, affording an abundance of native hay in the dry seasons and quickly freshening up into green forage after a rain. In the same situations, also, were to be found a bewildering variety of quick-growing watergrasses which afforded most nutritious feed while they remained green. On the knolls and in the drier places, the crowfoot grama and the six-weeks grasses, so-called, supplemented in the rainy season the more abundant forage of the lower levels. When it rained upon these grass-covered plains, the water, being obstructed in its downward course by the abundant vegetation, sank largely into the ground and very slowly made its way into the underflow of the great valleys, finally reappearing in the Gila river. In so doing, much of it was utilized by growing vegetation, while the residue, gradually joining the main watercourses, insured a constant flow of water. When severe storms occurred, with their resulting floods, the abundant bunch grasses at the lower levels obstructed the flow to such an extent that the water, in its downward course, was spread laterally over great areas and its force dissipated. At the same time, the silt brought down from the higher levels, including quantities of fertilizing material, was deposited in these places, with the result that the bottoms of the valleys were kept level and were enriched and made the scene of an ever perpetuated growth of beautiful and luxuriant grasses.

It was into these lovely wild pastures that the cattleman, about 30 years ago, began to drive his herds. Although Arizona has been inhabited by the Mexican people for 200 years and more, the cattle industry was never developed for the reason that the hostile Indians made the maintenance of herds upon the open ranges impossible.

But shortly after the Civil War the establishment of military posts in Arizona and the issuance of treaty rations to the Apache Indians created a heavy demand for beef. Large herds were consequently driven in from Texas and, under the protection of newly established posts, the cattlemen gradually established themselves.

After the completion of the Southern Pacific railroad in 1881, small owners shipped in their herds from worn out districts in Texas and elsewhere, while still others, driving their cattle overland to California, stopped by the way.

The multiplication of small herds with their natural increase, together with restricted sales due to the low prices of cattle at times during the eighties, soon caused the range to be stocked to its utmost capacity, even in favorable years. In seasons of scarcity, when feed was short, the cattle began to perish from starvation, devouring in their desperate struggle for existence, almost every vestige of growth upon the plains. Being compelled in their wanderings back and forth between the higher and lower grounds, to take twenty steps for a mouthful of food where formerly but one was necessary, they deepened their paths from place

Fig. 2 *THE RUIN OF A VALLEY*—Wash five miles south of Solomonville in San Simon valley; formed in the last eight years, twenty feet deep and fifty feet wide, where was formerly a level plain.

to place; the prevailing winds blew the dust from these paths until they lay inches below the general surface, and then, upon a country prepared for destruction, came the rains. The water, collecting in the trails from the bared and devastated surface of the country, fell swiftly to lower levels, gullying the trails as it ran and gathering in destructive freshets in the larger valleys. The bunch grasses, having been depleted by the starving cattle, were no longer able to withstand the rush of the floods, and the gullying process began on a large scale through the very heart of what were formerly the most luxuriantly grassy regions of the country. When these channels are once established through a given district, the water is thereafter destined to flow through them, no longer

Fig. 3. *THE RUIN OF AN INDUSTRY*—A familiar sight on depleted ranges, especially after a hard year.

spreading out over the level bottoms and no longer being available for the growth of the bunch grasses which formerly throve in these situations. In this way, when a valley has once been so gullied as to carry the water in streams, instead of spreading it out in broad floods, the very existence of the richest grazing districts is rendered impossible. A striking instance of this process of ruin is offered by the San Simon valley. This once beautiful district has been despoiled and hopelessly ruined within the short space of some fifteen years. At Solomonville, the great barranca which has cut its way up the valley is about fifty feet across and from ten to twelve feet in depth. From this point it is stated to extend southward for sixty or seventy miles, with tributary washes and barrancas branching out to a yearly increasing distance on either side.

Let us consider this state of affairs in its bearing upon the various industrial interests of Arizona. In the first place, the stockraising industry itself has suffered in some localities almost to the point of extermination. The ruinous methods which seem to be inevitable upon a public range have so destroyed its value and have so changed the original condition of the country that in many sections, in spite of the present high prices for cattle, the ranges now carry but a tithe of what they once did. Definite figures are not at hand; yet even casual conversation with the stockmen of this depleted range shows it to have been commercially destroyed. In the San Simon valley alone, judging from the statements made to the writer by observers of its history for the past few years, it is judged that the number of cattle has fallen off from seventy-five to ninety per cent.

Furthermore, the operations of the stockmen upon the range watersheds of the Gila and Salt rivers intimately concern the welfare of the irrigation farmers along their banks. As previously stated, the vegetation on the range, especially the bunch grasses in the lower swales, at one time so obstructed the flow of water that the rainfall found its way but gradually over the surface of the ground to the main watercourses, while a large portion, sinking into the ground, joined the underflow and found its way down yet more slowly. The result was a constant and not excessively muddy flow of water, whose fluctuations were not extreme; but now, in the more denuded condition of the watershed, a heavy storm in an upper valley causes a tearing torrent to appear below.

The evil effects to the irrigator of a rapid run-off of water of this nature are two-fold in character. In the first place, a quick rush of water soon carries off the whole of the rainfall and leaves the stream-courses dry, so that the irrigation farmer is overwhelmed one week with floods and threatened next with prospective drouth.

In this way, it is either surfeit or starvation with him most of the time. Again, a washed and gullied country contributes enormous quantities of silt to its drainage water. This not only inconveniences the farmer, filling his ditches and embarrassing him in handling his water, but becomes a complicating factor in connection with the great storage reservoir propositions which have in recent years been discussed hopefully as a possible solution of the irregular supply of irrigation waters caused by the overstocking and mal-administration of the watersheds.

Appreciating the necessity for the acquisition of scientific knowledge concerning worn out range country and the ways and means for its reclamation, the Arizona Experiment Station has taken its first step towards the dissipation of our ignorance on this very important matter. About half a square mile of worn out range country near Tucson, has been fenced, with a view to studying its restoration to the original grass-covered condition. Looking to the future, however, it must be remembered that scientific knowledge of this subject must be coupled with legal ingenuity in order to be effective, and that the application of such knowledge over an occupied range of considerable extent is a problem which experience only can solve. Forestry reservation and administration presents similar difficulties, the actual work in this case being undertaken by the Government. The often discussed leasing of public lands to private parties, on the other hand, leaves the practical work of range improvement to individuals. The relative merit of these two general methods must, in part, be decided with the aid of fuller scientific knowledge of the subject than we now possess.

With this passing suggestion as to the administrative difficulties of range improvement, it may be stated in conclusion that the hoped for outcome of range study is: 1. The betterment of stock interests by demonstrating methods for reclaiming grazing lands; 2. The improvement of irrigation interests, by showing how measurable control may be exerted upon the run-off of a given range; and 3. By adding to the life of reservoirs in lessening the amounts of silt carried in flood waters.

R. H. Forbes,
Director.

THE VALUE OF A DAIRY HERD RECORD.

NO. 23, DECEMBER 1.

In a previous Timely Hint concerning the selection of dairy cows, the necessity of testing and keeping a record of the product of the individual cows of the herd was strongly urged. In order to demonstrate this necessity when intelligent management of the herd is attempted, the writer has kept such a record of two herds during the past year, following the plan that he would recommend for general practice.

The milk was weighed and sampled at every milking and the samples tested twice a month, the writer testing the milk and keeping the record as his share of the work. The owners of the herds state that the extra time required to weigh the milk, record the weight and take the samples, did not exceed one minute per cow. The samples tested every two weeks were composite samples consisting of a part of the milk from each milking during the two weeks, and were kept in condition for testing by the addition of bichromate of potash and bichloride of mercury in about equal parts. The time required for testing each set of samples for the two herds was about a half day.

It was the original idea to secure herds fairly representing the different breeds used for dairy purposes, but the men owning Shorthorn and Holstein herds failed to co-operate when the time came to begin the test. Of the two herds of which records were kept, one consisted of twelve full-blood Jerseys, and the other of thirty-five cows of mixed breeding, some being high-grade Shorthorns, some grade Jerseys, and others of various admixtures of blood. Of this latter herd, thirty cows completed a year's record, which is given below. This record, we think, speaks for itself, and demonstrates what a similar record of any dairy herd will demonstrate, that *it pays to keep a record.*

In addition to the record of the pounds of milk and butter fat produced by each cow, we have calculated the comparative profits returned by the different animals. The gross receipts have been determined by multiplying the pounds of butter fat by twenty hundredths, twenty cents per pound being the average price paid for butter fat in the valley during the year. The net receipts have been calculated by substracting thirty-two dollars, the estimated cost of pasture and milking, from the gross receipts. The skim milk should pay for hauling the milk to the factory, at least. No attempt has been made to determine the value of the calf for each cow. The bull calves and the heifer calves from the least valuable cows, would about pay the interest on the money invested in their dams, while the heifers from the best cows might be worth more.

A YEAR'S RECORD OF A DAIRY HERD.

NO. OF COW.	AGE.	DAYS IN MILK.	POUNDS OF MILK.	PER CT FAT.	POUNDS OF FAT.	GROSS RECEIPTS	NET RECEIPTS
1	5	357	7978	4.36	348.74	$69.75	$37.75
2	10	335	8727	3.66	319.13	63.83	31.83
3	7	315	7294	4.28	311.75	62.35	30.35
4	5	350	6614	4.45	294.82	58.96	26.96
5	7	365	6433	4.38	282.99	56.60	24.60
6	8	330	5363	4.84	258.96	51.79	19.79
7	5	333	5383	4.72	254.36	50.87	18.87
8	7	351	6351	3.98	253.31	50.66	18.66
9	15	288	7770	3.25	252.42	50.48	18.48
10	7	284	7052	3.4	239.85	47.97	15.97
11	5	365	5118	4.66	238.55	47.71	15.71
12	7	256	5305	4.5	238.38	47.68	15.68
13	4	291	4459	5.28	235.74	47.15	15.15
14	3	343	5862	4.02	235.74	47 15	15.15
15	5	315	4951	4.75	234.34	46 87	14.87
16	7	345	5940	3.73	221.27	44 25	12.25
17	5	365	4855	4.51	219.21	43.84	11.84
18	3	338	4327	5.01	217.02	43.40	11.40
19	7	228	4766	4.49	214.27	42.85	10.85
20	4	233	5434	3.89	211.12	42.22	10.22
21	7	344	4470	4.69	209.53	41.90	9.90
22	15	271	6727	3.07	206.31	41.26	9.26
23	6	311	5041	3.94	198.57	39.71	7.71
24	7	241	5838	3.36	196.19	39 24	7.24
25	7	285	4239	4.53	191.94	38.39	6.39
26	8	319	5420	3.53	190.51	38.10	6.10
27	4	365	3964	4.41	174.74	34.95	2.95
28	3	342	3741	4.39	163.70	32.74	.74
29	4	305	3559	4.43	157.87	31.57	— .43
30	5	335	3126	4.51	141.13	28.23	—3.77

In order to compare this herd with others intelligently, it may be stated that the average gross receipts per cow per month was $4.25. The average per cow for the Jersey herd tested was $4.66. There were one or two other herds supplying milk to the same creamery probably averaging higher than $4.25, and possibly higher than $4.66, but the number of cows in milk was not reported for the twelve months, so that we are unable to calculate their averages exactly.

One herd reported for nine months, gave a monthly average of $1.49 per cow, and the fact is sad but true, that figures are available showing that there are too many such herds in the Territory. Eight herds reporting the number of cows milked every month, show the following averages per cow:

No. 1	$4.25	No. 5	$3.61
No. 2	3.94	No. 6	3.56
No. 3	3.85	No. 7	3.25
No. 4	3.77	No. 8	3.24

It seems as though it would be a good idea for the readers of this article who have dairy herds, to sit down and add up the amounts of their creamery checks for the year, divide the sum by twelve and then by the number of cows in their herds, compare the average with those given above, and ask themselves how many unprofitable cows they think they own, and how they think they are going to pick them out.

In connection with a study of the above table, we would like to emphasize the following points:

1. The value of a dairy cow is not determined by the blood she is supposed to possess, unless that blood is of ancestors that are known to have produced butter fat at a profit. The cow that heads the list in the table is a grade Jersey, while the one standing next is a high-grade Shorthorn. The best cow in the full-blood Jersey herd tested, gave a net return of $38.45, only seventy cents more than that of the best grade in the other herd. The cow standing second in the Jersey herd was outranked by three grades in the other herd, including a grade Shorthorn; and there were twenty-six grade cows better than one of the full-blood Jerseys.

2. The value of a cow is not to be estimated by the amount of milk she gives. While it will be observed that the heaviest milker in the herd is the second best cow, and the cow standing second in milk, ranks first in profit, it will also be seen that the cow standing sixth in the amount of milk given, is twenty-second in profit.

3. The value of a cow is not to be estimated by the richness of her milk. Eighteen cows tested higher than the best cow in the herd, this number including the four poorest ones; and twenty-four tested higher than the second best cow. It is pounds of butter fat and not per cent that count.

4. The comparative value of the cows in a herd is not to be based upon the gross, but upon the *net* receipts. Compare cows No. 1 and No. 27. No. 1 gave practically twice as much milk of about the same richness, and is therefore, you will probably say, twice as good a cow as No. 27. Is this true? Look at the net receipts. No. 1 returned $37.75 and No. 27, $2.95, from which it is easy to calculate that instead of being twice as good a cow as No. 27, No. 1 is between twelve and thirteen times as valuable. Two cows, it will be observed, failed to pay expenses. How are such cows as No. 30 and some of her near neighbors on the list, to be weeded out of our herds, unless the individual record is kept? If there is one such cow in a herd averaging $4.25 per head per month, how many are there liable to be in herds averaging less?

In the matter of time, this Hint is certainly timely, coming as it does, just long enough before the end of the year to give every dairyman time to make plans for keeping a record during the coming year.

GORDON H. TRUE,
Department of Animal Husbandry.

THE USE OF THE BABCOCK TEST.

NO. 24, DECEMBER 15.

The Babcock milk test is an outgrowth of the co-operative system of butter and cheese making. When the creamery and cheese factory first came to take the place of the home dairy, and the milk from a large number of dairies was brought to one factory for manufacture, it was a common practice to divide the proceeds on the basis of the number of pounds of milk or cream delivered by each patron, regardless of quality. Even if the milk delivered had not been tampered with by skimming or by watering, this method, on account of the difference in the quality of milk, was clearly unjust. With a view to furnishing a means for overcoming this injustice the Babcock milk test, among others, was introduced, and today it is used as an arbitrator in practically every creamery and cheese factory in our country.

But the use of so valuable an accessory to the dairy industry was not to stop with the factory. The fact that milk from different herds varied in value, applied as well to the milk from different cows of the herd, and alert dairymen were not slow in taking advantage of this new means of helping themselves to an increased profit by using it in weeding out the poor cows of the herd. To-day intelligent dairymen, not satisfied with herds "as good as the average," sell cows as well as milk by the Babcock test.

The following may be given as some of the reasons for the almost universal use of this test:

1. The first cost is not great and its operation is inexpensive.
2. The test is accurate and quickly made.
3. No knowledge of chemistry is necessary in its use.
4. The per cent of fat is measured directly upon the neck of the test bottle and no calculations are necessary.
5. Not only whole, sweet milk, but cream, skim milk, butter milk and whey may be tested by its use, and sour milk, as well, if accurately sampled.
6. But a small quantity of milk is used, and after the sample has been measured into the test bottle it need not be tested for weeks.
7. The machine is simple and does not easily get out of order.

The prices at which manufacturers list Babcock testers are as follows: Four bottle machines, $8.00; six bottle machines, $9.00; and eight bottle machines, $10.00. This includes everything necessary for testing whole milk, including a small amount of acid. Special bottles for use in testing skim milk and cream come extra, as well as the preservative for keeping milk when composite tests are made.

The following firms manufacture good machines and are reliable: Vermont Farm Machine Co., Bellows Falls, Vt.; Creamery

Package Mfg. Co., Chicago; Cornish, Curtis & Green, Fort Atkinson, Wis.; F. B. Fargo, Lake Mills, Wis.

Sulphuric acid which is used may be purchased at almost any drug store, but if a bottling establishment is available it is better to get your supply there; druggists sell so little of it that it is likely to be weak from long standing. The acid costs, in Arizona, from five to eight cents a pound and that amount is sufficient to test about fifteen samples.

The writer has found bichromate of potash a satisfactory preservative on account of its cheapness and efficiency, and the fact that it colors the milk renders it unlikely to be used by mistake for purposes other than testing. It may be purchased (powdered) of druggists at ten cents per quarter of a pound; this amount should be sufficient for 250 to 300 tests. A 32-short cartridge with a wire handle makes a convenient measure and holds the right quantity for keeping a pint of milk a week.

In purchasing a tester it is always advisable to get a good machine. Cheaper ones than those mentioned above are on the market, but unless it becomes a question of a cheap one or none at all, it is not best to buy that kind. By all means do not get a machine having a friction gear. The accuracy of the test depends upon the speed at which the bottles are whirled and with a friction gear it is impossible to determine the speed.

The directions accompanying the tester, if followed, are usually adequate for its successful operation. The following points, however, should be carefully watched:

1. *Sampling the milk.* The milk from which the sample for testing is taken must be thoroughly mixed so that the cream is evenly distributed through it. Avoid shaking in such a way as to churn the butter fat.

2. *Strength of acid.* The acid should have a specific gravity of 1.82 to 1.83. This is determined by the use of a glass float which may be purchased with the machine at a cost of from 35 to 75 cents. Acid is weakened by the addition of water.

3. *Temperature of milk and acid.* The temperature of the milk and the acid should be from 60° to 75°F. If you have no thermometer buy one with your machine. No dairyman should try to get along without one. The writer has found it conve-

nient to cool the milk for testing by allowing the test bottles, into which the samples have been measured, to stand over night and then test in the morning. If you do not have ice, wrap a damp cloth about the bottles at night and they will be cool enough when morning comes.

4. *Pouring acid into the test bottles.* Hold the bottle in a slanting position so that the acid will run down the side and not through the milk.

5. *Adding hot water.* The water should be hot, too hot to bear the hand in it. Soft water is to be preferred where it is available.

6. *Measuring the fat.* The fat must be in a liquid condition when the readings are made, and the measurement be from the very top to the bottom of the column of fat.

7. *Speed of the machine.* A machine ten inches in diameter (from the bottom of one bottle packet to the bottom of the opposite one) should be given 1075 revolutions per minute; a fourteen-inch machine 910 revolutions. Count the number of the revolutions of the bottles to one of the crank and thus determine the rate of turning for yourself.

While the operation of testing milk by the use of the Babcock test is simple, care must be exercised in its use; inaccurate results will surely follow careless work.

GORDON H. TRUE,
Department of Animal Husbandry

PLANT-LICE.

NO. 25, JANUARY 1.

Plant-lice (*Aphididæ* of entomologists) are soft-bodied insects of small size, which suck the sap of plants by means of a long beak, the tip of which is thrust into the tissue of the plant. They are allied to the scale-insects (*Coccidæ*) and are especially abundant in temperate regions, the scale insects taking their place to a great extent in the tropics. In the cooler parts of North America, plant-lice are exceedingly numerous and destructive, but as we go south they are less noticed, although some kinds affect even the sub-tropical fruit-trees of Florida. In Salt River valley, in accordance with this general law, plant-lice are not particularly troublesome in the hot weather, but in the late winter and early spring they flourish exceedingly, the same cool and mild weather which permits the growth of garden vegetables being exactly suited to their taste. In the Mesilla valley of New Mexico the winter and early spring are too cold for the vegetables or lice, and the summer is hot, so here plant-lice are not much in evidence. It results from these facts that we have a region to the north and again one to the south, troubled by plant-lice and capable of growing certain crops, while an intermediate region has few lice and is less suitable for the crops in question.

