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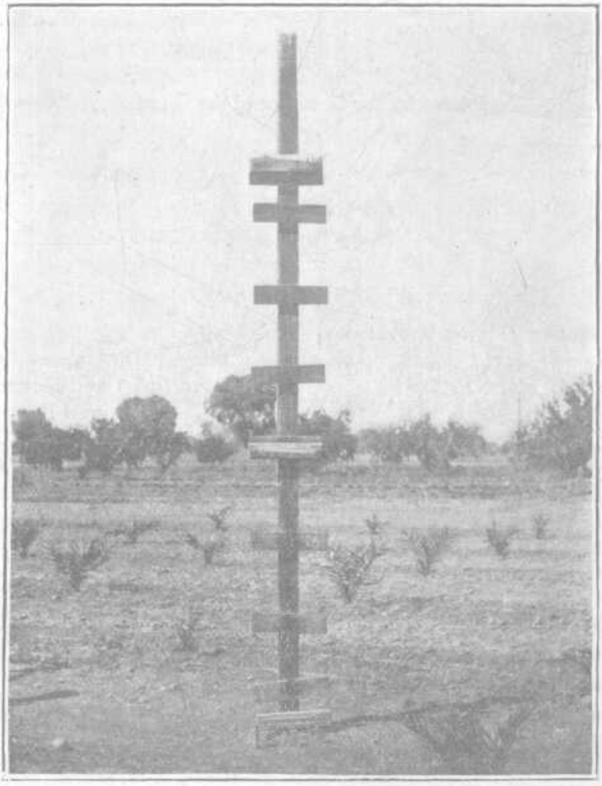

Six self-registering thermometers in open air.

Relation of Weather to Crops.

BY ALFRED J. McCLATCHIE

Tucson, Arizona, June 10, 1904.

The Experiment Station office and the botanical and chemical laboratories are located in the University main building at Tucson. The range reserve is suitably situated adjacent to and southeast of Tucson. The departments of agriculture and horticulture and of animal husbandry conduct operations on the Experiment Station farm, 3 miles northwest of Phoenix, Arizona. The date-palm orchard is 3 miles south of Tempe, Arizona.

Visitors are cordially invited, and correspondence receives careful attention.

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

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

Address,

THE EXPERIMENT STATION,

Tucson, Arizona.

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Seewah Date tree bearing 200 pounds of fruit. A crop well adapted to the climatic conditions of the region.

RELATION OF WEATHER TO CROPS.

By A. J. McClatchie.

INTRODUCTION.

In the following pages the aim is not only to record and discuss the observations made during the past six years upon the relation of the weather to crops, but to bring together in one publication many minor facts that have not found their way into previous bulletins. The large number of inquiries received concerning crops adapted to the region indicates the need of printed information on the subject. As new settlers are continually coming to the region, and as the indications are that large numbers will come in the future, a publication giving general information will undoubtedly be serviceable.

The total *amount* of agricultural products that Arizona will yield is limited principally by the quantity of *water* available for irrigation, the area of arable land being far in excess of the acreage for which there is a water supply. The *nature* of these agricultural products is determined largely by the *climate* of the region. The relation of the water supply to crops and crop production was discussed in Bulletins 41 and 43. In this bulletin, the relation of the weather to crops and crop production is discussed. The water supply and the weather being the two chief factors affecting agriculture in the Southwest, the subjects discussed in these three bulletins cover the principal part of the ground.

The aim of the writer has been to state the facts as accurately and fairly as practicable. It is hoped that no statements are made that will be in any way misleading to any one who may consult the bulletin for guidance in farming operations.

CLIMATE OF ARID INLAND REGIONS.

Inland arid regions have a climate distinct in character from the climate of other parts of a country. The absence of a large body of water to modify temperatures, and the lack of moisture in the atmosphere to check radiation of heat permit variations of temperature that do not occur in humid and coast regions in the same latitude. The potent regulator of temperatures being water, in its absence either in a body or as vapor in the atmosphere, great extremes of temperature may occur. Consequently, inland arid regions have a greater range of temperatures than do other regions. The difference between winter and summer temperatures and the difference between the maximum and the minimum temperature occuring within the same twenty-four hours is considerably greater than in humid and coast regions in the same latitude. The winters are colder and the summers hotter; the nights are comparatively cooler and the days comparatively warmer

The climatic conditions that prevail in interior arid sections are trying to many plants. Some plants, however, have become so modified through long growth in such an environment as is found in the arid inland regions that they grow best there. But a large number of plants either cannot be grown under such conditions successfully, or their culture is attended with many difficulties, even though water be supplied artificially. Annual crops sensitive to cold cannot be grown in such regions during winter, and those sensitive to heat cannot be grown during summer, Crops sensitive to both heat and cold have only a short period during which they can grow. Some crops* though able to endure the temperatures to which they are exposed, and though supplied with plenty of water at their roots, cannot endure the aridity of the atmosphere. Perennials sensitive to cold are injured or killed by the winter frosts, and those sensitive to heat and drought cannot endure the high temperatures and the dry atmosphere of summer.

The agriculture and the horticulture of inland arid regions have, therefore, many limitations. The variety of crops is necessarily not as great as in humid coast regions in the same latitude; and the difficulties encountered in the production of many of the crops grown are greater. On the other hand, crops as a rule are freer from fungus diseases and from insect pests in arid regions. But insects and plant diseases are more easily combated than climatic conditions. On the whole, therefore, conditions in arid regions call for much perseverance and a careful study of the situation on the part of farmers Nowhere is greater intelligence and more alertness demanded; and nowhere will efforts directed along proper channels be more substantially rewarded.

CLIMATE AT STATION FARM.

GENERAL FEATURES.

The Experiment Station farm is situated in a typical arid semi-tropical valley, one of the warmest argicultural sections in the United States. The valley lies on either side of the Salt River, extending ten to fifteen miles north and south and about thirty-five miles east and west, the farm being situated near the center of this area. The surface of the valley is even and nearly level. Before settlement, most of it was only sparsely covered with vegetation, being a part of a large area, consisting of contiguous valleys, called "desert." The average rainfall is less than seven inches; the rains occurring mostly during two seasons — one being in the winter, and one in the summer. During and following these two rainy seasons native annuals spring up and mature, and perennials make a fresh growth. During most of the year, the air is very dry, and evaporation consequently rapid. Crops can be grown only by the application of irrigating water, the most of which is brought from the Salt River through a system of canals. At present about 120,000 acres, or less than half the area of the valley, are under cultivation; but the cultivated area is to be increased about one-half by the creation of a large reservoir for storing the flood waters of the Salt River.

The climate at the farm is distinctly inland in type, there being sharp frosts in winter and very hot weather during summer. The coolest weather occurs during December and January, during which months the mercury usually falls to or below freezing, at the ground, the majority of the nights. The lowest temperatures usually occur between the middle of December and the middle of January, the mercury falling to 18 to 20 degrees Fahrenheit, in a government shelter located five feet above the ground, once or more during most winters. February is generally considerably warmer than the two preceding months, little frost occuring during the month some years. March is still warmer, but frosts are liable to occur, usually between the tenth and the twentieth of the month. Subsequent to this month frosts seldom occur.

The weather becomes distinctly warm during May, and by the end of June the hottest dryest weather of the summer is liable to occur. The highest temperatures usually occur between the twentieth of June and the twentieth of July, the mercury rising to 112 to 114 degrees Fahrenheit in the government shelter most summers. Hot weather usually continues through August and much of September, after which it grows gradually cooler.

COMPARISON WITH CLIMATE OF COAST REGIONS.

The latitude of the Experiment Station farm is about the same as that of Charleston on the Atlantic coast, and intermediate between that of San Diego on the Pacific coast and Los Angeles situated about fifteen miles inland. As would be expected, its climate differs in a marked degree from that of these coast towns, in respect to humidity and range of temperatures. While weather records kept at the farm show a considerably greater range than do those kept at the Phoenix Weather Bureau office (due to the instruments at the latter place being situated on the roof of a building fifty feet from the ground) yet in order to make a fair comparison between the recorded climate of the Salt River Valley and that of the coast towns, it will be necessary to use the Weather Bureau figures from each place, it being assumed that the government instruments are similarly placed at each station. The Phoenix Weather Bureau record extends over a period of eight years, and the averages for the same period of time are used from the other stations.

The annual mean temperature at Phoenix is 69, and that of Charleston 66, a difference of only three degrees. The great difference between the climate of the two places is *in* the relative humidity, and the annual and diurnal range of temperature. The mean relative humidity is but 35 at Phoenix, while it is 76 at Charleston The mean annual range of temperature (the average difference between the highest and lowest temperature occurring during each year) is 88 at Phoenix and 81 at Charleston. The mean daily range (the average difference between the daily maximum and the daily minimum temperatures) is 29 at Phoenix, while it is but 13 at Charleston. The mean yearly maximum temperature at Phoenix is 84, and at Charleston, 73; the mean yearly minimum temperature at Phoenix is 55, and at Charleston, 60. Thus, though the nights average five degrees cooler at Phoenix, the days average eleven degrees warmer. The mean maximum temperature for the three summer months, June, July and August is 103 at Phoenix, and but 87 at Charleston; and the mean minimum temperature for the three winter months, December, January and February, is 39 at Phoenix, and 44 at Charleston. Thus, while the summer days average sixteen degrees warmer at Phoenix, the winter nights average five degrees cooler, the difference between the mean yearly maximum temperature at the two places being due principally to the high summer maximums at Phoenix. The combined effect of the low relative humidity and the wide range of temperatures at Phoenix is a climate that has a very different influence upon vegetation than has that of the seaboard city situated in so nearly the same latitude.