From a popular standpoint, plant-lice may be divided into three groups:

1. Naked lice.
2. Woolly lice.
3. Lice living in galls.

The last mentioned are commonly seen on cottonwood trees, their globular or oval galls being very conspicuous on the twigs or leaves. If one of these galls is broken open, the lice are found within. These gall-lice do no serious injury, but if the galls are considered unsightly they may be cut off and burned in the early summer.

One of the gall-producing kinds is the famous Phylloxera of the vine. This creature has done enormous damage in Europe, but in America, where it is native, it is not regarded with any fear. Dr. J. B. Smith says: "I have seen vineyards in New York and New Jersey in which almost every leaf showed these galls, yet withal no real injury had been done. In other words, most of the native American vines are able to sustain the attack of the species."

The woolly lice are known by their secretion of a white wool-like substance, really consisting of minute waxy threads, so that they look like little patches of mildew. The commonest of such lice is the woolly louse of the apple, or *Schizoneura lanigera* (See figures 4 and 5). This creature is probably a native of Europe, although in England it is known as "American Blight." It is certainly not a native of Arizona, but has been brought there on young trees, and is now very widely distributed in the apple orchards. It has two forms, one which lives on the branches of the trees, the other upon the roots. The former, although naturally the most conspicuous, is much the least harmful.

Many experiments have been made for the destruction of the woolly louse of the apple, and the results are well summarized by Mr. C. L. Marlatt in Circular 20, Division of Entomology, U.S.D.A.

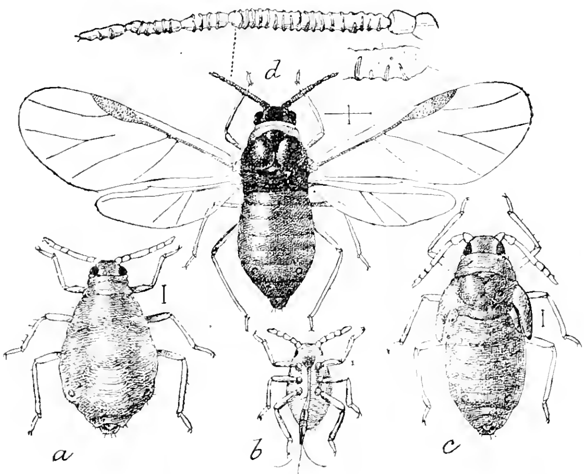


FIG. 4. Woolly louse of the apple.—*a*, Agamic female; *b*, young louse; *c*, pupa; *d*, winged female, with antenna enlarged above. All greatly enlarged, and with the waxy secretion removed. (Marlatt, Circular 20, 2nd Series, Div. Entomology, U. S. Dept. Agriculture).

The form which occurs on the branches can be killed by a spray of kerosene emulsion or soap wash, best applied warm. It can also be destroyed by applying kerosene to the colonies by means of a paint brush. This should be done, if possible, early in the year.

The root form is not so easily got rid of, but the following remedies have succeeded :

1. Hot water may be applied about the roots of the trees, the surface soil having been first removed.

2. Finely ground tobacco dust may be applied about the base of the trees, first removing the soil to a depth of 4 to 6 inches.

For large trees, two to five pounds of the dust may be used. Mr. Marlatt says: "The tobacco dust kills the aphides by leaching through the soil, and acts as a bar for a year or so to reinfestation. The dust is a waste product of tobacco factories and costs about 1 cent per pound, and possesses the additional value of being worth fully its cost as a fertilizer."

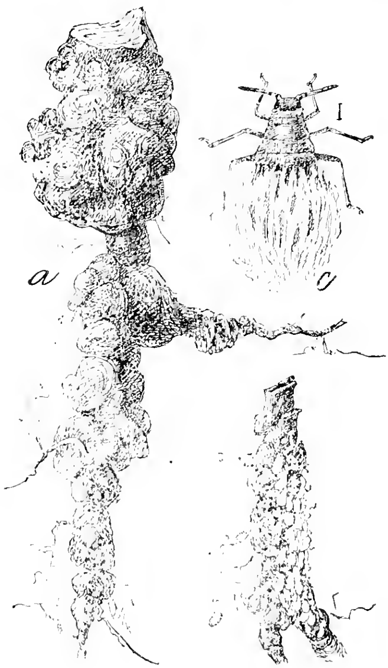


FIG. 5. Woolly louse of the apple.—*a* Root of young tree showing deformation produced by the lice; *b*, piece of root with lice upon it; *c*, female louse. *a* and *b*, natural size; *c*, enlarged (Marlatt, Circular 20, 2nd Series, Div. Entomology, U. S. Dept. Agriculture

3. Bisulphide of carbon can be applied in two or three holes about the tree to a depth of six inches to a foot, and not closer than a foot and a half to the tree. An ounce of the bisulphide should be put in each hole, and the hole immediately closed. This does not prevent later reinfestation, and is thus inferior to the tobacco dust.

Another woolly louse is that of the elm, named *Schizoneura americana* by Riley. I have found this at Mesilla, New Mexico, and it is not unlikely to occur in Arizona wherever elms have been planted.

The naked plant-lice (mostly of the genera *Aphis* and *Siphonophora*) are very numerous in kinds, and infest very many different plants. They are noted for their rapid increase, which approaches the miraculous. Professor Huxley calculated that the produce of a single aphis would, in the course of ten generations, supposing all the individuals to survive, weigh more than the whole population of China. Of course the individuals never do all survive; on the contrary, most of them perish, and for this we have to thank their numerous parasitic and predaceous enemies. Observe the flies hovering over a cabbage patch ; these are the syrphus-flies which lay their eggs among the lice ; and from these eggs hatch maggots which feed voraciously upon the lice, and ultimately turn into other flies like their parents. So also the little red beetles, so common wherever plant-lice abound, are the lady-birds which destroy more lice than we can count. Ignorant people sometimes are alarmed at the numbers of red lady-birds, and even think that they are the parents of the lice, but they could not make a greater mistake.

As regards the remedies for naked plant-lice, much depends on the kind of louse, the plant attacked, and the time and place. A good deal of work needs to be done in Arizona before we know what plant-lice occur there, much less how to deal with them. But in a general way, various suggestions may be offered.

Much may be done against most kinds, especially those living on fruit trees, by a spray of kerosene emulsion. The lice are soft and naked, not protected like scale-insects, so they are readily destroyed. Dr. J B. Smith says : "As a general insecticide, nothing is better than kerosene emulsion, which, when diluted ten times with water, kills all the young forms and adults of the green species. It has been found by experiment that the black or brown species are much more difficult to destroy, and one part of emulsion in six or eight parts of water is more likely to be effective." *(See note).*

The grey cabbage-louse, so well known to all raisers of vegetables, lives during the winter on old cabbage stumps. It is therefore of the utmost importance to remove them from the field and burn them, as well as all sorts of loose trash and weeds.

NOTE—*Kerosene emulsion, milk formula*—kerosene, 2 gallons; sour milk, 1 gallon.

Heating is unnecessary; churn three to five minutes, or until a thick, buttery consistency results. Prepare the milk emulsion from time to time for immediate use, unless it can be stored in air-tight jars; otherwise it will soon ferment and spoil.

How to use the emulsion—For summer applications for most plant-lice and other soft-bodied insects, dilute with 15 to 20 parts of water; for the red spider and other plant mites, the same, with the addition of one ounce of powdered sulphur to the gallon; for scale insects, the larger plant bugs, larvæ and beetles, dilute with 7 to 9 parts of water.

For subterranean insects, such as root lice, root maggots, "white grubs," etc., use either kerosene emulsion or resin wash, wetting the soil to a depth of 2 or 3 inches, and follow with copious waterings, unless in rainy season. *Year Book, U. S. Dept Agriculture.*

Spray Pumps—Full information about spray pumps, styles, cost, and where obtained will be supplied on application to THE EXPERIMENT STATION, Tucson, Arizona

The Arizona Strawberry-louse (scientifically called *Myzus fragæfolii*) is a pest of strawberry plants at Jerome and other places, and is quite destructive. It is very pale yellowish or greenish; the wingless forms, examined with a microscope or strong lens, are seen to have many knobbed hairs on the body. This plant louse swarms in great numbers on the leaves and stems, and even invades the blossoms, with the result that the fruit is defective. At present it has been found only on the cultivated strawberry; we have kept it in the laboratory on this plant, and have found that it will also live upon the wild strawberry of the mountains, but it refuses to attack beans or violets which are growing in the same box. This experiment indicates that it will probably feed only on the strawberry and its nearest allies; a fact of some importance, because if it should live on weeds near the strawberry beds, the difficulty of getting rid of it would be greatly increased.

In fighting this insect, it is of great importance to secure clean plants, and plant them where no infested strawberries have been. It may be well to give an infested field over to some other crop, and plant fresh strawberries in another part of the ranch. The plants about to be put in should be carefully examined, and it will be well to dip them in diluted kerosene emulsion or fumigate them with hydrocyanic acid gas. The ground which was infested should be plowed deeply.

T. D. A. COCKERELL.
Consulting Entomologist.

SUGGESTIONS CONCERNING DATE CULTURE.

NO. 26, JANUARY 15.

Dates being now grown in several parts of the Territory, and definite information as to their culture being lacking, it is deemed wise to furnish present and prospective growers with brief suggestions along this line. Letters received from various parts of Arizona and elsewhere indicate a growing demand for information relative to the culture of this fruit.

It seems to be now fairly well established that dates of good quality and in commercial quantities can be produced in the warmer parts of Arizona. During the past year, three imported trees at the Experiment Station farm near Phoenix bore over 500 pounds, the fruit ripening between August and January. The portion placed upon the market sold at 25 cents per pound wholesale, at Phoenix. Thousands of pounds could have been sold at this price. Packed in neat labeled boxes, they retailed at 50 to 70 cents per pound.

The seedling date trees in various parts of the Territory bore last year 40 to 200 pounds per tree. Those of a good quality sold for 25 cents a pound wholesale, at Phoenix. For some years yet, the principal part of the dates grown in the region will be on seedling trees.

To secure the setting of the fruit of date trees and to bring it to maturity, it is important that certain precautions be exercised. To begin with the winter season, trees should be permitted to remain without water and to keep as nearly dormant as possible during the coolest months, that they may be subjected to the danger of frost as little as possible. About the first of March irrigation may begin, water being applied copiously until the trees bloom. An abundance of water about the roots is said to stimulate blossoming. When they have put forth their cluster of blossoms, water should be withheld until the fruit has set.

In order to bring about the setting of the fruit, it is essential that the female blossoms be pollenated. Date trees, unlike most other fruit trees, bear the two essential parts of the flowers on different trees. Hence it is necessary either that pollen-bearing trees be grown near fruit-bearing trees, or that pollen be brought to the latter. Last year a large quantity of dates failed to fill out properly because of a want of information on this point, or because of the inability of the owners of the trees to secure pollen at the proper time. If pollen-bearing trees do not grow within 30 or 40 feet of fruit-bearing ones, it will be necessary to cut away clusters of the pollen-bearing flowers and hang them in the fruit-bearing trees. This must be done very soon after the female flowers appear, or it will be too late for fertilization to take place. If pollenated too late, the result often is the development of a few of the later-blossoming flowers, while the rest remain undeveloped and seedless It is not necessary to depend upon the pollen produced the same year that it is desired to pollenate the female blossoms, since pollen may be kept from year to year and dusted upon the clusters of female flowers at the proper time.

After having made sure that the female flowers have been adequately pollenated, the date trees will require little attention, except occasional watering, for several months. As the dates approach their full size, it is important that the trees be supplied with an abundance of water, it being impossible to give them too much water from the time the fruit begins to ripen until it is fully matured. A good way to insure a thorough soaking of the soil about the roots of the trees is to make a basin 15 to 25 feet in diameter, by excavating some of the soil and throwing up a circular ridge, and then to fill this basin with water about once a week.

As the dates begin to ripen, they will be devoured by various species of birds, the cactus-wren and the Gila woodpecker being the most destructive about Phoenix. In order to save their dates from these depredations, some have resorted to a procedure that has resulted in the wasting of much fruit—the removal of the clusters from the tree that they may be taken to a place of safety. Green dates once severed from the tree do not mature properly. In order that the tannic acid with which they are abundantly supplied may all change to the sugar that is so desirable and which causes them to be so delicious, it is necessary that an abundance of water reach the fruit. And this cannot take place if the bunches are removed from the tree, and thus cut off from their water supply. If the ends of the cut stems are placed in a vessel of water and the cluster treated as a bouquet, the unripe dates will wither more slowly and more of them will come to maturity. Or the clusters may be enclosed in an air-tight box, and loss of moisture from the fruit thus checked, the water in the large stem commonly being sufficient to enable the necessary chemical changes to take place. But in no case will the flavor be equal to that of those ripening naturally upon the tree.

A better way to save the fruit from the ravages of the birds is to cover the cluster with cheese-cloth. This can be easily and cheaply done by making sacks of the proper size, slipping one over each cluster, and tying the mouth securely about the stem, the leaves that might interfere with the work being first cut away. Besides preventing the depredations of birds, this cover keeps off bees and other insects, and catches the ripe fruit as it falls.

After being removed from the tree, dates require little treatment to preserve them. Most varieties contain sufficient sugar to keep them indefinitely. Those ripening during late summer and early autumn may usually be packed at once, the need being to prevent them becoming so dry that they cannot be eaten. If, however, they are placed in air-tight receptacles, they will often mould some. Those ripening during late autumn may need a little drying before being packed away.

The greatest drawback to the preservation of dates is the work of larvæ that hatch from moth eggs deposited upon the fruit before it is packed. In our experience, untreated fruit is always ruined within a few months by these insects. The best preventative we have found thus far is carbon bisulphide; but better methods of treatment will no doubt be developed as the industry becomes more important. To treat them with the bisulphide, they are placed in an air-tight box, a few ounces of the liquid poured into a dish sitting above the fruit, and a tight cover placed over all. In a few hours the cover may be removed and the gas permitted to escape, when the fruit will be ready to pack.

We still receive so many inquiries concerning the possibility of securing suckers from imported date trees, that it may be well to repeat what has already been stated in a previous bulletin—that there will be no suckers available from any American source for at least three or four years. The only source of these suckers at present is the date-growing regions of the Old World. The quickest way to secure dates at present is to plant seed. They may be planted at any time from now until next July, but will not germinate until warm weather comes. The seeds may be planted where the plants are to remain, or the latter may be transplanted when a year old. Although adult trees endure considerable alkali, the experience of the past year at the date palm orchard south of Tempe indicates that date seeds will not germinate freely in alkaline soil, and that young seedlings are injured by the presence of much alkali. A fairly good place to plant the trees is along ditch banks, although the supply of water cannot be controlled there. As has been stated in previous bulletins, there is no certainty as to what the character of the fruit of these seedlings will be. Like that of the seedlings of most other fruits, it is pretty sure to be inferior to that of the established varieties. Besides this uncertainty, a half of the seedlings are likely to be males. The only way to secure date trees of a definite sex, bearing fruit of a definite character, is by suckers.

A. J. McCLATCHIE.
Department of Agriculture and Horticulture

THE SPRING VEGETABLE GARDEN.

No. 27, FEBRUARY 1.

While there is no time of the year when it is not possible to have some vegetable or vegetables growing and furnishing something for the table in Southern Arizona, the spring is the season of the year when vegetables are grown most easily. Spring begins here during the latter part of January or during early February. During the first ten days of the latter month, more vegetables may be planted with a reasonable hope of a successful outcome, throughout most of Southern Arizona, than during any other ten days of the year. Those who contemplate growing their own vegetables should, if they have not already done so, begin work on the vegetable garden as soon after the receipt of this bulletin as practicable. The longer the work is delayed, the less chance there will be for success.

For the spring garden a warm situation and soil should be selected. If the latter is not already rich in decayed vegetable matter, a heavy dressing of well-rotted stable manure should be given. The manure should be turned under when the soil is as moist, from irrigation or from rain, as possible. After being thoroughly harrowed and, if clods are present, rolled, the soil will be ready for seeding.

The piece of land selected may be divided into sections, each being devoted to vegetables that should be sown at the same time and in similar manner. The sections may be situated end to end in the direction the irrigating water is to run, or they may be side by side. In either case, it will be well to leave between them space to walk upon when irrigating, cultivating, or gathering the vegetables. In deciding the direction in which the water is to run, the fact should be kept in mind that too much fall is as undesirable as too little. A slope of two to three inches to the hundred feet is about right for most vegetables.

Beets, carrots, lettuce, parsnips, peas, radishes, spinach and turnips should be sown as early in February as possible. During most winters in most parts of Southern Arizona seeds of several of these vegetables will germinate readily at this time of the year without irrigation if sown in moist soil. This is especially true of beets, parsnips and peas, the size of the seed making it possible to cover them sufficiently to prevent the soil drying out before germination occurs. Seed of these vegetables may be sown in level ground, and not furrowed for irrigation until the plants have attained a considerable size. This method may also be pursued with radishes, spinach and turnips, if the soil is fairly retentive of moisture and the weather not too warm and dry. In the case of the smaller seed, such as that of carrots and lettuce, it will be safer to provide an irrigating furrow before the seed is planted, and sow the latter along the margin of it. Water can then be run through the furrow and the soil about the seed thereby nourished. The radish and turnip seed should germinate within four to eight days; the beets, lettuce, peas and spinach in seven to twelve days; the carrots and parsnips in about two weeks, or a little more.

Of some of the above vegetables it is important that varieties adapted to the region be sown. Of beets, all varieties thrive here, the ones most commonly sown being the Blood Turnip and the Long Blood. Of carrots, Danver's Half-long, the Ox-heart and the Short-horn are the most popular. All varieties of lettuce will grow at this time of the year, but some are much more desirable than others. At the Experiment Station farm the Golden Queen has proven to be the earliest variety. The standard heading varieties, the most desirable ones to grow, are Hansen, Wonderful, and Henderson's New York. In most sections only early varieties of peas should be sown at this time of the year. The most satisfactory varieties are the American Wonder and Little Gem. Where the hot weather does not come for three or four months, the later varieties, such as Yorkshire Hero, Horsford's Market Garden and Stratagem may be sown. The French Breakfast and the Scarlet Turnip are among the earliest varieties of radishes. Of spinach, the Prickly seeded and the Long-standing are good varieties. All varieties of turnips are successfully grown here.

Potatoes should also be planted as early in February as possible. The more growth they are permitted to make before the hot weather of early summer, the heavier the yield will be. They should be planted in soil as moist as possible, in just the same manner as they are where irrigation is not practiced. We have found the best method to be to open furrows, four to six inches deep, drop the seed promptly and throw the soil back again with the same turning plow, before the soil has had time to dry. The field is then harrowed level, and given no further attention until the young potatoes show the need of water, or weeds appear. We have found the most profitable distance to be about one foot in the rows, with the rows about thirty inches apart. The Early Rose is the most suitable variety for this region, of which the seed is available.

If good cabbage and cauliflower plants have been grown or are available, early varieties, such as Early Jersey Wakefield, Winningstadt, and All Seasons cabbages and Burpees Best Early cauliflower may be set out. Late varieties will not mature from spring setting.