A comparison of the climate of Phoenix with that of San Diego and Los Angeles furnishes further illustration of the difference between the climate of this arid inland region and that of a moist coast region:

	Mean Rel. Humidity	Mean Max. Temp.	Mean Min. Temp.	Mean Annual Temp.	Mean Annual Range.	Mean Diurnal Range.	Mean Summer Max.	Mean Winter Min.
Phoenix	35	84	55	69	88	29	103	39
Los Angeles	72	73	51	62	66	22	79	45
San Diego	74	67	54	60	54	13	70	49

It will be observed that the figures from the three places constitute a regular gradiation, the relative humidity increasing from 35 at Phoenix to 74 at San Diego, the mean maximum temperature decreasing from 84 at Phoenix to 67 at San Diego, the mean annual range from 88 to 54. the mean diurnal range from 29 to 13, and the mean summer maximums from 103 to 70, while the mean winter minimum temperature increases from 39 at Phoenix to 49 at San Diego. It is quite evident that the absence of the regulating influence of the ocean, combined with tbat of a moist atmosphere consequent upon its proximity, permit ranges of temperature at Phoenix that cannot occur in a coast region in a similar latitude.

As has already been stated, the range of temperatures at the Station farm is considerably greater than those recorded from the Weather Bureau instruments situated on a building in Phoenix. The mean annual maximum temperature at the farm (in a regular Weather Bureau shelter like the one in use at the station in Phoenix) is 86, the mean minimum temperature 51 and the mean diurnal range 35, the mean maximum being, therefore, two degrees higher than at the Weather Bureau and the mean minimum four degrees lower, while the mean diurnal range is six degrees greater. The combined effect of such climatic conditions is very trying upon some crops that are grown at the farm and in the surrounding valley, and prevents the successful culture of many crops experimented upon at the farm and attempted by neighboring farmers.

CROPS GROWN AT THE STATION FARM.

Before proceeding with a discussion of the collated data upon the climatic conditions at the farm, or a consideration of the results of the study that has been made of the relation of the temperatures that occur there to growing crops, it will be well to state what crops have been grown on the farm, and what crops we have not succeeded in growing there satisfactorily. For, since all crops grown in the region, and all that there seemed any probability of growing successfully, have been subjects of experiment during the past six years, considerable knowledge as to what crops are adapted to our climatic conditions is in the possession of the Station.

Of annual crops, those grown in nearly all other parts of the United States can be grown here, if planted at the proper time of the year. However, all cannot be grown profitably, and the culture of some others is attended with many difficulties. Many crops are grown here during quite a different period of the year from that during which they are grown in most other parts of the country. The crops sensitive to extreme heat and not sensitive to cold, and grown during the spring and early summer in cooler regions, are grown here during the winter and early spring. Crops sensitive both to heat and cold are grown during the spring and early summer, or during the fall. A few long-season hardy crops can be successfully grown only by planting them during early fall. All hardy vegetables are grown principally during autumn, winter and early spring. Few crops thrive during mid-summer. They are chiefly such heat-loving ones as sorghum, Kaffir corn, Egyptian corn, millets, cotton, cow-peas, sweet-potatoes and dates.

Of perennials, a large percentage are not so successfully grown as are the annuals, since they cannot be grown during such a time of the year as to escape the unfavorable portions, but must endure the climatic conditions of the entire year. Hence only perennials that can endure both low temperatures and a dry hot atmosphere thrive here. Most of them are necessarily deep rooted, and all must endure frost. Deciduous trees and shrubs survive the low temperatures of winter by becoming dormant, just as in colder regions; and some herbaceous perennials survive the heat of summer by dying to the ground as the heat becomes intense.

But the leaves of evergreens must necessarily be exposed to the weather the year round, and therefore only those whose foliage endures both heat and cold can thrive. Some evergreens perish during cold winters, and others cannot endure the beat of summer. Some can endure neither the heat of summer nor the cold of winter. The number that endure well the climatic conditions of the entire year is small, being mostly introduced from similar regions in the Old World. A few have proven to be especially adapted to the region, and are being grown very successfully.

GRAINS.

Wheat, Barley, Oats and Rye.

The common small grains are all grown successfully during winter, being sown from October to February and harvested during May and June. The principal grains sown are wheat and barley, the yield being from 1500 to 3000 pounds per acre, depending upon the soil and the water supply, but oats and rye can also be successfully grown. Only the white soft varieties of wheat are generally grown, but all varieties of barley do well.

Indian Corn.

Corn is not so easily grown as the smaller grains, and is not extensively cultivated in the valley, the spring period between late frosts and hot dry weather being too short to give a crop time to mature. If planted about the middle of July the tassels and silk usually escape the intense dry heat of summer, and early varieties escape the frosts of autumn. Consequently a good crop can be often grown during this part of the year.

Egyptian Corn and Kaffir Corn.

The non-saccharine sorghums can be planted for grain production, and are grown for this purpose to some extent. The Egyptian corns, Milo Maize, Jerusalem corn, and Kaffir corn, all give fair yields, but the best one tested at the farm is the brown Egyptian corn, or brown dhoura. Unlike Indian corn, it thrives during the hottest and dryest weather of summer, being planted during spring and early summer, and maturing during late summer and early fall, the yield of grain usually being 2000 to 3000 pounds.

Buckwheat.

Buckwheat cannot be easily grown here. Being very sensitive to cold and quite sensitive to heat, there is no period of the year quite suited to its successful culture, Like corn, it could be best grown during the latter part of summer and the early part of fall.

LEGUMES.

Peas and Beans.

The legumes grown during the summer in cooler regions are not easily grown on a large scale in this region. They can be grown only during fall and spring, and then the yield is not sufficient to make them very profitable. Peas do fairly well, but bush beans, being sensitive to both heat and cold are grown less successfully. Field peas do best if planted about the middle of autumn, and common beans come nearer to growing satisfactorily when planted during late summer and early autumn.

Cowpeas and Soy Beans.

Cowpeas and soy beans are quite well suited to culture during the summer, the former being productive and quite easily grown. They may be planted at any time during late spring and summer, and grow until the frosts of autumn. Chickpeas do not grow as satisfactorily as the above two legumes.

CROPS USED IN INDUSTRIES,

Broom Corn.

Broom corn is successfully grown in the region, and has been used for some years in the manufacture of brooms on a small scale. Being a warm region plant, it thrives throughout the summer, being cultivated much as Egyptian or Kaffir corn is.

Tobacco

This crop has not been thoroughly tested at the Station farm, or elsewhere in the region, but the indications are that it may be grown fairly successfully, A fairly good crop was secured the one season it was tested, and a fairly good product obtained; but it seems evident that better results would have followed earlier planting.

Cotton and Flax.

Most varieties of cotton can be successfully grown in the region, but this crop has not yet been cultivated in any but an experimental way by whites. Formerly the Pima Indians grew one of the short staple forms for clothing, and Egyptian cotton has been quite thoroughly tested at the Station farm. If supplied with plenty of water, it grows thriftily throughout the summer and produces a good crop of excellent cotton. It is planted during the latter part of March and early part of April, and the crop is harvested during September, October and November.

Flax, being hardy to frost and quite sensitive to extreme dry heat, is best grown during winter and spring. It may be planted during October or during January and will be ready to harvest for fibre during the following spring

Canaigre and Sugar Beets,

Canaigre grows wild in the sandy river bottoms of the valley, and its culture as a field crop has been thoroughly tested, both upon the farm and elsewhere. It proved to be quite easy of cultivation and very tenacious of life when once established in a field; but the yield was not sufficient to make it profitable. Consequently its culture has been abandoned here, as in all other parts of the Southwest.

Sugar beets have been the subject of quite thorough experiment at the farm and elsewhere in the valley, and the erection of a factory was begun last fall as a result of the data thus obtained* They may be planted during the latter part of September or the early part of October for a winter crop that matures about the first of March. But the best time for planting them has proven to be during February, in which case they mature during July, The yield of beets in the experimental plats under the supervision of the Station has been from nine to eighteen tons in soil suited for their culture, and the percentage of sugar in the beets from eleven to eighteen, depending on the soil and care of the crop,

Castor beans are quite well adapted to our climatic conditions, but have not yet been grown for commercial purposes,

FORAGE AND GREEN-MANURING CROPS*

For green or dry forage the principal crops grown are the annual, grain-producing members of the grass family and the perennial leguminous plant, alfalfa* Quite a variety of other forage crops are grown to some extent, but the list of those successfully and profitably grown is not nearly as long as in a region having & less trying climate.

Grains and Grasses.

For winter pasturage and for an early crop of hay, barley, wheat and oats are grown instead of the grasses used in cooler regions These grains are sown both upon the fields of alfalfa and in freshly plowed soil. In the former case, the seed is covered with a disc harrow. In fresh soil the seed is either disced or harrowed in When sown upon alfalfa fields, it is usually done during early fall. In fresh soil seeding is done throughout fall and early winter The resulting growth is commonly pastured during winter, and then permitted to grow up for hay during spring, being cut in April and May when the kernels are quite well formed. Oats make the best hay, and they are now sown for this purpose more generally than formerly. The usual yield of grain hay is one and a half to three tons per acre.

Very few of the perennial grasses endure the summers well enough for culture for pasture or hay, and none of the hardy annuals produce as well as the grams. Perennial rye-grass is used for winter lawns, but it is not practicable to grow it for forage. Bermuda grass makes a good growth during summer that is fairly satisfactory for pasturing, but does not produce feed during winter. Brome grasses do fairly well, but do not yield as heavily as the grain-producing grasses, or as alfalfa. Kentucky blue-grass is grown with great difficulty, being used only for favorably-situated lawns Orchard grass will grow under favorable circumstances, but has not proven profitable for pasture or for hay.