Tomato seed may be planted outdoors in all the warmer parts of Arizona during early February. We have found the most satisfactory method to be to plant the seed in hills where the plants are to remain. Furrows are run about four feet apart and the seed planted along their margin in hills three to four feet apart. If the soil is kept moist by running water through the furrows, the young plants will appear in about two weeks and will endure all the frosts that commonly occur. Tomato plants grown this way produce fruit earlier and more abundantly than if grown in beds or boxes and transplanted. The Dwarf Champion is the most satisfactory variety to grow in Southern Arizona.

During February corn and summer squashes may also be planted. Each is planted along furrows, the former three to four feet apart each way and the latter four to six. Adams Early and Adams Extra Early are the most satisfactory varieties of corn to grow. The common Mexican variety is productive. None of the varieties of sweet-corn or field-corn yield satisfactorily if planted at this season of the year.

During March beans, cucumbers and melons may be planted in the warmer parts of Arizona, as also a second sowing of beets and radishes. None of the standard varieties of string-beans are easily grown in the warmer valleys of Arizona. The easiest one to grow is the common Mexican pink bean. The small early Lima beans will also produce fairly well, and may be sown even earlier than March. Of cucumbers the Long Green and the White Spine are among the most satisfactory varieties. All varieties of melons thrive here, earliness and quality being the most important considerations. The Augusta and the Florida, Favorite and Fordhook First are good, early varieties of watermelons. Other desirable varieties are Georgia Rattlesnake, Sweet Heart, and Kleckley Sweets. Of muskmelons the Rockyford is the most popular.

With a fair amount of care, the spring vegetable garden may be made to produce something for the table from early April until after the Fourth of July. But if it is to do this, it must be given immediate attention.

Seed may be procured of the Texas Seed and Floral Company, Dallas, Tex., and of the Germain Fruit Company, Los Angeles, Cal.

A. J. MCCLATCHIE,
Department of Agriculture and Horticulture.

SOME TREES AND PLANTS FOR BARREN PLACES.

NO. 28, FEBRUARY 15.

It is often a perplexing matter to beautify a Southern Arizona home with its appropriate setting of green. The wide daily and yearly range of temperature makes the number of available trees and plants much less than in the more even climate of Southern California; while the aridity of the air and the scarcity of water makes drouth-resisting forms to be preferred.

The experience of several years past on the University grounds has shown some things especially suitable for an arid mesa underlaid with the limy hardpan commonly known as caliche.

Trees. Among trees, the pepper stands not far from first for such a situation, being a graceful evergreen, a rapid grower, and thriving on relatively little water. This tree, sweeping the ground with its lower branches, may serve admirably as a screen, but may also be trimmed up into a taller and more shapely form. The Arizona ash is a slow grower, but never sulks; prospering when water is abundant, maintaining life and waiting for its opportunity when water is scarce. The Bagote, a species of Palo Verde, is an attractive oddity, evergreen, graceful and covered with a wealth of yellow blossoms for three weeks in the spring. One tree on the University grounds has thriven for three years past without irrigation, but is slightly damaged by our coldest winter weather, say 20 degrees F. The date palm is highly ornamental and when well watered takes strong hold on rocky soils. When ornament alone is considered, however, *Phœnix canariensis*, closely resembling the date palm, is perhaps preferable. It is a more vigorous grower and does not put forth the troublesome growth of suckers which must be removed from the date. The native cottonwood, too, though it has its enemies, is an excellent thing to plant—next year. This year you should watch the trees in your neighborhood and mark the males—those which produce pollen-bearing blossoms and no cotton. Switches from this source will produce clean trees free from the annoying nuisance of cotton. Perhaps the handsomest trees on the University grounds are three cottonwoods, about nine years old, but 50 feet high and with trunks 16 to 20 inches in diameter. All of these trees will force sufficient root room for themselves in caliche, if properly irrigated.

The olive, the umbrella tree and the Washingtonia palm are less hardy in the hardpan soil of our location, being occasionally subject to a destructive root rot where, apparently, the health of the tree is impaired by adverse conditions. In most cases, it is desirable to prepare root room in a hardpan soil by blasting, as a growing tree will otherwise soon become cramped for room. When caliche is found within two or three feet, it is well to drill three or four feet further and shake things up with a stick of No. 2 Giant on top of a large handful of black powder.

Hedges. The pomegranate takes vigorous hold of rocky ground, as does also the California privet *(Ligustrum japonicum)* but both require attention with regard to water in the hot season. The privet is especially beautiful for this purpose, evergreen, vigorous and easily and cheaply propagated by cuttings from the established plants.

Vines. On a south exposure the trumpet creeper thrives, yielding a mass of green foliage and orange-red blossoms in summer, but rather bare and unsightly in winter. The Virginia creeper will also endure our summers, but its near relative, *Ampelopsis Veitchii*, is a handsomer and cleaner vine with an ivy-like leaf. *Ampelopsis Veitchii* does best in shady places. The honeysuckle *(Lonicera japonica)* also thrives on south exposures, as does the English ivy in sheltered places, but the latter is perhaps less adapted to this climate even when protected from the heat.

Lawn plants. Bermuda grass, perhaps, heads the list as a summer-grower and drouth-resister. Its harsh texture, and the difficulty of killing it, however, do not make it many friends. Alfalfa makes a beautiful summer-green, stands prolonged drouth when once established and will force its roots deeply into hardpan soil, thus preparing them for subsequent planting. "Sour" clover (yellow sweet-clover, bitter melilot) fulfills the same purpose, but grows in winter. A very promising plant for lawns in this section is *Lippia repens*, a near relative of heliotrope and verbena. This plant is a rapid grower, matting closely to the ground and spreading like a strawberry plant, striking root from the joints as it runs. It is evergreen, full of bloom in summer, is a drouth-resister, prospers best in the hottest places, and stands the frosts of this locality fairly well. The lawn of the future, however, is doubtless to be composed of native grasses. In the most interesting struggle for existence between two or three score grasses and clovers on the University lawns, the natives are making an excellent showing, being decisively conquered by Bermuda only,—but more of this, perhaps, another year.

Where water is scarce or costly, or where a home is abandoned during the hot summer season, a selection of drouth-resisters may be made which will beautify barren surroundings with minimum cost and care. The pepper tree, the Arizona ash, and the Bagote; the native *Larrea* or creosote bush, agaves and yuccas; native grapes and honeysuckles; native grasses, and possibly, also, *Lippia repens* for lawns, is a selection which will go far in the reclamation of barren surroundings.

But beware of the traveling agent who wishes to sell you an ornamental foreign tree that "will grow without water." The chances are against the purchaser, and such selections can be made far more safely from native trees.

A few more seeds of the Bagote may be obtained of the Experiment Station, and Dr. F. Franceschi of Santa Barbara, Cal., has *Lippia repens* and other plants and vines suitable for Southern Arizona.

R. H. FORBES,
Director.

THE USE OF HAND SEPARATORS ON THE FARM.

NO. 29, MARCH 15.

Climatic conditions over the greater part of Arizona practically necessitate the use of the cream separator where home dairying is practiced; the best of care is required to get milk to the creamery in good condition, while the conditions necessary to a satisfactory separation of the cream from the milk by setting are practically unattainable.

The writer has found that in certain localities in another state where well water at a temperature of 50 degrees is available for the deep setting of milk, the average loss of butter fat in the skim milk is about one per cent, or from one-fifth to one-third of the total fat. This loss of one pound of butter fat in every hundred pounds of skim milk in a herd of five cows, each giving 4000 pounds of milk, would in a year amount to fifty dollars.

Even where butter is made at the factory, the use of a separator on the farm is of a distinct advantage to the farmer. Instead of having the whole volume of milk to cool down for delivery to the creamery, only the cream, amounting to ten or fifteen per cent of the whole milk, demands that attention; the skim milk, still warm from the cow, is in the best of condition for feeding to young stock, both morning and evening; and, at the usual rate of ten cents per hundred pounds for hauling to the factory, the farmer with the herd of five cows would pay out during the year $3.00 for hauling cream, instead of $20.00 for hauling milk.

The best hand separators on the market, properly operated, should leave not more than one-tenth of one per cent of butter fat in the skim milk. Every additional tenth of a per cent means one pound of butter fat in a thousand pounds of skim milk, or about $5.00 per year in our herd of five cows. The best separator is the cheapest, and a poor one is expensive at any price.

In using a separator the directions accompanying the same should be carefully followed. When setting up the machine it should always be borne in mind that it must be *level* on a *solid* foundation. In operating, three points should be given most careful attention—the temperature of the milk, the rate at which the milk is fed to the machine, and the speed of the separator bowl.

Milk is in the best possible condition for separation when fresh from the cow; it should not be allowed to cool down below 85 degrees.

Skim milk should be tested to ascertain whether the machine is skimming clean or not when fed at a given rate. Never guess at the speed, but count the revolutions of the crank and know. When directed to give 45 to 50 turns per minute it is safe and best to give 50 turns.

Do not neglect to fill the bowl with water before starting, as, in all cases, it may be gotten up to speed with less vibration when this is done, and in some cases it prevents much cream from sticking to the inside parts.

One should never try to regulate the thickness of the cream by the rate of turning—there is a cream screw for that purpose.

Sample No. 24 below is an illustration of what may be expected where thin cream is gotten by slow turning.

The following table will give the reader an idea of the success with which hand separators are used upon the farms in the Salt River valley. This is not supposed to show what the different machines are capable of doing under the best conditions, but what they are actually doing at every day work in the hands of farmers. While the skim milk was tested by the writer, in every case the samples were taken by the farmers themselves and each sample tested was composed of skim milk from a number of different skimmings :

Sample	*Kind of Separator*	*Per cent of fat in skim milk*
1	De Laval	.05
2	United States	.06
3	Kneeland Omega	.06
4	De Laval No. 3	.07
5	De Laval No. 1	.08
6	De Laval No. 3	.08
7	De Laval No. 2	.10
8	United States	.11
9	De Laval	.11
10	De Laval	.12
11	De Laval No. 3	.12
12	United States No. 5	.14
13	United States No. 5 (improved)	.14
14	De Laval No. 3	.15
15	De Laval	.20
16	United States (improved)	.24
17	United States No. 5	.30
18	Kneeland Omega	.32
19	United States	.42
20	Kneeland Omega	.44
21	De Laval No. 3	.46
22	American	.68
23	De Laval	.96
24	De Laval No. 3	1.20

The writer was unable to learn that more than one of the owners of separators had taken the trouble to test the skim milk, though some were in the habit of setting it to see if any cream would rise. That this is not a sufficiently accurate method of testing skim milk is shown by the fact that samples contained as high as three-tenths of one per cent of butter fat where the owners were unable to get any trace of cream upon the milk when allowed to stand.

As stated above, this should not in any sense be taken as a report of results of a test of the different makes of separators The results given show this: That close skimming can be done with hand separators when properly operated; that excessive losses result from careless handling; and that every owner of a hand separator should run a Babcock tester and test the milk from his separator as well as from his cows.

GORDON H. TRUE,
Department of Animal Husbandry.

WELL WATERS FOR IRRIGATION.

NO. 30, APRIL 1.

As the number of artesian wells, and those from which water is pumped for irrigation, increases, interested inquiry is made as to the probable effects of these waters upon the soils to which they are applied.

In answering questions of this nature for irrigating waters in this region, three factors must be considered: 1, the silt which they carry; 2, the various soluble "alkaline" salts; 3, soluble plant foods, especially nitrates.

Silt is, of course, absent in all well waters. In river waters this material, containing organic matter and mineral plant foods, is of great value to the lands upon which it is applied. The deficiency of silt in well waters, however, is not without advantage, since these waters are more uniformly wholesome for stock and dairy purposes, the offensive character of river waters at flood time being a matter of common observation.

Alkaline salts in solution vary greatly in amount in different localities. In irrigated districts, well waters are usually heavily charged with salts, originally contained in solution in irrigating water or leached from the soil, and carried down to ground water level by drainage. In Salt River valley, the average for thirty-six wells, from fifteen to 146 feet deep, was 169 parts of soluble salts in 100,000 parts of water. In some instances these solubles were in part composed of carbonate of soda, or "black alkali," but for the most part chiefly consisted of chloride and sulphate of soda. Wells drawing their supply from the underflow of mountain washes are, on the other hand, of far purer character. A sample from the underflow of Agua Fria contained but 30 parts of salts in 100,000 of water; while the University well near Tucson, probably fed by the drainage from the mountains to the eastward, contains only 26 parts.

The artesian waters of Southern Arizona form a class by themselves, being uniformly more or less black alkaline, but varying widely in the amount of salts in solution.

The following is a statement of analyses of the least and the most saline artesian waters thus far examined :

		Parts in 100,000	
	Total soluble solids	*Common salt*	*Carbonate of soda*
1	16	1.1	7.5
2	212	130	7.2

The amounts of the various soluble compounds proving injurious to crops depends upon the nature of the compound, the kind of soil, and the crop grown. Of the common soluble compounds, carbonate of soda is most injurious, common salt next, and sulphate of soda least.

Speaking of barley, Dr. Hilgard of the California Station, states that, while a full crop was obtained on land containing 25,440 pounds of soluble salts per acre in the surface four feet, it refused to grow in soil containing 32,480 pounds. The same author also remarks that leguminous plants (clovers, beans, etc.), crucifers (mustard, kale, etc.), and citrus trees are more sensitive to alkali than barley. On the other hand, Bermuda and certain salt grasses, the salt bushes, pomegranate and pear, the date palm, and certain root crops (including sugar beets), will thrive in soils containing much greater quantities of salts than barley will tolerate.

Now, reckoning on three acre-feet of water a year for mixed farming, at least which is necessary in Southern Arizona, a supply containing 100 parts by weight of soluble salts per 100,000 parts of water, would carry on to the land 8167 pounds of salts per acre in one year.

Comparing this amount with the injurious quantities mentioned above, it is evident that in a very few years such a water would bring harmful amounts of alkali upon the soil, provided

Fig. 6. Typical artesian well 6 miles southwest of Pima, Arizona.

that they all remained. This depends largely on the character of the soil. A light, sandy soil, well drained, will retain but a portion of the alkali from the irrigating water; but a dense adobe, holding a large amount of water, bringing water by capillary action from greater depths to the surface where it is evaporated, and draining with difficulty, accumulates much larger quantities of salts. With waters of stated composition, and soils of a certain character, therefore, a rough judgment may be formed as to the probable future of a certain district. Speaking for California, Dr. Hilgard says that "when . . . . a large proportion of the solids consists of carbonate of soda or of common salt, even a smaller proportion of salts than 40 grains per gallon (=68 parts per 100,000), might preclude its *regular* use, depending upon the nature of the soil to be irrigated."

Nitrogen in the well waters of this region may also augment their value for irrigation, this important plant food being commonly deficient in our soils.

In irrigated districts, well waters nearly always contain appreciable amounts of nitrogen apparently derived from the seepage from irrigating water, which contains important quantities of the compounds of this element, derived from decaying animal and vegetable matter.

Thirty-six wells of Salt River valley averaged 1.24 parts per 100,000 of sodium nitrate, which is 16.35 pounds of nitrogen in three acre feet of water,—a significant amount when it is remembered that 50 bushels of wheat require not far from 59 pounds of nitrogen from the soil.

But in some cases well waters are nearly or quite free from nitrogen, and this fact, in connection with the lack of nitrogen in our desert soils, must make it necessary to supply this ingredient to lands irrigated from such supplies. In farming operations this is done by means of alfalfa and other crop plants of the clover tribe, which gather nitrogen from the air, and thus supply the deficiency. For gardens and house grounds irrigated by means of windmills, horse-power pumps, etc., the manure pit is a most excellent device. This is an excavation of convenient area and depth, into which compost materials are thrown as they come to hand. In the University barn lot a pit 10x12 and 3 feet deep receives the manure from two or more horses, leaves, rubbish, and occasional unfortunate cats and dogs,—all of which are in time reduced to rich compost most useful in our tree holes and gardens.

This is certainly a neater and more profitable method of disposal than to laboriously haul off and throw away, or leave an unsightly pile of offensive rubbish exposed where the sun and rain will dry it out or leach it of its valuable properties.

In greenhouse work, or for the fertilization of citrus and other valuable trees, commercial fertilizers containing nitrogen may be used, such as Chile saltpeter, tankage, etc. But it would be wise to make use of the waste from the farm before purchasing expensive fertilizers for these purposes.

R. H. FORBES,
Department of Chemistry.

HOME-MADE FERTILIZERS.

NO. 31, APRIL 15.

It has been well said that "a thrifty farmer may be judged by the size of his manure pile." This should be modified, however, for quality as well as quantity should be taken into consideration. How often do we hear the statement made by farmers that "I applied a certain number of loads of barnyard manure per acre to my field," which means very little indeed unless the quality of the manure applied is taken into consideration. I have seen barnyard stuff put upon land when it was not worth the labor of hauling, owing to the fact that nearly all of the plant food which it originally contained had been allowed, by improper care, to escape. This, naturally, leads to the question of the losses to which manure is subject. Barnyard manure is a very complex substance and undergoes very rapid changes, by which much of its value may be lost if it is not properly cared for. Loss is due to two chief causes. First, fermentation, of which there are two kinds, one of which, for its growth, requires an abundant supply of air, while the other grows without air and will die when exposed to it. The first of these ferments is the most active and destructive.

The second source of loss is by leaching or weathering. The leaching, of course, is not the serious problem in Arizona that it is in the more humid regions; yet serious loss of soluble plant food may occasionally occur in this way. It is necessary, however, that the manure be kept in a fairly moist condition; the destructive fermentation spoken of above is thereby held in check, while the coarse stuff, as straw, etc., is decomposed, and the plant food which it contains made more available.

To demonstrate that this loss does occur, a few experiments were conducted with this end in view. A sample of horse manure was thoroughly moistened with water, then allowed to drain over night and samples analyzed, both before and after treatment. It was found that, with an almost minimum amount of leaching, the loss in total nitrogen was about 5 per cent,—a small figure in itself, but when applied to a pile of manure representing tons, and a proportionally larger amount of water, the result is significant. Another lot of barnyard manure was divided into portions and one part exposed to the sun in July, 1900. A second part was loosely placed in a covered barrel and kept under a shed, protected from sun and rain, but with free access of air. These samples were left undisturbed until March, 1901, at which time an analysis showed that 22 per cent and 27.7 per cent, respectively, of the total nitrogen had been lost.

So much then for the loss, the question being, how to prevent it. The means of doing so are comparitively simple, the method of application, however, depending largely upon circumstances. It is very true that the Arizona small farmer can not afford any great outlay, while on the large dairy farms of the East they deem it of sufficient importance to build special buildings for keeping and preserving manure. Probably the very best plan for this region is that of placing the manure in pits. The method has several advantages. It is cheap; and the pit can be made of such size as the number of animals demand, yet readily enlarged to accommodate circumstances. It can be so arranged that it is a comparatively easy matter to get water upon the contents, which, as before mentioned, is necessary, although an excess of water is to be avoided. The pit, as it is gradually filled, can be more or less protected by boards, or even a covering of straw will prevent the contents drying out too rapidly. Such a a pit has been dug in the stable yard at the University and serves an admirable purpose.

Another source of plant food frequently allowed to go to waste is bones and slaughter-house refuse, a certain amount of which collects around every farm, and when properly prepared is a most excellent fertilizer, much sought after by eastern farmers and orchardists. Such a product is valuable for its high percentage of phosphoric acid and nitrogen, and is worth in the eastern market from $25.00 to $35.00 per ton. This waste matter should be collected and kept until sufficient quantity has accumulated to make the handling practicable. For this purpose, also, a covered pit is a cheap and easy means of storing it. In order that the plant food in these materials may be easily available, it is necessary that it be either decomposed or reduced to a very fine condition. This may be accomplished in several ways. Treatment with acid, or grinding, are the two methods employed by manufacturers of fertilizers. The acid treatment is impracticable on the farm, but where the supply of material is sufficient to warrant it, the grinding is not. Mills for such a purpose may be found advertised in agricultural journals; and even though coarsely ground, bones then more readily yield their nitrogen and phosphoric acid to the orchard trees or valuable crop plants to which they may be applied.

Another way of decomposing bones is by means of unleached wood ashes. This method, however, is to be advised against, owing to the fact that the ashes contain a high percentage of carbonate of potash, very similar to the "black alkali," whose injurious effects are too well known to need further comment.

The Station has from time to time received considerable correspondence in regard to the fertilizing of orange trees, which indicates the need of more concentrated fertilizing materials in the citrus orchards of Southern Arizona. Our arid region soils are deficient in nitrogen and organic matter, but rich in potash. This deficiency has frequently been made apparent by the condition of the trees, the yellow color of the leaves, or "frenching," probably indicating lack of nitrogen.

In applying fertilizing materials, therefore, it should be the aim to supply these deficient elements of plant food. Field observation also warrants the above belief; for, where green-manuring has been practiced, as well as where some good nitrogenous and phosphatic fertilizer has been used, the improvement in fruit, foliage and trees has been very marked. Ground green bones and tankage, supplemented if need be with a little potash, make a very desirable fertilizer for this purpose. A fertilizer of about the composition given below has frequently been advised by the

Station for fertilizing orange orchards, and is believed to be in every way suited to the purpose. It should be applied at the rate of from 500 to 1500 pounds to the acre, according to age of trees and quality of soil, and "plowed in deeply at the edge of the branches, about the beginning of the growing season."

Formula.

6 per cent nitrogen, from organic material,
1 per cent nitrogen, from nitrate of soda,
1½ per cent potash, from sulphate of potash,
6½ per cent available phosphoric acid,—

which in certain cases can be compounded with economy by the farmer himself from the following materials:

1000 pounds 10 per cent bone tankage,
140 pounds nitrate of soda,
60 pounds sulphate of potash,
800 pounds dissolved bone (16 per cent available phosphoric acid).

A home-made fertilizer resembling this in composition would result from the accumulation of bones, carcasses and slaughter-house refuse, dried, worked up and preserved, as suggested, and would result in saving at least a part of the expense of chemical fertilizers.

W. W. SKINNER,
Assistant Chemist.

WILD BARLEY.

No. 32, MAY 15.

There is now maturing in Southern Arizona the seed of a grass that should be destroyed as promptly and as thoroughly as practicable. It is known in this region most commonly as "fox-tail." There are about a dozen grasses in the United States known as foxtails, but the one called by this name in Arizona is not so called in many of the other parts of the world to which it has spread from Europe, the place of its origin. It belongs to the same genus as our common cultivated barley, and is simply a wild barley. Cultivated barley was called *hordeum* by the Romans, and is now known among botanists as *Hordeum hexastichon*, which is simply the Latin for "sixrowed barley." The botanical name of the troublesome weed is *Hordeum murinum*, the Latin for "wall barley." Since we call the corresponding species of oats "wild oats," this weed is very properly called "wild barley."

But whatever its correct common name, or whatever it is to be called, it is certainly a very troublesome pest. It is by far the most noxious weed of the Salt River valley, the writer receiving more inquiries concerning it than concerning all other weeds combined. The inquiries have been especially numerous during the past year, indicating that the weed is becoming more common and troublesome. The fact also that Professor Toumey in Bulletin 22, "Something About Weeds," issued only a little over four years ago, does not mention this one, indicates its recent introduction, or at least that it has only recently become troublesome. It is now the most widely spread and most common winter and spring weed of at least the Salt River valley. It is everywhere, along roads, fences and ditches, and in fields.

Wild barley is an annual that grows from seed just as cultivated barley does. It starts to grow in the fall or early winter, at about the same time that barley is commonly sown, and matures in the spring or early summer, as does cultivated barley. Like the latter, it grows readily with alfalfa during winter, making the most of its growth while the weather is too cool for alfalfa to grow rapidly. It is in alfalfa meadows and pastures that it is the most troublesome. When young it is eaten quite freely by cattle, but as it approaches maturity, it is avoided by them, and thus gets an opportunity to produce seed. Even when grazed quite closely, it manages to produce short-stemmed heads that cattle avoid. The reason it is allowed to mature seed in pastures, as cultivated barley would not be, is that the grain is very small and the beards very rigid and very irritating to the mouths of stock. Consequently the wild barley succeeds in producing a good crop of seed with which to sow the ground for the coming season.

Not only does the wild barley have the objectionable beards of the common cultivated barley, but its heads break up into

Fig. 7. Wild Barley, *Hordeum Murinum*, ⅓ size.

short sections with sharp piercing points that work into the lining of the mouth and other parts of the digestive tract of animals. This causes this pest to be very objectionable in alfalfa meadows, where it approaches maturity just in time to be cut with the first crop of hay. Its presence in alfalfa hay causes an annual loss of thousands of dollars to the farmers of the Salt River valley. A combined effort that would destroy the pest, or so reduce its numbers that it would no longer infest meadows and pastures, would be worth a large sum to Arizona.

To eradicate this weed will be no easy task, but much can be done to check its spread and to decrease its prevalence. If all the wild barley seed that is maturing this month were destroyed, there would be much less of it next season. It would be impracticable to destroy it all, but much of that growing along roads, fences and ditches can be cut and burned. This is what every farmer in Arizona should do. It will be useless to attempt to eradicate it from fields, if that which grows elsewhere is permitted to mature and seed the fields. The heads, as has been stated, break up into short sections that cling to animals, to clothing, or are carried along by wind or irrigating water. To prevent this distribution of seed, it would pay a farmer to destroy the wild barley growing along fences and ditches of his neighbors, if the latter failed to do so. Every farmer should at least see that the public roads adjacent to his lands are cleared at once of the seed now maturing.

While seed destruction should be the present procedure, the prevention of seed formation should be the aim during the coming season. Plants are more easily destroyed when small than at any time late in their development. As this grass is the principal one that makes its appearance along fences and in other waste places during fall and winter, all young grass should be destroyed as rapidly as it appears, with whatever implement will best accomplish the desired result. In alfalfa fields the disc harrow is the best implement for the destruction of the grass when young. Running this implement over pastures and meadows one to three times during the winter does much to destroy the wild barley, and benefits rather than injures the alfalfa.

A. J. McCLATCHIE,

Department of Agriculture and Horticulture.

THE AUSTRALIAN SALTBUSH IN ARIZONA.

No. 33, JUNE 1.

The saltbushes of Australia are very numerous as would be expected from the alkaline and arid conditions which prevail over large areas of that island continent. Many of them have been introduced into this country, and have been received with varying degrees of favor in the several arid sections of the western United States. However, only one (*Atriplex semibaccata*) has been universally appreciated. For this reason one is allowed to speak of this plant as *the* Australian saltbush.

Although spoken of as a "bush," it forms under favorable conditions for its development, large quantities of quite succulent forage which is readily eaten by either horses, cattle or sheep. It is much less woody than the common "sages" of Southern Arizona, to which it is closely related; and furnishes a much larger as well as a much more succulent growth. Like them it is a perennial and therefore does not require reseeding except at long intervals, unless it be pastured too closely. At the same time, it produces an abundant supply of seed that germinates readily in this region at any time of the year when there is sufficient moisture and in any but our coldest weather. One plant has been known to produce a "bush" one to two feet high and three to five feet in diameter in a single year. When it first appears above ground, it has two small elongated leaves at the extremity of a short stem which is often tinged with red. In this stage it closely resembles the troublesome pigweeds to which it is not distantly related. But it may soon be distinguished from these by the subsequent leaves, which are somewhat oval in outline and have sparsely toothed margins, as well as by the red pulpy fruit which is abundantly produced from August to December. The accompanying illustration will give an excellent idea of the habit of the plant.

The experiments which have been conducted with this plant in this Territory are quite encouraging, and at least warrant further investigations. On the University campus at Tucson, where the caliche comes within 12 to 18 inches of the surface of the ground, it has made quite a respectable growth during the past year without artificial watering. The conditions here give it rather a severe test, for it thrives best, according to all reports, in a deep loamy soil. It is highly recommended for ditch banks where the soil washes badly, as its prostrate stems growing in a thick mat on the ground interfere quite effectually with the erosive action of water.

Mr. J. T. Hildreth, of Safford, Arizona, has had remarkable success in growing this plant. In a recent letter in answer to an

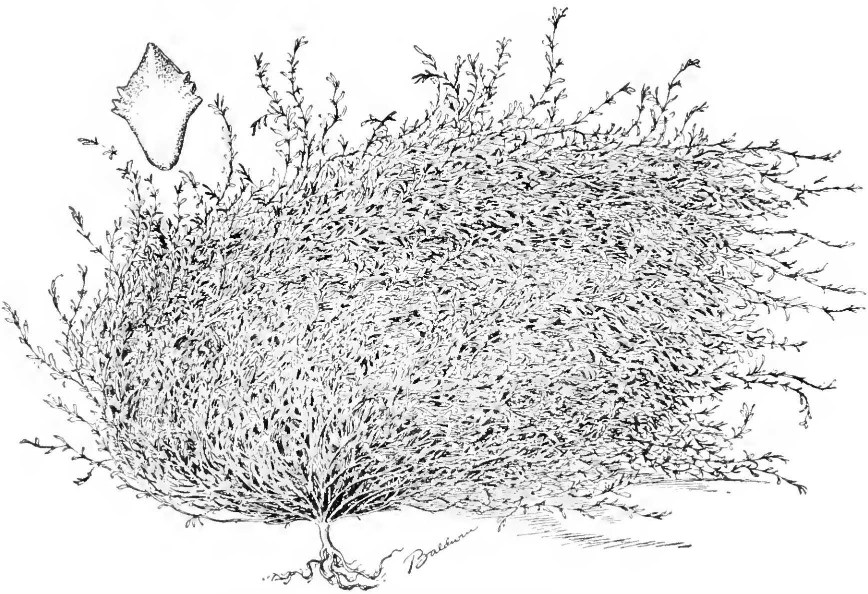


Fig. 8. Australian saltbush, *Atriplex semibaccata.*
Bull. 108, U. S. Department of Agriculture, Division of Agrostology.

inquiry, he expresses the belief that it is far superior to anything yet introduced in his locality for the improvement of the range. He has already seeded nine acres and will put in considerable more the coming season.

This Station planted a little less than an acre in January. This is now up and looking well. Of course these experiments are simply indicative, and by no means prove that this plant will be a valuable one in this Territory. They are, however, encouraging, and suggest that the rancher may improve his native range by a judicious introduction of this dry land saltbush.

In view of the necessity of finding some crop which will produce winter and spring feed, it has been thought wise to offer the ranchers and farmers an opportunity to determine for themselves what this plant will do in their immediate vicinity. We now have reason to believe from Mr. Hildreth's experiments and our own that the plant will be a valuable one for the vicinity of Safford, but it is well known that the conditions in the Territory are very diverse, and it will be necessary to test the matter in many localities before any extended recommendation can be made. The Station can test the matter only to a limited extent, and is doing so now in eight localities in Southern Arizona; but a plant of such promise should be further investigated.

This Station is able to offer seed of *Atriplex semibaccata* to all who apply for it. No attempt will be made to furnish any individual with enough seed to make any great quantity of pasturage. On the contrary, we will furnish such a quantity as will enable the rancher to determine the value of the plant for his particular locality, and, if he chooses, after a year's observation, he can collect his own seed. About one-fourth of a pound, or enough to seed one-fourth of an acre, will be distributed to each individual who applies.

It is recommended that the seed be sown during the summer rains. It should be covered very lightly with a fine tooth harrow or if preferred it can be dropped in hills and pressed into the soft earth by pressure of the foot. In any case care should be exercised not to cover it too deeply.

DAVID GRIFFITHS,
Department of Botany.

MILLETS.

NO. 34, JULY 1.

The number of inquiries received concerning the culture of millet indicates considerable interest in this forage crop. While there is probably no section of the Territory where it should be made a primary crop, yet as a catch crop or a supplementary crop it has a place in Arizona agriculture. A crop may be secured in so short a time after seeding, that a farmer may often utilize a piece of land that might otherwise grow up to weeds, and supplement his supply of forage without interfering much with the growing of the regular staple crops.

There are a great many varieties of millet grown in the United States, each possessing certain merits. Some are better adapted to dry regions than others, and some will make a crop on land too poor for other varieties. These varieties may be arranged into three groups: Foxtail millets, Barnyard millets, and Broomcorn millets. The most of those grown in the United States belong to the first group, characterized by having compact, bristly, foxtail-like heads. To this group belongs Common Millet, German Millet, Golden Wonder Millet, and Hungarian Millet. The Barnyard millets have branched heads and are closely related to the grasses that grow in summer along irrigating ditches and in other moist places, and known in Southern Arizona as "water grasses." To this group belongs the "Ankee" grass of the southwest, Shama Millet or Jungle Rise, and Sanwa Millet. The second variety is simply a cultivated form of the grass with leaves banded with purple stripes that grows so luxuriantly along Arizona ditch banks during warm weather. The Broomcorn millets have bushy heads, resembling more or less those of broomcorn. The seeds of this group are white, yellow or red. The varieties are numerous, the best known in the southwest being the Manitoba, California Beauty, French, Turkish and Hog Millet.

Millets are grown for two purposes; for forage and for the seed. The forage is fed to both cattle and horses, but principally to the former. The seed is used for both human food and food for stock. The use of the seed for human food is confined to the Old World, almost exclusively. For seed for stock feed the Broomcorn millets are the principal ones grown in this country.

The Foxtail millets are the ones grown most extensively in this country, and of this group, the one most generally grown in Arizona is German Millet. These millets not only endure excessive heat and bright sunshine, but will make a crop with less water than others. The Common millet is the hardiest of the group, and endures drouth the best. German Millet gives a heavy yield under favorable conditions, but requires more water. The hay is coarser than that of Common Millet. The Hungarian Millet does not endure drouth as well as Common Millet, but under most favorable conditions usually gives a heavier yield. For a crop of seed the Golden Wonder Millet is the best of the Foxtail millets, the forage being coarse. This variety endures less drouth than any of the Foxtail varieties mentioned.

Millets prefer a rich, mellow, loamy soil, thriving in neither heavy clay or adobe soil, nor in a light, sandy soil. While it is better to prepare the soil well, millet may be sown on quite rough land. Where the soil is not too compact or the surface covered with too rank a growth of weeds, it may be simply "disked" in. This method is especially applicable to stubble land, after the grain is off.

Millet is a warm weather plant, thriving in heat and sensitive to cold. In Southern Arizona it may be sown any time from the first of May to the end of September. While it may be sown early in the summer, it is not usually advisable to do so, as the month of June is apt to be very trying on it, irrigating water commonly being short as well as the air dry. The most favorable time is during July and August, the exact date advisable depending on the weather, the water supply, and local conditions. The time that the forage is desired may also be a factor in deciding upon the time to sow. The varieties vary considerably as to the length of time required for growth, but the average time is about two months. As it is quite sensible to frost, it must be sown early enough to reach the stage desired before there is danger of freezing. Thirty to forty pounds of seed of the Foxtail or Broomcorn millets is the usual amount sown per acre, and fifteen to thirty pounds per acre of the Barnyard varieties. Rich, well prepared land requires less seed than poor or rough land. Sowing too little seed is likely to result in coarse-stalked hay. Most varieties of millet enjoy plenty of water, hence there is little danger of irrigating the crop too heavily during July, August or September.

Millet should be cut before the seed begins to ripen, especially if it is intended for horses. But it should not be cut too green, as the hay is liable to have a somewhat laxative effect upon stock. Less harm results, however, from cutting it too green than cutting it too ripe. The best time to cut it is considered to be when the majority of the heads have distinctly appeared. It should not be permitted to become entirely dry in the swath, but should be raked when partially dry, and allowed to cure in cocks.

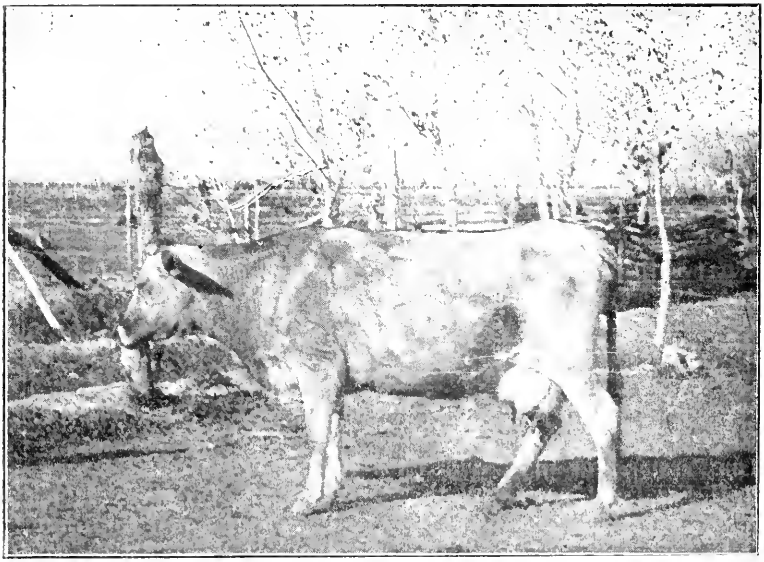
Instead of cutting the millet, it may be pastured within a month or so after being sown. Varieties that make second growth from the roots, such as Common Millet and Hungarian Millet, are best suited for pasturing. Poor alfalfa pastures may be much improved during the hot weather of summer by "disking" in millet seed, where the supply of irrigating water makes it possible.

A. J. McCLATCHIE,
Department of Agriculture and Horticulture.

University of Arizona

Agricultural Experiment Station.

Bulletin No. 39.



Cow No. 1. Record 7945 Pounds of Milk. 352 Pounds of Butter Fat

Dairy Herd Records.

BY GORDON H. TRUE.

Tucson, Arizona, August 20, 1901.

UNIVERSITY OF ARIZONA

AGRICULTURAL EXPERIMENT STATION

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The Bulletins of the Station are sent to all residents of Arizona applying for them.

Address,

THE EXPERIMENT STATION,

Tucson, Arizona.

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DAIRY HERD RECORDS.

By Gordon H. True.

INTRODUCTION.

ARIZONA AS A MARKET FOR DAIRY PRODUCTS.

Among the agricultural pursuits of Arizona the dairy industry is one of much importance. The home market for agricultural products, including those of the dairy, will always be good. It is generally estimated that less than half of the butter and cheese consumed in the Territory is of home production, and, with an already great mining industry increasing from year to year, and with agriculture limited by the meager rainfall upon which it must depend for its necessary irrigation water, this must always be the case.

With a good market for his product assured, the dairyman will find that his profits depend largely upon certain conditions, all of which are in part and some entirely under his own control. Among these may be mentioned the cost of manufacture, the quality of butter and cheese made, and the quality of cows kept. It is the object of this bulletin to give the results of some investigations bearing on the one condition mentioned which is entirely within the control of the dairyman,—the quality of cows kept, but it may not be out of place in this introduction to touch upon the other conditions named.