Sorghum, Corn, Teosinte, Millets.

Sown any time from April to the end of July, sorghum ordinarily gives a heavy yield of fodder. It is quite easily cured in our climate, but is usually fed as it stands in the field. Kaffir corn and dhoura grow well, but do not give as satisfactory results for forage or sorghum, Indian corn grows fairly well during part of the year, but does not yield as much fodder as sorghum. Teosinte has been quite thoroughly tested. It makes a luxuriant growth but did not on the whole seem to be as satisfactory as sorghum, the season not being of sufficient length for it to mature its seed.

Most varieties of millet can be quite readily grown, although the yield is not as great as in some cooler regions. The ordinary varieties are sown during August and harvested during the fall, as in other regions, Pearl millet may be planted during spring, and will grow luxuriantly all summer, but does not seem to be as desirable as sorghum for a forage crop.

Alfalfa and *Clover*.

The member of the large and useful family of leguminous plants that is most extensively grown for forage and green-manuring in this region, as elsewhere in the Southwest, is alfalfa or lucern, an herbaceous perennial introduced from the southwest of Asia. When supplied with plenty of water, it grows luxuriantly during the spring, early summer, and early fall. During the cool weather of late fall and winter and the hot weather of mid-summer its growth is too slow to be utilized for hay, but furnishes considerable pasturage. The short growth of summer is often cut for its seed. It is usually cut two to four times for hay and pastured the remainder of the year, the yield of hay being three to six tons per acre. It is sown during early fall or early spring, and may be cut the following season. Alfalfa has been for many years, and probably will continue to be, the leading crop of the region.

Many varieties of clover have been tested, but none have proven satisfactory as forage plants, and only one is useful as a green-manuring plant. The perennial clovers do not endure the summers, and only one annual endures either the summers or the winters. The so-called "sour clover" (*Melilotus indica*) makes a vigorous growth between early fall and late spring, Upon account of this vigorous growth during a time of the year when irrigating water is most plentiful, it is the legume best adapted to the region for green manuring. It makes the best growth if sown during October.

Burr clover grows well during winter, but does not yield heavily enough to make it especially valuable either as a forage or a green-manuring crop.

Egyptian clover, or Berseem, has not proven satisfactory either for forage or for green-manuring, alfalfa being more useful for either purpose, and the Melilotus more useful for the latter.

Crimson clover, wherever tested, made less growth than the Berseem, and Red clover, as elsewhere in the Southwest, is not successfully grown here.

Cowpeas and Velvet-Beans.

Cowpeas may be grown during the summer, being a valuable crop therefore to follow and precede grain crops, where sufficient water for their culture is available. If fed green or cut for hay, the roots and stubble left behind enrich the soil; and if the entire growth be plowed under, a still greater addition is made to the fertility of the field. The feet that they grow only during summer wben irrigating water is comparatively scarce has prevented as extensive culture as would be possible with a more abundant water supply.

Velvet-beans, which are reported to grow so luxuriantly and be so valuable as a forage and green-manuring crop in some portions of the South, have not thus far proven to be valuable for this region, the aridity of the atmosphere probably being too great for their successful culture.

Lupins and Vetches.

None of the lupins or vetches so commonly grown in many other regions for forage and green-manuring, have proven to be quite adapted to our conditions. Lupins, like Berseem, make what growth they do make during early fall before either newly sown alfalfa or Melilotus will attain much size. Like Berseem they begin blooming and producing seed as winter approaches, and are much injured by the heavy frosts of December and January. They could be utilized to some extent for fall feed and for plowing under before a winter crop, and could be used in the same way during early spring before a summer crop.

The vetches have given less satisfactory results than the lupins, the growth being quite scanty, whatever time of the year they are sown. Possibly, however, in the case of many of the legumes mentioned, the failure to grow satisfactorily has been due partly to lack of a proper kind or a sufficient number of the organisms that assist them in securing nitrogen, and is not entirely attributable to an unsuitable climate.

Australian Salt-bush.

The Australian Salt-bush, a relative of some of our native small shrubs, seems quite at home in the valley. When tested several years ago, it made a good growth and has since continued to grow spontaneously in waste places about the farm. It does not seem to be useful for a forage plant, except in dry or alkaline locations where alfalfa and other more palatable and nutritious forage crops will not thrive. It requires little water and endures considerable alkali.

Root Crops.

Few roots are grown for cattle feed in the region. Among those tested at the farm, the sugar beet was one of the most satisfactory, mangels usually yielding less per acre. Under favorable circumstances a fair yield of the latter can be obtained, although upon account of standing higher in the ground, they do not endure the heat of summer well. While all varieties of turnips and bagas can be grown, the yield is not usually large enough to warrant their culture for cattle feed. The same is true of carrots. Alfalfa furnishes succulent food such a large part of the year that there is not the need of root feeds that there is in regions having severer winters.

VEGETABLES.