COST OF MANUFACTURE.

The cost of production, if he be a creamery patron, is not controlled by the single dairyman; but experience has taught that the co-operative system of manufacture is most successful, and in the dairy districts factories operated by stock companies have followed the co-operative plan. The best of results can be attained only when the spirit of co-operation exists between the manufacturers and the patrons. At present much butter is made in private dairies on account of the cost of manufacture at the creameries. This is not to be wondered at when it is known that the factories pay three to five cents per pound less for butter fat than they receive for butter, which amounts to a charge of from seven to ten cents per pound for manufacture. Some of this dairy butter is of better quality than average creamery product, which is a good reason for its being made, but the bulk of it is inferior in quality and is sold at a loss to its makers and all who handle it, and to the detriment of the general market If all this butter could be made in the factories the cost of manufacture could be reduced, as it should be, for it costs no more to run a factory at its full capacity than it does at less. For the benefit of all concerned, producers and manufacturers should recognize their mutual interests and work together. In the opinion of the writer the best interests of the producers are served through the medium of the factory; but it should be within the power of the patrons of a factory to prevent unnecessary expense in the manufacture and sale of their product.

QUALITY.

The quality of butter and cheese made at a factory depends chiefly upon the quality of the milk used in its manufacture. Upon every individual patron, therefore, rests a responsibility for the general market value of his line of goods. The value of the whole output of a factory is often very much lessened by the lack of care on the part of a very few of its patrons. The factory operator has enough of adverse conditions due to climate to contend with without having the shortcomings of his patrons to work against. Arizona butter competes in its home markets with Kansas and California butters. In some cases the result of this competition has been that the imported butter has held the trade while the home product has been exported to sell as a low grade butter on a poorer market. This failure to hold our own trade is in the opinion of the writer, due to the lack of care in handling milk before it reaches the factory. Climatic conditions are conditions to be overcome and not to be given as an excuse for the delivery of a poor quality of milk.

CARE OF MILK.

We should bear in mind always in considering the matter of caring for milk that the changes in milk such as souring and curdling, always take place as a result of the introduction of some sort of germ life after the milk leaves the udder of the cow; that the best of butter and cheese can be made from milk only when these changes are under the control of the maker; and that it is therefore most important that the handling of milk should be such that it will remain in the condition in which it leaves the udder of the cow as long as possible. The first point, therefore, in the care of milk is to prevent the introduction of anything into it, and the second to prevent the development of any germ life that may have gotten in. The first is effected by cleanliness in milking and in the care of the utensils in which the milk is handled. All milk pails and cans should be thoroughly scalded and exposed to the sun. Sour milk or whey should not be brought home from the factory in the same cans used for the sweet milk. Cows should be milked in a clean place free from dust, and the flanks and udders of each cow should be carefully brushed and dampened with a wet cloth or sponge before milking, to prevent the falling of any dust or hair into the milk. Milk should be immediately strained, preferably through a cloth strainer that has been scalded since last used. Cans of milk should be left uncovered in a place free from all bad odors. By wrapping the cans in wet burlap the temperature of the milk may be much lessened. Aeration and cooling not only retard the development of germs in the milk but free it from so-called animal odors. By following these rules in the care of the milk from the Station herd we have always gotten our milk to the factory in such condition that we have had no complaint. While the Arizona dairyman's income is somewhat effected by the price of dairy products, dependent upon quality of the same, it is, we think, affected most by the quality of the cows of his herd. We do not hesitate to state our belief that the profits of the dairy farmers of the Territory could be doubled by a judicious selection of dairy cows without increasing the number.

A COMPARISON OF THE YIELDS OF DAIRY HERDS.

During the year ending with the month of October, 1900, the writer kept as nearly as possible a record of the number of cows milked by each creamery patron of Salt River valley, the amount of milk and butter fat produced by each herd and the cash received for the same. The number of cows was ascertained by the milk weighers at the creameries and the other figures were furnished by the creamery managers. In spite of an earnest effort to have this record complete, the desired information was secured only concerning the herds of less than half the creamery patrons of the valley. In some cases there was a suspicion on the part of the ranchman that some one wanted to know too much about his private business and information was withheld. Many sent milk to the creamery only a part of the year. The data obtained, however, seemed to be sufficient to demonstrate the point that the writer wishes to emphasize, that there are too many unprofitable cows in the dairy herds of our Territory.

With too many of our ranchmen a steer is a steer and a cow is a cow regardless of the individual animal. This indifference exists to such an extent that in some cases entire herds fail to pay the cost of their keeping.

In some localities the difference in profit returned by different herds might be attributed in a large degree to the different methods of handling and feeding. To a certain extent this may be true in Arizona, but in a far less degree perhaps than in any other state or territory. In Arizona the almost universal practice is to feed cows alfalfa hay or pasture, or a combination of the two, without shelter. If there is a difference in feed it is in amount. So we consider it fairly safe to attribute differences in profit to differences in quality of the cows.

The year during which this record was kept was a particularly hard one on account of the very severe drouth, and the returns from the dairy herds of the Territory are probably somewhat below the average on that account. The difference between different herds is, we think, in but few cases to be accounted for by the difference in feed.

The facts collected are given in the tables following. The first table relates to herds concerning which data were collected for the year.

In the second column is given the average number of cows milked each month. This number is probably somewhat less than the actual number of cows in the herd, as no account has been taken of the number of dry cows, of which there are nearly always some in a herd. On account of the habit Arizona ranchmen have of buying, selling and renting cows, seldom keeping the same herd for a year, it was considered that in most cases the average number reported as in milk each month would most nearly represent the number of the herd for the year.

The third column shows the average number of pounds of milk per cow for the year. The figures are obtained by dividing the total number of pounds of milk delivered at the factory by the number of cows given in the second column.

The last column gives the gross return per cow. This is obtained by dividing the total cash returns by the number of cows in milk, or by multiplying the number of pounds of butter fat by 20 cents. The price paid for butter fat at the different creameries for the year varied a fraction of a cent, but we have assumed that the same price, 20 cents per pound, was paid in all cases, thus having a single basis for the comparison of all herds.

We have estimated the cost of keeping a cow a year to be thirty-two dollars, twelve dollars for care and milking and twenty dollars for feed. The latter figure would be high in ordinary years, but during the unusually dry year in which this record was made prices of feed were high enough, we think, to warrant this estimate.

In the table the figures relating to herds failing to give a gross return of thirty-two dollars per cow are printed in black faced type.

TABLE I.—SHOWING THE AVERAGE YIELD OF MILK AND BUTTER FAT PER COW, WITH GROSS CASH RETURNS FOR THE SAME, IN FIFTY-EIGHT ARIZONA HERDS.

No.	*No. of cows.*	*Av. lbs. of milk.*	*Av. lbs. of butter fat.*	*Av. cash return*	No.	*No. of cows.*	*Av. lbs. of milk.*	*Av. lbs. of butter fat.*	*Av. cash return*
1	21	7409	274	$54.80	30	25	4865	191.15	$38.23
2	8	7587	269.20	53.84	31	9	5240	189.30	37.86
3	43	5936	247	49.40	32	19	4795	188	37.60
4	48	6676	236.60	49.32	33	11	5167	187.90	37.58
5	23	5659	243	48.60	34	54	5150	185.20	37.04
6	4	6019	238.15	47.63	35	19	4302	183.60	36.72
7	9	3447	233.85	46.77	36	9	5312	183.60	36.72
8	21	4438	234	46.00	37	7	5229	179.25	35.85
9	12	6176	222	44.40	38	5	4833	178.55	35.71
10	31	6442	219.10	43.82	39	6	4667	177.35	35.47
11	24	6048	214.40	43.00	40	8	4632	176.30	35.28
12	16	5672	214.85	42.97	41	9	5095	169.05	33.81
13	23	4972	214	42.80	42	9	4655	161.10	32.22
14	29	5863	214	42.80	43	11	4292	158.20	31.64
15	9	5255	213.85	42.77	44	7	4154	154.70	30.94
16	25	5778	210	42.00	45	12	4282	150.40	30.08
17	12	5559	208.15	41.63	46	7	4187	145.20	29.04
18	55	5681	205.15	41.03	47	6	4411	144.25	28.85
19	15	5944	204.60	40.92	48	12	4248	127.55	25.51
20	11	5607	202.50	40.50	49	3	2973	125.80	25.16
21	15	Cream	201	40.20	50	10	4085	125.75	25.15
22	6	5942	200.45	40.09	51	11	3520	124.25	24.85
23	43	5505	200	40.00	52	6	3735	113.	22.60
24	4	4774	200	40.00	53	4	3075	109.10	21.82
25	10	4819	199.50	39.90	54	5	3059	102.50	20.50
26	17	4658	199.50	39.90	55	20	3297	101.65	20.33
27	6	5886	198.10	39.62	56	5	2585	99.80	19.96
28	44	5232	197.50	39.50	57	5	2642	87.15	17.43
29	9	5462	192.25	38.45	58	11	2019	66.40	13.28

An examination of the above table reveals the fact that of the fifty-eight herds reported, sixteen failed to pay what we have estimated to be the cost of keeping. The difference between the return of the average cow of the poorest herd and the average cow of the best herd is the difference between a loss of $18.22 and a profit of $22.80.

Besides the fifty-eight herds reporting for a year, forty-three herds reported for six to eleven months. We have collected the results of these reports in the following table, giving the number of cows milked, the number of months reported and the average gross returns for those months. As in the preceding table the figures relating to herds not paying their keeping are printed in heavy type.

TABLE II.—SHOWING AVERAGE GROSS RETURNS PER COW IN FORTY-THREE HERDS REPORTING FOR A PART OF A YEAR.

	No. of cows.	*No. of months*	*Average gross returns per month*		*No. of cows.*	*No. of months*	*Average gross returns per month*
1	19	10	$5.20	23	8	6	$2.72
2	6	8	4.84	24	8	7	3.15
3	18	9	4.78	25	18	10	2.90
4	6	7	4.21	26	10	10	2.89
5	5	7	4.20	**27**	**8**	**9**	**2.65**
6	22	6	4.07	**28**	**11**	**9**	**2.63**
7	25	6	4.00	**29**	**6**	**7**	**2.57**
8	19	6	3.88	**30**	**10**	**11**	**2.55**
9	9	8	3.83	**31**	**16**	**11**	**2.40**
10	15	9	3.80	**32**	**5**	**9**	**2.21**
11	15	7	3.77	**33**	**7**	**8**	**2.15**
12	11	10	3.76	**34**	**8**	**8**	**2.12**
13	17	6	3.73	**35**	**5**	**7**	**2.05**
14	4	10	3.55	**36**	**8**	**9**	**2.03**
15	21	7	3.53	**37**	**12**	**8**	**2.00**
16	6	7	3.44	**38**	**6**	**8**	**2.00**
17	18	9	3.40	**39**	**7**	**8**	**1.97**
18	8	6	3.37	**40**	**5**	**9**	**1.97**
19	7	9	3.35	**41**	**6**	**6**	**1.85**
20	7	11	3.20	**42**	**33**	**9**	**1.56**
21	14	6	3.19	**43**	**18**	**5**	**1.22**
22	12	9	3.15				

These two tables should furnish dairymen food for thought. Here is demonstrated the fact referred to above, that there are too many unprofitable cows in our dairy herds.

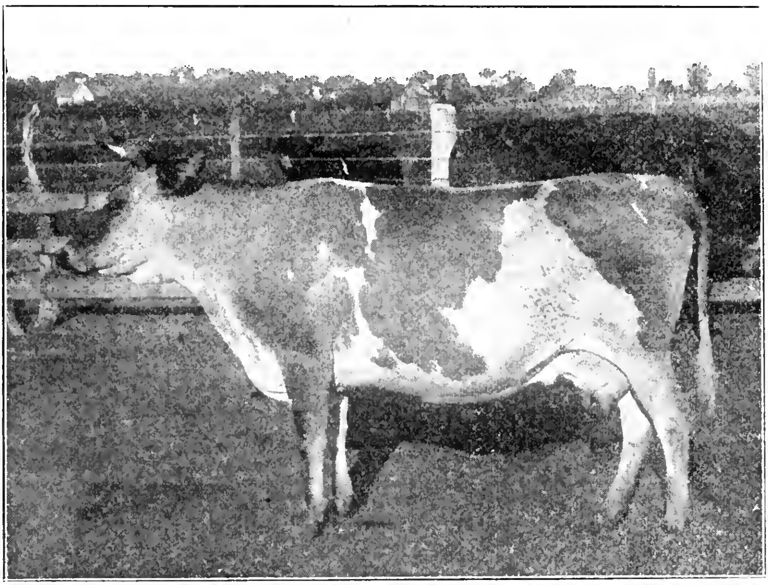
These figures, however, do not show how many, for, in order to do this, a record of individual cows must be kept. In some of the herds that failed to pay expenses there may have been some good cows while in the berds showing fair returns there were undoubtedly many unprofitable ones. In all probability there are few herds reported above from which the profit could not have been increased by selling some members of the herd for beef. One must go farther than to simply determine the gain or loss of his herd; he must know which particular cows are responsible for gain and which for loss. That this is essential is demonstrated in the following part of the bulletin.

A DAIRY HERD RECORD.

For a year the writer kept a record of the individual cows of two herds. The milk was weighed and sampled at every milking and the samples tested twice a month, the writer testing the milk and keeping the record as his share of the work. The owners of the herds state that the extra time required to weigh the milk, record the weight and take the samples, did not exceed one minute per cow. The samples tested every two weeks were composite samples consisting of a part of the milk from each milking during the two weeks, and were kept in condition for testing by the addition of bichromate of potash and bichloride of mercury in about equal parts. The time required for testing the samples for the two herds was about a half day. The Babcock test was used.

It was the original idea to secure herds fairly representing the different breeds used for dairy purposes, but the men owning Shorthorn and Holstein herds failed to co-operate when the time came to begin the test. Of the two herds of which records were kept, one consisted of twelve full-blood Jerseys. The other consisted of thirty-five cows of mixed breeding; some high grade Shorthorns, some grade Jerseys and others of various admixtures of blood. Only thirty cows in the latter herd completed the year's record.

In the following tables the record is given as of a single herd, except that the figures relating to the cows of the full blood herd are in italics in Table III. The record as it was kept shows the amount of milk and butter fat given by each cow of the two herds for each period of two weeks during the year, and from each we have taken the following summary which gives not only the number of pounds of milk and butter fat produced during the year, with the average per cent of fat, but an estimate of the gross and net returns from each cow for that time. As in the preceding part of the bulletin, gross returns are figured on the basis of 20 cents per pound for butter fat and thirty-two dollars per head as the cost of keeping a cow a year. The table hardly needs any explanation.



Cow No. 2. Record: 7978 Pounds of Milk. 348 Pounds of Butter Fat.

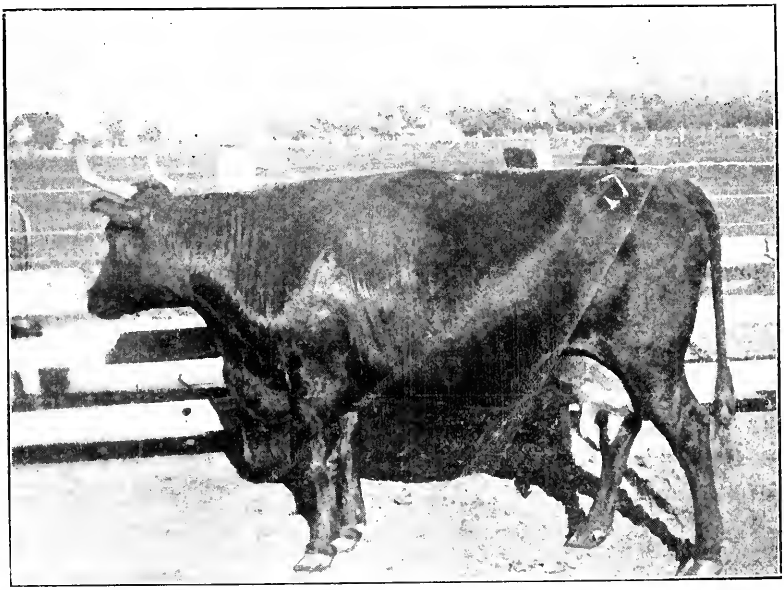
TABLE III.—SHOWING INDIVIDUAL RECORD OF FORTY-TWO COWS.

No. of cow	Age	Days in milk	Pounds of milk	Per cent of fat	Pounds of fat	Gross receipts	Net receipts
1	11	353	7945	4.43	352.23	70.45	38.45
2	5	357	7978	4.36	348.74	69.75	37.75
3	10	335	8727	3.66	319.13	63.83	31.83
4	7	315	7294	4.27	311.74	62.35	30.35
5	14	340	6489	4.60	298.75	59.75	27.75
6	5	350	6614	4.45	294.82	58.96	26.96
7	12	345	6527.5	4.5	293.85	58.77	26.77
8	7	365	6433	4.39	282.99	56.60	24.60
9	4	365	6535.5	4.25	277.51	55.50	23.50
10	12	348	5990	4.36	261.44	52.29	20.29
11	8	330	5363	4.84	258.96	51.79	19.79
12	5	333	5383	4.72	254.36	50.87	18.87
13	7	365	4933	5.1	253.79	50.76	18.76
14	4	351	6351	3.98	253.31	50.66	18.66
15	15	288	7770	3.25	252.42	50.48	18.48
16	7	284	7052	3.40	239.85	47.97	15.97
17	5	365	5118	4.66	238.55	47.71	15.71
18	7	256	5305	4.50	238.38	47.68	15.68
19	4	324	5192.5	4.58	238.00	47.60	15.60
20	4	291	4459	5.28	235.74	47.15	15.15
21	3	343	5862	4.02	235.74	47.15	15.15
22	4	350	4654	5.04	234.76	46.95	14.95
23	5	315	4951	4.73	234.34	46.87	14.87
24	12	360	5728.5	3.87	221.58	44.32	12.32
25	7	345	5940	3.73	221.27	44.25	12.25
26	5	365	4855	4.51	219.21	43.84	11.84
27	3	338	4327	5.01	217.02	43.40	11.40
28	7	228	4766	4.49	214.27	42.85	10.85
29	4	233	5434	3.89	211.12	42.22	10.22
30	7	344	4470	4.69	209.53	41.90	9.90
31	3	361	4180.5	4.95	207.2	41.44	9.44
32	15	271	6727	3.07	206.31	41.26	9.26
33	6	311	5041	3.94	198.57	39.71	7.71
34	3	356	4557.5	4.35	197.99	39.60	7.60
35	7	241	5838	3.36	196.19	39.24	7.24
36	7	285	4239	4.53	191.94	28.39	6.39
37	8	319	5402	3.58	190.51	38.10	6.10
38	13	365	3830	4.82	184.45	36.89	4.89
39	4	365	3964	4.41	174.74	34.95	2.95
40	3	342	3741	4.39	163.70	32.74	0.74
41	4	305	3559	4.43	57.87	31.57	0.43
42	5	335	3126	4.51	141.13	28.23	3.77

For the sake of comparison it will be interesting to know that these two herds gave an average gross return for the year of $53.28 and $48.60 respectively, thus ranking among the very best herds in the Territory, and yet two cows failed to pay the requisite thirty-two dollars.

COMPARISON OF METHODS.

Certain writers on dairy subjects have suggested various short cut methods of keeping so-called dairy herd records. It has been stated, for example, that an average of the samples taken at the end of six weeks and of six months after calving would be fairly representative of the milk for the whole year, and that a



Cow No 3. Record: 8726 Pounds of Milk. 319 Pounds of Butter Fat.

sample taken toward the end of the fourth month would be the same. In cases where the comparison could be made, the writer has compared the average per cent of fat for the year with that of the two week period about the end of the fourth month, as suggested, and he found that in several cases the difference was as high as one half of one per cent, and in one case eight-tenths of one per cent, making a calculated difference in the year's return of a cow of from thirty to fifty pounds of fat. The writer believes that in building up or maintaining a dairy herd enough is involved to make it profitable for the dairyman to know what his cows are doing and not to be satisfied with estimates. Any method which does not involve the weighing and testing of all the milk is a method of estimating and not of determining the value of his cows.

Many dairymen who have never tested any of the cows of their herds think they know which are the best ones, usually judging by the amount of milk given or the supposed richness of the milk. To such and to others it will be interesting to note the ranking of the cows of these herds according to cash returns, richness of milk, and amount of milk given in the following table, which shows that the most profitable cow stood twentieth in richness of milk and third in amount of milk and so on. The cows are numbered in this, as in all the tables, in the order of their true value as shown by the amount of butter fat produced.

TABLE IV.—SHOWING RANK OF COWS ACCORDING TO REAL VALUE, RICHNESS OF MILK AND AMOUNT OF MILK.

Number	*Richness*	*Amount*	*Number*	*Richness*	*Amount*
1	20	3	22	3	31
2	25	2	23	8	27
3	37	1	24	34	19
4	28	5	25	36	16
5	12	11	26	15	19
6	19	8	27	4	33
7	17	10	28	18	39
8	23	12	29	33	20
9	29	9	30	10	35
10	26	15	31	5	37
11	6	23	32	42	7
12	9	22	33	32	26
13	2	28	34	27	32
14	31	13	35	40	17
15	41	4	36	14	36
16	39	6	37	38	21
17	11	25	38	7	39
18	35	14	39	22	38
19	13	24	40	24	40
20	1	34	41	21	41
21	30	18	42	16	42

VARIATIONS IN PER CENT OF FAT.

From the original record we have taken the figures which appear in the following table showing the extreme variation in per cent of fat in each cows' milk during the year and the greatest variation between two consecutive two-week periods. The variation in per cent of fat in milk is, with most dairymen, a knotty problem, and is sometimes a source of trouble between the creamery man and his patrons. That variations occur is shown in the table; why they occur would be hard to explain.

TABLE V.—SHOWING EXTREME VARIATIONS IN THE PER CENT OF FAT IN THE MILK OF EACH COW DURING THE YEAR AND BETWEEN CONSECUTIVE TESTS.

No.	Year	Test periods	No.	Year	Test periods
1	3.6—4.8	3.6—4.4	22	3.8—5.7	3.8—4.6
2	3.5—4.8	3.5—4.4	23	3.4—5.2	3.4—4.8
3	3.6—5.1	3.8—4.4	24	3.6—4.2	3.8—4.2
4	3.5—5	3.5—4	25	2. —5.3	4.6—5.3
5	3.8—5.8	4.6—5.5	26	3.5—4.8	4—4.6
6	3.8—6.1	3.8—4.4	27	3.8—5.4	3 8—5.4
7	3.7—5.6	3.7—4.8	28	4. —6.6	4.2—5.1
8	3.8—4.4	4.2—4.8	29	2.5—5.6	2.8—3.4
9	3.6—5.4	4.4—5	30	3.6—5.6	4—5.5
10	3.6—5.4	3.6—4.4	31	3.8—5.8	3.9—4.9
11	4—5	4—5	32	2.6—3.6	33.—3.6
12	3.9—5.5	3.9—4.8	33	3.4—4.4	3.6—4.4
13	4.6—6.2	4.4—5.4	34	3.4—5.4	4.3—5.4
14	34.—4.4	3.4—3.8	35	3.1—5 3	3.1—3.6
15	2.7—4.1	3.2—4	36	3.8—5.6	3.8—4.6
16	3—4.5	4—4.5	37	3. —4.2	3—3.4
17	4.1—5.6	4.1—4.6	38	4. —5.5	4.6—5.2
18	3.3—4.2	3.5—4	39	3.8—4.9	3.8—.46
19	3.6—7.5	5.8—7.5	40	3.6—5.	3.9—4.9
20	3—5.2	3—3.5	41	3.8—4.8	3.8—4.3
21	3.5—5.4	3.6—4.2	42	3.5—6.1	3.5—4.2

With such wide variations in the per cent of fat in the milk of the same cow, the lack of value of single tests should be apparent. This is another illustration of the importance of keeping the year's record of our dairy cows.

University of Arizona

Agricultural Experiment Station.

Twelfth Annual Report.

For the Year Ending June 30, 1901.

Consisting of the Reports of the Departments of

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

Tucson, Arizona, October 17, 1901.

UNIVERSITY OF ARIZONA
AGRICULTURAL EXPERIMENT STATION.

The Bulletins of the Station are sent to all residents of Arizona applying for them.

Address,

THE EXPERIMENT STATION,

Tucson, Arizona.

LETTER OF TRANSMITTAL.

To His Excellency, N. O. Murphy, Governor of Arizona:

SIR: In accordance with the Congressional act of March 2, 1887, I submit, herewith, the Twelfth Annual Report of the Arizona Agricultural Experiment Station, for the fiscal year ending June 30, 1901.

Very respectfully,

R. H. FORBES,

Director.

CONTENTS.

Sacaton grass (*Sporobolus wrightii*) protected by fence in Santa Cruz valley, showing its value for the restraint of flood waters. Photo by D. Griffiths. See range improvement, pp. 333.

TWELFTH ANNUAL REPORT.

DEPARTMENT OF ADMINISTRATION.

IN GENERAL.

During the year just completed, the Arizona Station has proceeded along the lines and upon the principles stated and emphasized in the eleventh annual report,—according to which the different members of the Station staff have been enabled to carry on their investigations in those localities best suited to the accomplishment of results.

Notable progress has been made in all departments of effort, and, though interruptions have occurred, the advantages of organization and of well-defined experimental objects have enabled the Station to hold to its general plan without serious loss of time or achievement.

Freedom from political interference during the past two years, moreover, has made it possible for the scientific staff to maintain that spirit of loyal service and devotion to agricultural interests, which should always characterize the true, professional experiment station worker.

With such favorable administrative conditions, actuated by such motives, and with fine natural opportunities, the Arizona Station is steadily adding to, and applying, and diffusing knowledge of southwestern agriculture. A fitting maxim, indeed, for an investigator enlisted in the service of a hungry, growing, young western commonwealth is: *Not "science for science's sake," merely; but, science for humanity's sake.* Such a maxim accords well with the fact that the sole reason for the maintenance of an agricultural experiment station, both in law and in ethics, is the needs of the agricultural public to whose service it is dedicated.

Herewithal, it is not to be understood that station work must be "practical" in the business sense of the term. It is for the investigator, working in economic fields by slow and costly methods, to ascertain useful facts; it is for the farmer, placed in possession of these facts, to make them pay.

PUBLICATIONS.

The publications of the Station, as last year, are divided into two sets,—the longer and more technical bulletins and the brief, though most carefully written, "Timely Hints for Farmers."

The longer bulletins serve for the record and discussion of the more important investigations of the Station. They are of value to other scientific workers and to a minority of farmers whose leisure and interest permits them to read. Through these men, also, whatever of value may be contained in such bulletins slowly reaches the great majority of those for whom it was intended.

The "Timely Hints," however, directly appeal to the busy, everyday farmer whose time, and whose common-school education perhaps, do not permit him to master a lengthy and technical bulletin. They are short because, if they are read at all, it will be during a pause from other work. They are in newspaper type because that best fits the popular eye. They are in plain language because they are intended for all to understand. They have vitality because they are, as far as possible, founded upon our own experiments and observations. Above all, they aim to convey timely information which will be of immediate utility to as many as possible of those who receive them.

During the year ending June 30, 1901, nineteen publications have been distributed to the names on our mailing list, in whole or in part as advisable, as follows:

Eleventh Annual Report, 45 pages; including a discussion of the principles on which the work of the Station is conducted, and notes on forage crops, vegetables, winter irrigation, stockfeeding, dairying, sugar beets, irrigating waters, and other agricultural subjects, by various members of the staff.

Bulletin 36, 21 pages; Experimental Work with Sugar Beets during 1900, by R. H. Forbes.

Bulletin 37, 36 pages; Winter Irrigation of Deciduous Orchards, by A. J. McClatchie.

Timely Hints for Farmers:

No. 19, Oct. 1, 1900. Let's Go to School Again.—By R. H. Forbes

No. 20, Oct. 15, 1900. Stinking Smut of Wheat and Its Prevention.—By David Griffiths.

No. 21, Nov. 1, 1900. The Use of Chemical Preservatives in Milk.—By Gordon H. True.

No. 22, Nov. 15, 1900. The Open Range and the Irrigation Farmer.—By R. H. Forbes.

No. 23, Dec. 1, 1900. The Value of a Dairy Herd Record.—By Gordon H. True.

No. 24, Dec. 15, 1900. The Use of the Babcock Test.—By Gordon H. True.

No. 25, Jan. 1, 1901. Plant Lice.—By T. D. A. Cockerell.

No. 26, Jan. 15, 1901. Suggestions Concerning Date Culture.—By A. J. McClatchie.

No. 27, Feb. 1, 1901. The Spring Vegetable Garden.—By A. J. McClatchie.

No. 28, Feb. 15, 1901. Some Trees and Plants for Barren Places.—By R. H. Forbes.

No. 29, Mar. 15, 1901. The Use of Hand Separators on the Farm.—By Gordon H. True.

No. 30, Apr. 1, 1901. Well Waters for Irrigation.—By R. H. Forbes.

No. 31, Apr. 15, 1901. Home-Made Fertilizers.—By W. W. Skinner.

No. 32, May 15, 1901. Wild Barley.—By A. J. McClatchie.

No. 33, June 1, 1901. The Australian Saltbush in Arizona.—By David Griffiths.

No. 34, July 1, 1901. Millets.—By A. J. McClatchie.

These writings have been distributed to a mailing list of some 3000 persons in Arizona and other states, while the bulletins have in addition been sent out to the official list of some 1500 names. In this way the office has forwarded something over 60,000 pieces of mail during the year.

In addition, there is a large correspondence with the farmers of the Territory, as well as with prospective settlers from other states, who appeal to the Station for reliable information relating to the agriculture of this region.

EDUCATIONAL VALUE OF STATION WORK.

In view of the difficulties which have retarded the development of the school of agriculture in the University, the Experiment Station has endeavored in various ways to make its work of educational value to the public, although not itself responsible for results along this line.

The field operations at the Station farm, in the date orchard, and with sugar beets, together with the explanations of those in charge, have afforded excellent object lessons to numerous visitors.

The publications of the Station, also, are full of reference to those principles of agricultural science involved in the subjects treated; and the Timely Hints especially, distributed every two weeks for nine months of the year, serve as lesson sheets for a class of some 3000 Arizona readers.

In order to afford a more systematic and complete course of reading than the Station publications afford, a carefully selected library of books and papers, giving a fairly complete treatment of farming in the various departments, was offered at cost ($2.91) to those who desired. Small response to this opportunity was made, but it is believed that experience will greatly improve this branch of service.

Institute work, which last year's experience proved highly desirable in many localities, was crippled this year for want of traveling funds. On a few occasions the Station staff has assisted on agricultural programs, but could be much more useful with sufficient means to travel.

PERSONAL.

The Station staff, with one exception, remains the same as during the year. Dr. David Griffiths, botanist, after remaining nine months, followed his predecessor to the U. S. Department of Agriculture, and has been succeeded by Professor John J. Thornber, whose study of problems relating to range reclamation in Nebraska should enable him to continue this important line of botanical work in Arizona with little interruption.

SCIENTIFIC INVESTIGATION.

The year's investigations have followed the lines laid down two years ago. The department of chemistry has nearly completed an extensive study of the irrigating waters of the Territory—a study the inferences from which relate to the future of agriculture in the irrigated regions of Arizona. The work with sugar beets has also been brought to completion, and will be laid aside during the current year.

The department of botany, with the co-operation of the Division of Agrostology, U. S. D. A., for part of the year, has begun the important work of studying grazing conditions in the Southwest, and has made progress along several lines of inquiry relating to range problems. The range reserve of 350 acres near Tucson, although it has been under fence but eight months, shows in marked degree the recuperation of native vegetation when protected from stock. It is hoped that this study will grow into large importance as affecting the declining value of the ruinously managed ranges of the Southwest.

Questions relating to entomology and meteorology have from time to time been referred to the consulting members of the staff. This arrangement, so far as it goes, is very satisfactory, combining economy with a fair degree of service.

The department of agriculture and horticulture has operated upon the Station farm near Phoenix, having increased in usefulness and grown in favor in that very suitable location. The investigations of forage plants, grains, orchard management, and duty of water all relate closely to the welfare of this region. In the same place, the department of animal husbandry, now in its second year, has continued and extended its operations. The acquisition of 28 acres of land for feeding work has afforded facilities for the handling of a satisfactory number of animals, and for the increase of the number of experiments.

Both of the last named departments, however, as, indeed, the Station as a whole, are working under financial limitations. Improvements, however, have been made in modest amount, and are additionally assured to a considerable extent during the current year.

THE DATE PALM ORCHARD.

After one year's operations, the large shipment of palms received and planted at the orchard south of Tempe and at the Station farm, gives evidence of the probable outcome of the experiment. The extremely dry summer of 1900, and the exceptionally cold, ensuing winter imposed severe difficulties upon the work; but unusual efforts were made for the preservation of the trees. Because of the deficiency of irrigating water, a 4-inch San Jose pump was installed in the orchard, and water was hauled in barrels to the suckers as needed during the year. This task was undertaken by Mr. Harry Walker, of Tempe, to whose conscientious attention is largely due the satisfactory condition of the orchard at the present time.

In all, there were 384 suckers planted south of Tempe and 21 at the Station farm, making a total of 405 trees, comprising 26 varieties. A careful examination made July 13, 1901, nearly one year after planting, revealed the condition shown in the following table:

CONDITION, JULY 13, 1901, OF THE SHIPMENT OF DATE SUCKERS RECEIVED JULY 17, 1900.

Varieties.	*Living, mostly growing vigorously.*	*Living, but very feeble*	*Dead*	*Total of each variety.*
Rhars	157	14	23	194
M'Kentichi degla	2	2	2	6
Arechti	5	2	2	9
Deglet nour	59	13	15	87
Hamraia	3	2	2	7
Tentebusht	4	0	1	5
Amari	5	1	4	10
Tennessim	2	0	0	2
Rhazi	5	1	0	6
Timdjouert	5	0	2	7
Safraia	6	0	0	6
Hallona	2	1	2	5
Itima	7	1	2	10
Azerza	3	2	3	8
Tazizaout	2	0	0	2
A'oochet	0	1	0	1
El kattar	0	1	0	1
Retbet regaia	1	0	0	1
Beida hammam	0	0	1	1
M'ch' degla	0	0	1	1
Tidmamet	1	0	0	1
Kerbons	1	0	0	1
Taurarhet	1	0	0	1
Bent kabeda	1	0	1	2
Bent kebala	1	0	0	1
Tadala	2	0	2	4
No name	11	2	10	23
	286	43	73	402
			Not judged,	3
			Total,	405

From this statement, it appears that 71 per cent of the suckers, including 22 varieties, are established; 11 per cent are yet doubtful; and 18 per cent are dead. This result is quite satisfactory considering the experimental methods of shipment employed, the two months' journey during the hot season, and the unfavorable conditions at the time the plants arrived.

In tracing out the causes which influenced final results it appears:

1. That it is much better to transport the suckers immediately after cutting them from the parent tree than to grow them in tubs or garden before shipment. The two methods resulted as follows:

	Growing and living.	*Doubtful.*	*Dead.*
Biskra and Ourlana purchases shipped immediately after cutting,—333 plants....	75%	11%	14%
Yahia and Rossier lots grown one year before shipment,—69 plants.	52%	9%	39%

Also, a small lot of 6 palms grown 1 year in tubs at Algiers, were received in the tubs of earth in 1899, at Tempe, having been necessarily somewhat jarred in transit. Five of these perished slowly, and the remaining one, after starting to grow, being moved a few inches to straighten a row, also died. It seems that at the time when the date sucker is creating its root system, it is sensitive to disturbance, being much more hardy immediately after severing from the tree and before its vitality has been expended in the output of new roots.

2. The different methods of packing employed present no marked advantages over each other. Those palms which were shipped with no packing whatever, came through as well, or better than, those carefully bound in wet moss or packed in charcoal. As a precaution, however, against unusual delay in transit it is probably safer to bind coverings of wet moss about the bases of the suckers and provide for renewal of moisture on the road.

3. Fumigation with hydrocyanic acid gas for the destruction of scale, does not readily injure the hard, dry foliage of the date palm. These suckers were subjected for 1 to 12 hours to .3,

.4, and .5 per cent fumigations with scarcely any apparent and no lasting injury; while the scale insect, July, 1901, appears to have been nearly or quite (?) all killed.

4. Alkaline soil does not hinder the establishment of the suckers. Comparison of results in the extremely alkaline Tempe orchard and the fresh soil of the Station farm shows the following:

	Growing and living.	*Doubtful.*	*Dead.*
Tempe orchard,—384 suckers...............	71%	11%	18%
Station farm,—21 suckers....................	72%	5%	23%

—an almost identical condition.

Reliable comparisons could not be made as to the shipping endurance of different varieties, although it is noted that a larger per cent of Rhars (82 per cent) is now active than of Deglet Noor (70 per cent). Size apparently had little to do with results, some of even the largest as well as the smallest individuals perishing. Very small suckers, however, are less desirable for field operations.

The main points observed thus far in caring for the suckers have been to plant not deeper than their greatest diameter; and to water assiduously after planting. Water was applied daily for the first six weeks, and frequently thereafter. Decided growth was not apparent until the following April.

A further consignment of 18 large plants, in 5 varieties, from Egypt, by mail, was received and planted in July; but the future of this lot is not yet evident.

FINANCIAL.

It has been difficult, with the funds available, to accomplish the work which could not, and would not, be ignored. Certain items of income outside the Hatch fund, however, have helped us through.

The resources for the year have been:

Receipts from the Treasurer of the United States..............	$15,000.00
Balance on hand July 1, 1900..................................	262.70
Proceeds from sale of 8 steers................................	367.65
Greenhouse sales..	59.40
Sales of milk, fruits, etc....................................	411.41
	$16,101.16

EXPENDITURES FOR THE YEAR ENDING JUNE 30, 1901, BY DEPARTMENTS.