Most vegetables grown in cooler parts of the United States can be grown here, if planted at the right time of the year, and a few vegetables peculiar to semi-tropical regions do well. All do not thrive as they do in less trying regions, but the most of them do sufficiently well to furnish vegetables for the table, and, to a certain extent at least, for market.

Potatoes and Tomatoes.

While potatoes are not easily grown, they do fairly well when the methods that it is essential to follow for their successful culture are understood. Being sensitive both to the frosts of winter and the heat of summer, they can be grown only during late winter and early spring, and during fall. For the spring crop they are planted during the latter part of January or the early part of February, and mature about the first of June. For a fall crop they are planted during the latter part of August or the first few days of September. The fall crop does not always fully mature before the frosts of November, but usually furnishes a limited supply of young potatoes for the table. The yield from the spring crop is usually from 3,000 to 6,000 pounds per acre, and that from the fall crop considerably less. As all root crops decay rapidly during warm weather, the crop must be harvested and marketed promptly after it ripens during June. Sweet potatoes are much better adapted to the climate, and are quite successfully grown. Plants are put out during April and May and continue growing until the frosts of autumn.

Tomatoes, enduring as they do more heat than potatoes, grow throughout the summer, if suitable varieties are planted during spring. They may be grown either by planting the seed where the plants are wanted, during February, or the plants may be grown under shelter in boxes in the usual way and set out in the field during April. The plants growing from the seed planted in the field usually produce tomatoes earlier than those that are transplanted from boxes. Tomatoes begin ripening during the latter part of June, or the early part of July, and continue throughout July and the most of August. During the hot weather of midsummer no tomatoes are set, and consequently no ripe tomatoes are produced during September and the most of October. The tomatoes that set after the warm weather ceases usually begin ripening the latter part of October or the early part of November, and continue doing so until the vines are killed by frost. The yield of tomatoes is usually from 8,000 to 12,000 pounds per acre, about half usually ripening previous to the hot weather of midsummer, and about half during the fall.

Melons and Cucumbers

These two crops being less sensitive to heat than either potatoes and tomatoes, grow and produce, to a certain extent at least, throughout the summer. They are usually planted about the middle of March, and vines growing from this planting continue growing and bearing well until the hottest weather of midsummer. Watermelons usually begin ripening about the middle or latter part of June, and the vines produce abundantly until the end of July. During August the crop is lighter, but if the vines are cut of by discing or cultivating the ground, they resume melon production during September and continue until the cool weather oi late fall. For a fall crop also, a planting may be made during the latter part of June or the early part of July. The yield is usually from 20,000 to 30 000 pounds per acre

Muskmelons and canteloupes seem especially adapted to the region and are grown quite extensively for shipping. They begin ripening about the first of July, and yield 5,000 to 10,000 melons per acre.

Pumpkins and Squashes.

Pumpkins and squashes can be quite readily grown here if suitable varieties are used and they are planted at the right time of the year Only summer squashes should be planted during early spring, winter pumpkins and squashes not growing well throughout the warm weather of summer. Summer squashes planted during the latter part of February or during March begin producing during May, and continue until the hot weather of July. Winter pumpkins and squashes planted during June mature the succeeding autumn. For a fall crop of summer squashes a planting may be made during July or August, although they do not do as well at this time of the year as during the spring.

Peas and Beans.

Peas cannot be grown throughout midsummer, but do quite well during the cooler parts of the year; and most beans can be grown only during spring and early summer, aad during late summer and early fall. Peas may be sown any time from August to February. Those sown during the former month begin producing green peas during November and continue until the heavy frosts of late fall or early winter. It is principally late varieties that are planted during the fall for an early spring crop. Early varieties will produce green peas during April and early May if planted during January and February.

Bush beans are planted during the latter part of March or the early part of May for a spring and early summer crop, and during the latter part of August and the early part of September for a fall crop. Vining beans grow fairly well through the summer.

Cabbage and Cauliflower.

These two hardy vegetables are quite readily grown during the winter. For the earliest cabbage, seed is sown during July and August and the plants put out during September or early October. Considerable growth is made during the fall, and when the warmer weather of February comes they begin making heads. The early or medium early varieties are apt to head up best, but all varieties do fairly well, making good heads by May at the latest. Cauliflower is less sure to head satisfactorily than cabbage, but some varieties do very well. Seed is sown during August and September and plants set during September and October.

Lettuce and Spinach.

These two vegetables may be grown any time during the cool part of the year, being ready for use within a month or two after sowing Seed may be sown any time from the early part of September to the end of February. They make little growth during the coolest weather of December and January, but if supplied with sufficient water make rapid growth when the warm weather of February comes, and continue to produce abundantly until the warm weather of late spring.

Beets, Carrots, Turnips, and Radishes.

These root vegetables all grow well, especially during the cooler part of the year. They may be sown any time from August until the next March, although carrots do not make a satisfactory crop except when planted during the fall. Beets may be sown later in the spring than any of the others, growing well up to the end of June.