	Administrative.	*Agriculture and Horticulture*	*Animal Husbandry.*	*General Farm Expenses.*	*Botany.*	*Chemistry.*	*Entomology.*	*Date Palm Orchard.*	*Sugar Beet Culture.*	*Miscellaneous.*	*Totals.*
Salaries	1350.00	1700 04	1500.00		550.00	1993.35	100.00				7193 39
Labor	217.33	1339.10	896 20		166.63	8.75		467.22	550 90	300 00	3946.13
Publications	195.19	260 39	21 00		16 90	113 84	9.50			180.34	797.16
Postage and stationery	152.74	35.43	15 00		4.00	7.00					214 17
Freight and express	2.55	22.40	47.55	14.13	1.05	82.19	3.09	3.25	17.34	50.69	244.24
Heat, light and water										125.05	125 05
Chemical supplies			16 50		.19	93.40					110.09
Seeds, plants and sundries.		71.31	22 22		34.40			22.80			150.73
Fertilizers				300 00				9.69			309.69
Feeding stuffs				100.73	2.15				18.25		121 13
Library	82.43				2.44	2.50		.40			87.77
Tools, implem'ts and mch'y		52.75	103.50	228.76	50.40	1 10		66 65	24.95	3.00	531.11
Furniture and fixtures	40.50					6 00				2 70	49.20
Scientific apparatus		6 58	11 83		98 02	119 98				27.11	263 52
Live stock	115.90										115 90
Travelling expenses	105.85		16 15		35.40			81.00	163.15		401 55
Contingent					163.25					120 00	283.25
Building and repairs			755.44	32.95	239 10			123 30	5.54	.75	1157.08
Totals	2262 49	3488.00	3405.39	676 57	1363 93	2428 11	112.59	774 31	780 13	809.64	16101 16

The expenditures have been about equally divided between the departments of agriculture and horticulture and of animal husbandry, operating at the Station farm; and the office, scientific laboratories, and miscellaneous undertakings of the Station at Tucson and elsewhere.

Preceding is the statement by classified items, and by departments and separate lines of work.

R. H. FORBES,
Director.

DEPARTMENT OF AGRICULTURE AND HORTICULTURE.

The work of the year has consisted of the following: A continuation of several lines of experiment begun three years previously,—orchard management, date culture, the growing of wheat, corn, melons, and potatoes, and the culture of Eucalypt trees; a continuation of one line begun one year previously,—the relation of temperatures to growing crops; and of an investigation of four subjects taken up during the past year,—cotton culture, strawberry culture, the "duty" of irrigating water, and a study of evaporation from water and from soil surfaces. Three lines of experiment were considered to have been pretty thoroughly worked out for this region, and have not been continued during the past year,—sugar-beet culture, vegetable growing and green-manuring.

DATE CULTURE.

The heavy fruiting of several of the date trees upon the Station farm, and of many trees in other parts of the region about Phoenix during the past year, furnished an excellent opportunity to make some observations regarding date culture that heretofore had been hardly possible. In the first place, it seems now to be pretty well established that most date trees of the valley, especially the heavy-fruiting ones, bear only on alternate years. During the summer of 1900 all or nearly all female trees in the valley bore a full crop, while during 1899 very few bore dates, and during 1901 comparatively few are bearing heavily. The principal enemy of the date thus far has been the birds, and it seems pretty well established that it will be necessary to protect with a covering of light cloth each individual bunch, at least until dates are produced in larger quantities than at present. The quantity of dates produced at the Station farm gave an opportunity to make some experiments in packing and marketing this fruit. It was found that the dates ripening during early autumn (September and October) could be packed directly from the tree, while those ripening during the cooler and moister weather of late autumn and early winter needed some drying before being packed. One of the principal difficulties encountered was too rapid drying of the dates after being packed, due to the extreme aridity of our atmosphere. It was found necessary to pack them in boxes surrounded with paraffine paper and keep them well covered, else they would soon become too dry to be eaten conveniently. The production of a large quantity of dates also furnished plenty of seeds for planting, and experiments were made as to the best time of year for sowing the seed. Judging from present indications, they make the best growth if planted during January or February, but may be planted any time during winter, spring or early summer. The results of some of the above observations and some suggestions regarding date culture were embodied in a "Timely Hint" that was issued during January.

FIELD CROPS.

The more abundant supply of irrigating water during the past year has made it possible to grow many field crops that an insufficient supply of water had prevented the growth of, during the past year or two. The testing of varieties of wheat was continued the past year, twelve varieties having been sown last autumn. The wheats grown belong to three classes,—local milling wheats, foreign milling wheats, and macaroni wheats. As heretofore, the Sonora wheat of the region was used as the standard with which to compare the rest as to length of season, yield, etc. Three foreign milling wheats compared very favorably with this variety in all respects. One variety from Japan—Onigiri—ripened with Sonora and gave a slightly heavier yield, and one Australian variety—King's Early—ripened earlier than Sonora and gave a heavier yield. Two other Australian varieties—Early Baart and Allora—ripened earlier than Sonora, but did not give quite as heavy a yield. An American variety—Ruby—ripened a little later than Sonora and gave a heavier yield. Of the macaroni wheats, the Nicaragua and Perodha gave the heaviest yields, equaling Sonora in this regard.

Considerable attention has been given to the growing of corn, both Indian and Egyptian. The Egyptian corn has been planted each month of the present spring and summer, Indian corn having been in some cases planted the same date. As was to be expected the spring plantings of Indian corn gave a very small yield, while the Egyptian corn bore heavily. As the latter variety produces two or more crops of grain upon the same stalks, the yield during the past season will not be known until its end.

The testing of varieties of melons has been continued, as well as a test made as to the amount of water needed to grow them. A record was kept of the dates of applying water, the amount applied, the number of melons produced per acre, the weight of the crop per acre, and the cash returns per acre. As heretofore, the Augusta proved to be the earliest variety, and at the close of the fiscal year (July 1st) had given the heaviest yield and the largest cash return. The yield during the remainder of the season and the cash returns from the same must be awaited before the results of the season will be known.

During the present season several varieties of Egyptian cotton are being grown—varieties that are grown in Egypt by irrigation and are reputed to produce high grade cotton. At the end of the year (July 1st) the crop is in excellent condition and gives promise of a good yield.

IRRIGATION.

Much attention has been given during the past year to the vital subject of irrigation. Besides the experimental field work, a study has been made of such phases of the engineering and legal departments of the subject as are of special importance to farmers. For, not only must the farmer apply economically the water he receives, but the canals and ditches (and reservoirs, if they exist) supplying him with water must be properly constructed, and there must exist just laws providing for the delivery to him of the water to which he is entitled.

The great importance to the farmer of storing flood water, and the danger of attempting to cultivate more land than a reservoir or reservoirs could store water for, suggested a study of the capabilities of reservoirs whose construction is now contemplated on the streams supplying the Salt river valley with water. The results of the study indicated that the estimated area that could be watered from these prospective reservoirs was somewhat too high, and that the water-shed of the Salt river and its tributaries does not supply water enough to irrigate thoroughly over 250,000 acres, just about the area under the present canal systems of the Salt river valley. It is the purpose of the writer to present in a bulletin during the coming year the results of the study that lead to the above conclusions.

The experiment in the winter irrigation of orchards was continued through the year, and a bulletin embodying the results of the past two and one-half years' experiments issued last May. Work is under way during the present season having for a purpose the determination of the amount of the winter-applied water that is used by the trees and the amount that is lost by evaporation from the soil. Experiments have also been made in irrigating strawberries by different methods but the work has not been continued long enough yet to indicate clearly what the results are to be.

Especial attention has been given to the study of the duty of water. All the water flowing upon the Station farm has been measured as it crossed the farm line, and the amount applied to each crop has also been measured. For this purpose a self-recording water register was installed in the ditch conducting water to the farm, and gauged measuring boxes were placed wherever needed in the ditches conducting water to the various parts of the farm. A record has been kept of the length of time water flowed through any particular box upon any particular crop, the depth of the stream in the box noted, and the quantity of water applied at each irrigation thus determined. A record of the yield of each crop has also been kept, and so far as practicable a record of the cash return, or at least the cash value, of each crop. A bulletin embodying the results of these experiments is contemplated for the future.

RELATION OF TEMPERATURES TO CROPS.

During the past two years quite careful observations have been made and complete records kept of the effect of high and of low temperatures upon the various crops growing upon the Station farm. During this period six to eight sets of self-recording maximum and minimum thermometers have been stationed at various points on the farm. One set was placed within a few inches of the soil, one set five feet above, and one set ten feet above the surface. Other sets were placed in various situations among growing crops. Besides keeping records from these thermometers, a record was made from the Government Weather Bureau thermometers kept in the regulation thermometer shelter.

Observations were made and notes taken upon the effects of low temperatures upon various crops, and of the temperature at which sensitive crops were killed by frost. Observations and records were also made of the high temperatures injuring or killing plants sensitive to heat.

EVAPORATION EXPERIMENTS.

During the past year a beginning has been made in a study of the rate of evaporation from water and from soil, under the varying degrees of temperature, of relative humidity, and of wind velocity. A record is being kept of the evaporation from a tank of water, by making measurements morning and evening; and cylinders of two sizes and depths filled with soil and placed with their rims even with the surface of the outer soil, are weighed morning and evening. The soil in the cylinders is irrigated and otherwise treated as nearly like the soil of fields as possible. The purpose is to obtain data that will be a basis for the intelligent handling of field soils. When sufficient data are obtained, the intention is to prepare a bulletin embodying the results.

A. J. McCLATCHIE,
Agriculturist and Horticulturist.

DEPARTMENT OF ANIMAL HUSBANDRY.

STEER FEEDING.

Experiments in steer feeding begun last year have been continued, following the same general plan, with a view to determining the comparative merits of feeding alfalfa alone and feeding it in combination with more carbonaceous materials, such as sorghum and grain hay.

The bunch of steers used in the experiments reported last year were carried through two more experimental periods. The first of these was preliminary to the second. During this period, from September 5 to October 9, the eight steers were all fed alike on alfalfa pasture and mixed barley and alfalfa hay, 10.6 lbs. of hay per day being eaten by each steer. Under this treatment the animals in Lot I made an average gain of 1.49 lbs., each, per day, and those in Lot II, 1.21 lbs.

PASTURE AND ALFALFA HAY VS. PASTURE AND WHEAT HAY.

The second period referred to above was one of nine weeks, from October 9 to December 11, during which Lot I was fed alfalfa hay and Lot II wheat hay, in addition to alfalfa pasture. The results are given in the following table:

Lot	*Feed*	*Steers*	*Weight at beginning*	*Pounds gain*	*Daily lbs. gain*
I	Alfalfa pasture and alfalfa hay, 8415 lbs.	2	1104	84	1.28
		4	1085	66	
		5	1171	100	
		8	947	72	
II	Alfalfa pasture and wheat hay, 6874 lbs.	1	1243	70	.83
		3	1035	56	
		6	1067	50	
		7	1013	32	

SUMMARY.

For seventeen weeks during this series of experiments alfalfa was fed against wheat hay or sorghum, to animals on pasture. During this time the four steers having only alfalfa gained 127 pounds more than the other four.

For sixteen weeks alfalfa hay was fed against combinations of alfalfa hay with corn fodder, Kaffir corn or sorghum, during which time the four animals receiving the other feeds in combination with alfalfa gained 59 pounds more than those having alfalfa only.

During the thirty-three weeks that alfalfa only was fed against combinations of alfalfa and other forages, the animals having only alfalfa gained 1.55 lbs. per day while those receiving the combination gained 1.46 lbs. per day.

In May a car load of range cattle was purchased of Col. H. C. Hooker of Willcox and with them experiments along this line will be continued.

THE DAIRY HERD.

On June 19th, 1900, six two-year-old heifers of unknown breeding were purchased. They had all been bred to calve at from eighteen to twenty-four months of age, had been in milk for about six weeks when purchased and were in very poor condition. Since their purchase the milk from each cow has been weighed and tested for butter fat and a record kept. During the year for which the record is given below the only feed received by the cows other than pasture was hay during the last two weeks in September and first two weeks in October, and sugar beets for two weeks in November and December. For three weeks in July and two weeks in August and September, instead of

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NOTES.—At the close of the last experiment the eight steers referred to above were sold to a San Diego buyer for Christmas beef at \$4.30 per cwt., \$3.75 and \$4.00 being the prevailing prices at the time.

These steers were from ten to fourteen months old when purchased and during the year fed gained 3817 lbs., an average of 477 pounds.

Steers No. 2 and No. 6 made the greatest gain—503 lbs. each—while steers No. 7 and No. 8 made the least gain—448 lbs. each.

Steer No. 6 made the greatest per cent gain over his original weight —82 per cent—No. 8 being second with 78 per cent gain.

Steers Nos. 1 and 5, the oldest and heaviest animals, ranked third and fourth in pounds of gain, and seventh and eighth in per cent of gain.

ONE YEAR'S RECORD OF THE STATION HERD.

Month		*No. 1*	*No. 2*	*No. 3*	*No. 4*	*No. 5*	*No. 6*
July	Lbs. milk	494.2	447.4	334.0	449.8	451.6	462.1
	% Fat	3.55	4.85	5.75	4 24	4.47	4 33
	Lbs. fat	17.53	21.68	19.19	19.06	20.17	20.00
Aug.	Lbs. milk	545.0	525.9	402.5	546.6	569.1	544.5
	% Fat	3.52	4.17	5.21	4.26	4.52	3 92
	Lbs. fat	19.21	21.92	20.96	23.33	25.71	21 32
Sep.	Lbs. milk	478.0	430.6	377.6	474.1	465.4	440 4
	% Fat	3.6	4.77	5.39	4.3	5.2	4.65
	Lbs. fat	17.18	20.54	20.35	20 39	24 24	20 49
Oct.	Lbs. milk	426.0	389.0	328.6	478.6	379.3	381.1
	% Fat	4.06	5.66	6.66	5.0	6.13	5.67
	Lbs. fat	17.72	22.04	21.89	23.93	23.24	21.62
Nov.	Lbs. milk	391.3	352.7	298.9	433.1	321 2	268 7
	% Fat	3.92	5.52	5.94	5.05	5.7	6.35
	Lbs. fat	15.22	19.52	17.76	21.86	18.30	17 05
Dec.	Lbs. milk	412.9	362.5	279.9	480.6	388.0	405.7
	% Fat	4.42	6.26	7.28	5.00	6.00	5.99
	Lbs. fat	18.27	22.70	20.39	24.56	23.26	24.32
Jan.	Lbs. milk	410.1	443.5	306 8	535.8	375.6	470.3
	% Fat	4.56	5.86	7.10	5.07	6.15	5.86
	Lbs. fat	18.48	26.10	21.78	27.19	23.08	27.54
Feb.	Lbs. milk	351.3	296.6	228.9	365 8	221.8	344.3
	% Fat	4.83	6.78	7.75	5.71	7.45	6.42
	Lbs. fat	16.99	20.34	17.74	20.81	16 53	22.11
Mar.	Lbs. milk	394.2	339.6	286.6	472.9	274.3	443.6
	% Fat	4.64	6.13	7.17	5.42	6.74	6.11
	Lbs. fat	18.29	20.82	20.55	25 64	18.49	27.12
Apr.	Lbs. milk	380 8	385.1	181.9	510.1	234.0	413.8
	% Fat	4.79	6.05	6.94	5 45	7.0	6.41
	Lbs. fat	18.27	23.29	12.69	27.82	16 04	25 55
May	Lbs. milk	413 0	441.7		561.8	9.5	451.5
	% Fat	4.79	5.87		5.41	5.7	5 95
	Lbs. fat	19.81	25.91		30.41	.53	26.85
June	Lbs. milk	391.0	409.2	599.5	501.5	685.0	427.6
	% Fat	4.78	5.58	4.59	5.07	4.47	5.57
	Lbs. fat	18.70	22.73	27.40	25.44	30 64	23.81
Total	Lbs. milk	5087.8	4823.8	3625.2	5810.7	4374.8	5053.6
	% Fat	4.24	5 54	6.08	5.00	5.5	5.5
	Lbs. fat	215.66	267.59	220.70	290.45	240.24	277.79

running on pasture, the cows were kept in corrals and alfalfa was cut and fed to them. They have had no shelter. So it may be said that our cows during this year have received about the same treatment given his cows by the average ranchman. The record, as showing the difference in value of the different cows, is especially interesting when it is known that cow No. 1 is most often selected by dairymen as the best cow in the herd.

RECORD.

In addition to the tabulated record the following chart will be of interest. Two cows of the herd calved before the end of the year and four proved not to be in calf. In the case of these four cows, therefore, the conditions affecting the production of butter fat and milk were the same for each throughout the year, and Fig. 1 is intended to show graphically their monthly variations in pounds of milk given, per cent of fat, pounds of fat and cash return during the year.

It will be observed that the first line, showing the variations in pounds of milk given, is the most irregular. This line shows the average daily milk yield of the four cows for each month of the year.

The second line, showing the variation in per cent of fat in the milk, indicated that as a rule an increase or decrease in milk flow was accompanied by an opposite change in the per cent of fat. In November, however, a decrease in milk flow was accompanied by no change in per cent of fat. In December there was an increase both in the flow and in the richness of the milk, while in June there was a decrease in both. Speaking generally, there was a gradual increase in the per cent of fat from August to May, after which there was a decrease.

This may be taken as an indication that the highest per cents of fat in milk are not maintained during the heat of summer.

The third line, showing the production of butter fat, is notably the most even, the amount of butter fat given being more constant than the amount of milk given or its quality.

The figures for which the fourth line stands were obtained by multiplying the pounds of fat given, and shown in the third

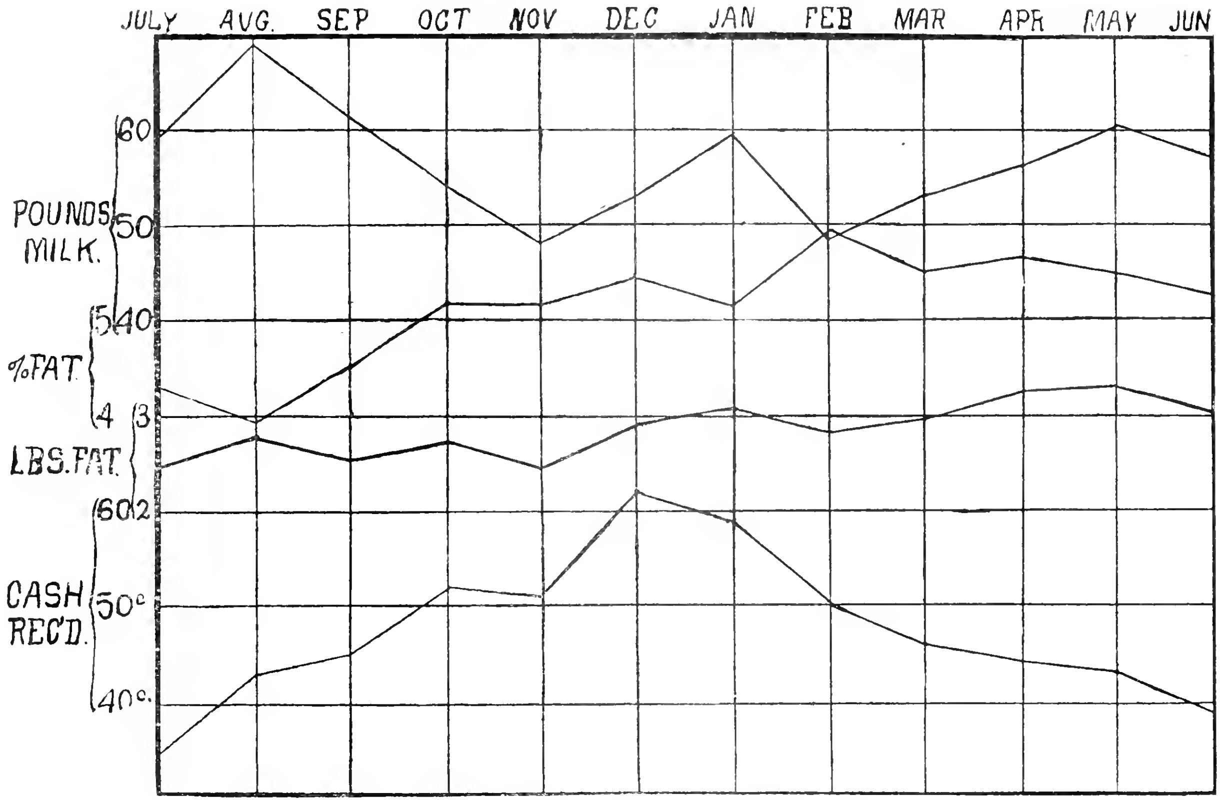

Fig. 1. One year's record of four cows of the Station herd.

line, by the price of butter fat at the creameries for each month. Here is illustrated the great advantage of winter dairying and the importance of having cows at their best during that part of the year when prices are invariably highest.