Onions and Celery.

These two vegetables require a large share of the year for maturing. Seed of the former is sown during the latter part of September and the early part of October, and the crop is harvested the next summer. Celery seed is sown from January to March, the plants set out during the early part of the next fall and the crop harvested during early winter. On account of requiring so long a season neither of them is very easily grown, although onions are less difficult than celery.

Asparagus and Rhubarb.

Of these two perennials the first is quite easily grown in our region, and the second grown with great difficulty. Both of them make the principal part of their growth during the cooler part of the year, being dormant most of the summer. Asparagus roots survive the heat of summer well, but the roots of the rhubarb do not, it being very difficult to maintain a growth of the latter.

FRUITS AND NUTS.

Most of the fruits and some of the nuts grown in cooler regions can be grown here, and besides these a few of the fruits and nuts of semi-tropical regions. All of the deciduous orchard fruits grown in cooler regions may be grown here to some extent, although all do not do equally well. The small fruits of cooler regions are grown with more difficulty than the orchard fruits. Only those of the semi-tropical fruits that can endure heavy frosts and hot dry summers thrive here; and only the nuts that endure warm dry summers can be grown.

Strawberries, Blackberries and Raspberries.

None of these small shallow-rooted fruits of the cooler regions are easily grown in this region, although until recent years strawberries were grown in considerable abundance. Raspberries and their relative, Loganberries, cannot be successfully grown here. Blackberries endure the trying summers somewhat better, but are not grown very profitably.

Strawberries do considerably better, but their culture is attended with many difficulties. The greatest difficulty is carrying the newly set plants through the first summer. After becoming thoroughly established they do fairly well. Plants may be set out from the first of November to the end of February, the plants set out the last two months being usually the surest to grow. If the fall-set plants become thoroughly established before the cold weather of winter, they usually endure the succeeding summer better than those set during early spring. Those set during either fall or early spring produce some fruits the following April, May and June, and some varieties produce some fruit again during the following November and December. But the first good crop that can be counted on if the plants survive the first summer is during the spring of the second year after setting. Plants of some varieties are more apt to survive the summer following their setting, if all of the first blossoms and runners are removed as they appear.

Currants and Gooseberries.

Neither of these bush fruits can be grown in our region, both succumbing to the heat of summer.

Mulberries and Persimmons.

Both of the above fruits are quite easily grown here by those who desire them. Mulberries do especially well, all varieties thriving under all kinds of conditions. They are one of the earliest trees to put out their leaves and bloom, and the earliest tree to produce fruit, the latter ripening about the first of May. The persimmon fruits more sparingly and does not ripen until late autumn.

Grapes and Figs.

A large variety of grapes do fairly well at the farm and in the surrounding valley, and a few varieties are grown with considerable profit. Like other warm valleys of the Southwest, the region is better suited to the culture of the French varieties of grapes, especially the wine and raisin varieties, than to the culture of the American table varieties. The varieties that ripen their fruit early in the summer and during the fall are the more desirable ones to grow, the fruit ripening during midsummer not being usually of as good a quality. Cuttings or rooted plants are put out during February, and usually begin bearing within two or three years.

Several varieties of figs are well adapted to the region if they are supplied with plenty of water. Some varieties do not endure well the trying conditions of summer, and all varieties require considerable irrigating water

Plums and Cherries.

Few of the varieties of either of these fruits grown in cooler regions do well here, and none of the varieties of cherries are profitably grown. A few of the varieties of plums native to America, and several Japanese varieties, are grown successfully and profitably. A few of the European varieties endure the summers for a few years and produce a fairly good quality of fruit, but most of them are short-lived, and many varieties of all classes produce fruit of a poor quality. Few varieties of prunes seem adapted to the climate, and none have been grown extensively here.

Peaches, Nectarines, Apricots and Almonds.

These stone fruits do better in the region than the two discussed above. All varieties of peaches do not endure the conditions here, but nearly all varieties of apricots and almonds do. Most varieties of peaches are comparatively short-lived, and many varieties grown in the cooler regions, especially those of the Persian type, are not adapted to the region. As a rule, peaches of the Chinese type are most prolific, although the quality of all varieties of this type is not always satisfactory. As a rule, the varieties that bloom very early or very late are the most apt to set a crop of fruit; and those that ripen their fruit very early or during the fall produce as a rule fruit of the best quality.

Apricots have been quite successfully and profitably grown in the valley for many years, the fruit of several varieties ripening earlier than in most other sections of the United States. Nearly all varieties usually bear well, and it is only a matter of selecting those that are the most desirable from particular standpoints.

Almonds have been grown fairly successfully and profitably, especially where an effort has been made to protect the bloom from the spring frosts. The sharp frosts of midwinter and the warm dry weather of spring and early summer seem to supply just the climatic conditions needed by this nut.