FEEDING SUGAR BEETS.

A few sugar beets on hand, as a result of experiments in growing them for sugar production, gave an opportunity for trying them as feed for cows. It was planned to feed beets to three of the cows on pasture for two weeks, to the other three cows for the following two weeks, and then compare the product of the six cows with and without beets during the month covered by the trial. Two conditions operated to lessen the value of the experiment; first, cow No. 2 refused to eat beets; second, a very trying storm from which there was no shelter, caused all the cows to drop off in both milk and butter fat to such an extent that one could not consider the variations during that period as due to feeding. Fig. 2, herewith, upon which the lines show the variation in production of butter fat by weeks for each of the six cows of the herd during the period of feeding, and the weeks immediately preceding and following, may be studied with interest. The effect of exposure to storm (during the second week of the trial, ending November 27th,) upon the production of butter fat is most clearly shown. This was not so great in the case of the two cows receiving beets. The increase shown

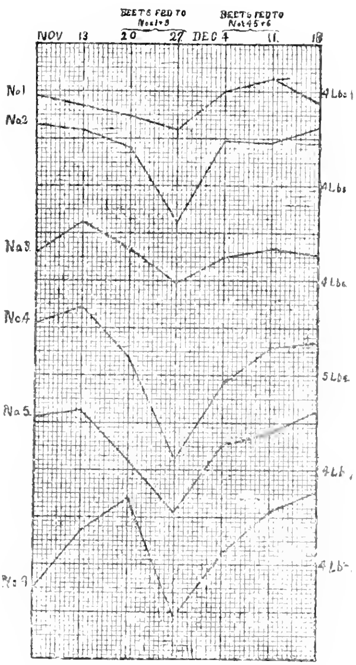

Fig. 2. Showing effect of storm upon butter fat production.

by cows Nos. 4, 5 and 6 during the two weeks immediately after the storm, when they were fed beets, is to be noted. There is no way of determining, however, how much of this gain is due to normal recovery following adverse conditions, and how much to additional feed.

Cows Nos. 1 and 3 ate 775 lbs. of beets each and cows Nos. 4, 5 and 6, 625 lbs. each.

SOILING.

Soiling experiments planned were seriously interfered with by the very severe drouth of the summer and fall. Our experience seems to point to the fact that feed may be very much economized by cutting and feeding instead of pasturing. Especially is this the case in seasons of shortage in irrigation water when it is impossible to irrigate any considerable part of a field at a single run of water. More experiments along this line are under way and will be reported in detail later.

DEHORNING COWS.

On January 30 the cows of the herd were dehorned by Mr. John Elvey by use of the Newton dehorning clippers. Again a storm prevented the observation of a change in condition, for rain fell on eight of the eleven days following the operation.

By referring to the tabulated record and to Fig. 1, it will be seen that a very serious falling off in amount of both milk and butter fat took place during the month following dehorning.

The per cent of fat in the milk increased but not sufficiently to overcome the decrease in amount of milk given.

How much of this falling off in butter fat is due to dehorning and how much to storm we are unable to determine.

GORDON H. TRUE,
Department of Animal Husbandry.

DEPARTMENT OF BOTANY.

RANGE IMPROVEMENT.

This division of the department's work has been conducted in co-operation with the Division of Agrostology, U. S. D. A., according to arrangements made with the U. S. Secretary of Agriculture.

The range improvement work in Arizona, being of a different character than that usually contemplated, and being in a region more completely divested of range grasses than probably any other in the entire country, required considerable careful study beforehand in order to discover the proper locality for experimentation. Accordingly, considerable time was spent in a survey of the surrounding country in the vicinity of Tucson, for the purpose of determining which of three typical areas (mesa, foothill, or river bottom) would be the most favorable and give the most conservative and valuable data upon which to base judgment of the results obtained by experimentation. Finally, a rather favorable mesa area was selected at an altitude of about twenty-six hundred feet above sea level, and about four hundred feet higher than the city of Tucson. This tract, which was subsequently reserved from entry at the request of the Honorable James Wilson, United States Secretary of Agriculture, is described in the government surveys as Sections 26, 27, 34 and 35; T. 14 S., R. 14 E., Gila and Salt river meridian.

Somewhat diagonally through the center of this area runs the Southern Pacific railway, and a short distance to the east of it is located Wilmot siding. The soil is a clay loam, mixed with considerable sand, and subtended at a depth of two to two and a half feet by a calcareous hardpan known among the Mexicans by the significant name, "Caliche." The slope, which is rather gentle, has a general northwesterly direction, and is traversed by three more or less distinct, broad, shallow depressions which receive the drainage of a considerable area of land to the southeast. Such a region, with broad, shallow washes, was purposely selected. It was the intention to attempt to conserve water flow on the mesa, and to discover what can be done towards preventing "run-off" of water during the rainy season of July and August. Such washes, although the most favorable for the growth of vegetation of all kinds, are nevertheless typical of large tracts of desert not only in the Santa Cruz, but in the San Pedro, Gila and Salt river valleys as well.

A triangular portion of this reservation, consisting of three hundred and thirty-six acres, adjoining the Southern Pacific right of way, has been placed under a substantial four-wire fence. The area compasses nearly all varieties of exposure, drainage and soils, and is, in short, a typical mesa region in every respect. The advantage taken of the railway fence enabled us to enclose the tract at a minimum cost. Two miles of fence, at an approximate cost of $150.00 a mile, covers practically the entire expense of the enclosure.

Recognizing that the greatest probability of success would attend our efforts if we restored as nearly as possible Nature's conditions, rather than attempt to introduce foreign plants (always of questionable adaptability), a special effort was made to secure native seed for experimentation; seed of those plants which we know grew in the region in greater or less profusion before the advent of the white man with his destructive herds of cattle and sheep. Accordingly, the writer made a short trip into the Sulphur Spring valley in October, and secured some eighty bushels of seed of a great variety of native forage plants. These were shipped to the Division of Agrostology, cleaned, and returned in January.

All the cultural operations which have been performed thus far were conducted during the month of January, and under very favorable auspices as far as climatic conditions are concerned. Fifty-two acres of the reservation is now under cultivation, and it is the intention to operate on more ground next season. The cultivated portions are distributed over the fenced area in four localities, each portion being subdivided into plots varying in size according to the quantity of seed available. The salt bushes have been planted in an area by themselves, in the edge of one of the broad washes described above. Considerable seed of foreign plants was put in here; but about half of the ground planted was put into native seed collected in the vicinity of Tucson and Tempe.

The main cultivated areas are two in number and extend in long strips four hundred feet wide directly east and west, and consequently diagonally across the shallow washes. These have been subdivided into rectangular plots of variable size, and sown mainly with seed of native grasses, but also with the more promising drouth-resisting varieties from other regions.

The cultural operations are vastly more simple than those usually employed. This is necessarily so, because *improvement of the range at the least possible expense* is the desideratum here, and not the growing of the greatest amount possible per acre. The production of forage is so small here at best that one is obliged to measure his pasture by square miles, rather than acres, and the operations in range improvement must be on a correspondingly large scale. It has been deemed wise, therefore, to operate simply, but on comparatively large areas. The only implements used are disc and fine tooth harrows Every possible combination of these has been employed. In some cases, the seed was sown directly on the mesa with no previous preparation of the soil; in others, discing or harrowing preceded planting. In all cases the seed was covered by discing or harrowing, or by both combined. As far as possible, all cultural operations extended lengthwise of the long strips, and therefore, diagonally across the washes. The gangs of the disc harrow were set so as to ridge up the ground as much as possible. This method spreads the run-off of water over more land, and the ridged condition holds it to a greater extent than any other method would do.

Similar cultural operations have been conducted on unseeded areas, to ascertain the effect on the native vegetation which springs up immediately after a season of rain.

The fifty-two acres under cultivation are divided into sixty plots on which have been sown about forty species of forage plants.

A small grass garden has been started on the University grounds, in which nearly all of the varieties sown on the reservation have been planted in small quantities. Here moderate irrigation is practiced. One of the objects of this garden is to form a check upon the seeded plots on the reservation.

Owing to the diversity of climatic and soil conditions which obtain in southern Arizona, it has been thought wise to extend operations over a greater variety of territory than would be possible in the immediate vicinity of the University. Consequently, a plan was inaugura to co-operate in the matter of range improvement with farmers and ranchers who were located in favorable situations. Aside from the work performed directly by the writer, experiments are being conducted at nine other stations in southern Arizona. In all of these cases those interested are doing the work with seed distributed from this Station.

In connection with the range work, three precipitation records are being taken, in order to determine to what extent variation in this particular obtains. The extremely local condition of rainfall during the summer season is a matter of common observation. It is, therefore, necessary that the relative rainfall of different areas be known in order to render more intelligently the significance of the experiments conducted upon them.

THE AUSTRALIAN SALTBUSH.

Encouraged by the experiments which have been conducted with this plant, the Station made a distribution of seed to those who applied for the same according to the offer made in Timely Hint No. 33. This valuable forage plant is now well distributed over the Territory, and it is hoped that if it proves to be adapted to this climate, it is well established. A portion of the seed distributed was furnished by the Division of Agrostology, U. S. D. A., and the remainder was kindly donated by the authorities of the California Experiment Station to whom acknowledgments are due.

PARASITIC FUNGI.

Considerable attention has been paid to this important line of investigation. While our correspondence has not been great with reference to any one plant disease, yet there are indications that considerable injury is being done by a goodly number of these pests in the Territory. The greatest amount of correspondence results from root rots of various forms.

The experiments conducted last year by Professor Tyler have been continued the present year and preparations are being made for still further investigations later in the season. The investigations of Professor Tyler were on the whole encouraging. The plot upon which experiments were conducted with various chemicals produced, according to reports of Mr. Grossetta's foreman, the best crop of alfalfa on the ranch. No distinction was observable, however, in the effect of the different chemicals used. The experiment is simply encouraging and does not indicate positive results because the treated plot received about four times as much water as any other portion of the field. The successful crop may be due entirely to the action of an abundant supply of water. However, even if this is true the experiment is valuable.

Experiments are being conducted on Mr. Grossetta's ranch again this year mainly for the purpose of determining the utility of the ditching system and also for the purpose of ascertaining whether areas over which the disease has passed can be successfully reseeded.

Small plots of alfalfa have been planted on the University campus with seed obtained from various sources. Inoculation experiments will be conducted on these plots during the month of August for the purpose of determining the communicability of the disease under variable moisture conditions.

ECONOMIC CACTI.

The writing on this line of investigation was quite exhaustive in the last annual report. Being plants of very slow growth, no special results can be expected for years to come. Many of the plants which were set out last year have died either from drouth or depredations of animals. These have been replaced as far as possible by other plants from the same source.

SCIENTIFIC.

Parallel with the economic work of the Station, considerable investigation of a purely scientific nature has been conducted. However, it is very difficult to state at this time how much economic bearing apparently pure scientific truths may have in the future.

A collection of about 400 plants bought by the University some time ago has been mounted and distributed in the herbarium together with some 300 sheets which were previously mounted. The working capacity of the herbarium has therefore been increased by about 700 sheets.

During the past favorable season a special effort has been made to secure specimens of the local flora. Since the first of September about 1200 numbers of plants (1500–2700) have been collected. These are, of course, to some extent duplicates of plants already in the herbarium, but even so they are very valuable in studying variation, distribution, etc. The grasses from these collections have been sent to Professor F. Lamson-Scribner, U. S. Department of Agriculture, who has recently published a pamphlet containing the results of his determinations. The collection he reports to be a large one for the time employed in its gathering. It contains about a half dozen species new to science.

The writer has published one paper * in which a new species of ergot collected on galleta grass at Cochise was described. This may be of some economic importance, for it is well known that the closely related common ergot of the wheat grasses is very injurious to cattle in some of the prairie states.

DAVID GRIFFITHS,
Botanist.

* Bull. Torr. Bot. Club, 28: April 1901.

DEPARTMENT OF CHEMISTRY.

IRRIGATION WATERS.

The examination of the water of the Salt, Gila and Colorado rivers, the three principal sources for irrigation purposes in the Territory, has been completed during the year. The work is being tabulated and studied, and the results are to be published in the near future. Some idea of the scope of the work may be gained when it is understood that samples were taken daily for one year, so far as possible, from the three above mentioned rivers, and sent to the Station laboratories of the University, where the examination to which they were subjected necessitated the making of over two thousand analytical determinations.

The year during which samples were taken proved to be in some respects an unfortunate selection, owing to the fact that it was abnormally dry, the rainfall in the watershed of the Salt river being less than one-half of the average for the five or more years for which the records have been kept. It therefore follows that all the figures obtained are below what they would be for a normal year. However, being a dry year, the amount of water used by the canals more nearly approached the total volume of the river; hence, the flow of Salt river at all times being known, the quantitative data for the effect of irrigation upon the lands of the Salt river valley are available, because the various amounts of silt and soluble salts carried upon the land very nearly approaches the total amount carried by the river.

The quantitative silt determinations, both by weight and volume, made upon these waters bear upon the discussions relating to storage reservoir construction. Our observations, though made during a year when the total silt was much smaller than the average, are accurate, afford a reliable basis from which to make estimations, and will yield a maximum figure for the life of specified reservoirs upon the streams stated.

The results will be of much value to the agriculturist, and to prospective investors, not only showing the character of the irrigation water but indicating probable future effects from the soluble salts that it may contain, both injurious and beneficial. It is of interest to note that the nitrogen, potash, and phosphoric acid, the three essential plant foods carried upon the valley by the Salt river during the period for which we examined it, had a market value of about one million dollars.

Thus this river in a measure stands in a somewhat similar relation to the valley farmer that a fertilizer factory does to his eastern brother.

There are other questions of importance which will be discussed more in detail in a station bulletin concerning this work, which will be issued in the near future.

SUGAR BEETS.

Experimental sugar-beet culture was continued in the vicinity of Pima and Safford, Arizona, during the season from January to August, and this line of work was brought to a satisfactory close. This year's investigations conclude a thorough examination into the possibilities of sugar-beet culture in the Territory, carried on for five years past. The results place Arizona in an intermediate position as to the quality of beets produced for the support of factories in other states.

Aside from quality of beets, certain agricultural and factory conditions, such as the advantage of irrigation over precarious rainfall; and fuel, water and limestone supply, may secure a place for the Territory among future sugar producers.

The following table states the results obtained at Pima and Safford this year :

Plot.	Date of planting	Date of harvesting.	Kind of soil.	Sugar in beets.	Purity	Tons per acre.	Variety of seed.
	1901			%			
1	Feb. 6	July 25	Alkaline, peaty, black soil	11.45	79.3	29.8	Kleinwanzlebener from Chino
2	" "	" "	" " "	10.45	77.4	38.4	" "
3	" 19	" 11	Clay loam	13.97	84.8	11.4	" "
4	" "	" 25	Sandy loam	12.73	82.5	16.4	" "
5	Jan. 31	Aug. 12	Sandy loam	12.81	77.1	31.1	" "
8	Feb. 26	July 22	Silty loam—in sugar beets last yr	12.97	85.5	13.0	" "
9	" "	" "	Silty loam-new alfalfa ground	12.47	81.9	13.8	" "
10	" "	Aug. 14	" "	14.8	84.1	12.3	K. W. Wohanka Ertragreicher
11	" "	" "	" "	14.37	82.3	15.7	K. W. Wohanka Zuckerreicher
12	" "	July 22	" "	14.8	84.5	11.3	Vilmorin, 3941 U. S. D. A.
13	" "	" "	" "	14.77	85.5	14.2	K. W. Russian, 4416 U. S. D. A.
14	" "	Aug. 14	" "	14.14	81.7	16.1	K. W. Russian, 3943 U. S. D. A.
15	" "	" "	" "	16.15	85.3	18.1	K. W. Dippe, 2868 U. S. D. A.
16	" "	" "	" "	13.3	80.1	22.7	K. W. Chino
17	" "	" "	" "	15.18	83.5	15.0	Vilmorin, 3941 U. S. D. A.
20	" "	" "	" "	13.47	80.4	25.6	K. W. Chino
22	" "	July 23	" "	11.38	76.9	22.5	K. W. Chino
			Average of all plots.	13.48	81.9	19.3	

The varying figures from these seventeen plots show the influence of soil, seed, and cultural methods upon beets produced in the same neighborhood, and will be discussed in a final bulletin on the subject.

The average result,—13.48 per cent of sugar in beets, 81.9 purity and 19.3 tons per acre, amounts to 5211 pounds of sugar per acre in a satisfactory condition of purity. This is above the average for the United States at large; but, so far as quality is concerned, is of course below the extraordinary crop which, after three years' drouth, has just been harvested in California.

MISCELLANEOUS.

Aside from the numerous samples of irrigating waters and sugar beets, attention has been devoted to miscellaneous samples of soil, milk, cream, silts, honey and minerals to the number of thirty-seven.

Requests for analytical work for private parties are received occasionally, which are attended to as time permits. When the results are of public interest and we are permitted to publish them, no charge is made; otherwise, compensation is received for such work, the proceeds being expended for the benefit of the Station.

R. H. FORBES,
Chemist.

W. W. SKINNER,
Assistant Chemist.

SUPPLEMENTARY — THE DATE PALM ORCHARD.

Referring to the date palm orchard on page 315, which, it should have been repeated, is co-operative between the U. S. Department of Agriculture and the Arizona Experiment Station:

As this report goes to press another carload, consisting of 35 very large date palms, has been received from Mr. D. G. Fairchild, Agricultural Explorer for the U. S. Department of Agriculture. Owing to the lateness of the season, these trees have been stored in the greenhouse at Tucson for the winter, and will be transplanted to the orchard next spring. The Egyptian agent from whom these trees were secured, contrary to instructions, shipped them rooted in tubs of earth in the old-fashioned way. The consignment in this shape weighed about 25 tons.

It is to be remembered that Mr. W. T. Swingle's shipment of last year, from Algiers, tabulated on page 316, also occupying a car, consisted of 440 suckers packed in wet moss and boxed.

It is due to Mr. Swingle's good judgment and experimental courage, in employing this mode of shipment for the first time, that an economical method of importation has thus been demonstrated. His success will no doubt materially encourage the importation of suckers by private parties and thus hasten the development of the industry. R. H. F.

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Indexed by Wilbur O. Hayes.

Annual reports, the titles of bulletins, and some important subdivisions of the texts are printed in capital letters. Scientific names are in italics. Numbers of bulletins and dates of annual reports are printed in heavier type than page numbers.

Note: On account of duplicate paging, bulletin 40 is indexed in italics.