Apples, Pears and Quinces

Of these three fruits the pear does the best under our climatic conditions. A large number of varieties bear well and can be grown successfully and profitably, including summer, fall, and winter varieties. Most varieties of quinces grow quite well, but the climate is too dry and warm for the successful and extensive culture of apples. A few of the earliest varieties, since they ripen before the hottest weather of summer, can be fairly successfully and profitably grown, and a few varieties that ripen their fruit during autumn produce fairly satisfactory fruit; but most of the summer, fall, and winter varieties do not produce fruit of a satisfactory quality. In nearly all cases the trees are comparatively short-lived.

Walnuts and Pecans.

While neither of these nuts Have been given a thorough trial in the region, from what experiments have been made indications are that no desirable varieties of either of them will thrive here, the summers being too hot and dry. The native walnut grows fairly well and produces a few nuts, and might eventually be used for grafting stock for better varieties. But as most desirable varieties of walrtuts do best in a moist and moderately cool climate, it is not probable that walnut culture can be carried on successfully here.

The pecan promises a little better, but the climate will probably prove too warm and dry for their extensive culture.

Olives and Dates.

Both of these evergreen semi-tropical fruits seem especially adapted to our region. All varieties of olives grow well here, and a large number of them are very prolific. They have been so far free from all insect pests and fungus diseases, and their culture promises to be one of the profitable industries of the region

All varieties of dates tested here grow well and a large number of them mature fruit of excellent quality For a few varieties the season is not quite long enough but for most of them our climate is well adapted. They are propagated by planting seed during winter, or by planting suckers during spring or early summer. Being a plant that makes growth only during quite warm weather, transplanting should be done only during a warm part of the year.

Oranges, Lemons and Pomeloes

None of these citrus fruits can be grown satisfactorily at the Station farm, but are grown to some extent in higher parts of the valley, where the temperature does not fall quite so low during winter. Pomeloes, enduring greater extremes of heat and cold than either oranges or lemons, grow fairly well at the farm but do not give promise of being profitable in its vicinity. Lemons, being very sensitive to extremes of heat and cold, especially the latter, have not been extensively grown in any part of the valley. Oranges being somewhat less sensitive to extremes of temperature than lemons, have been grown to some extent with moderate success. However, it cannot be said that their culture promises to be a generally profitable industry in the valley, unless it developes that an improved water supply will enable growers to carry their orchards through the summer in better condition.

Young trees of these fruits are put out during February, at the begining of the warm weather, and require careful attention and plenty of water during the first summer. They also need some protection from extremes of temperature during at least the first season.

Pomegranates and Loquats.

Both of these semi-tropic fruit trees grow well here, and the former produces abundantly. All varieties of pomegranates seem especially adapted to the region, and produce fruit of unusually good quality. Loquat trees, while they grow thriftily, do not produce fruit in the region. They bloom during the cold weather of winter when frosts occur many nights, and consequently set little or no fruit.

TIMBER TREES.

In the valleys of the Southwest where timber is scarce, and most of it must be imported from great distances, the growth of timber for commercial purposes is as important an industry as the growth of any other crop. One of the lines of work of the Experiment Station has been to determine what trees might be grown in the region for fuel, for posts, and for the general purposes for which timber is used.

Cottonwoods and Poplars.

All of the trees of this group grow fairly well here when supplied with plenty of water, but none of them have proven entirely satisfactory and reliable except the native cottonwood (*Populus fremonti*). This tree grows naturally along the river bottoms, and in many respects has proven a valuable tree for shade and for timber in the valley. Although its aspect is not an especially pleasing one, and though the timber is soft and not durable, yet its rapid growth makes it useful in many ways. It is grown both from seed and from cuttings. If grown from seed, half of them will ordinarily be female cotton-producing trees, and are less desirable tban the staminate or male trees which produce none of the cotton which is so objectionable upon account of falling upon vegetation and other objects. Trees that do not produce this objectionable cotton may be obtained by taking cuttings from adult trees that have bloomed and show themselves to be males.

Eucalypts.

These trees have been very thoroughly tested at the Station farm, and have been planted to some extent in various parts of the valley. Of the fifty or sixty species tested, only four or five have proven adapted to our climatic conditions. Most of the remainder either do not endure the frosts of winter, or succumb during the heat of summer. Three species have proven especially well adapted for culture here and are among the quite valuable ones of the genus. By planting these three species, timber can be grown for fuel, for fence posts, for making and repairing agricultural implements, for telephone, telegraph and electric poles, for railway ties, and for a great many other purposes for which durable hardwood timber is used.

Ashes and Walnuts.

Both of these trees are natives of southern Arizona and grow quite well in all parts, if supplied with sufficient water. While their growth is somewhat slow, yet the timber furnished by them is so hard and so useful for many purposes that they deserve to be planted quite extensively. The ash makes the taller growth and produces the more useful timber for many purposes.

RECAPITULATION.

The crops that are grown in the region successfully and profitably are:— Wheat, barley, oats, Egyptian corn, sorghum, alfalfa, potatoes, tomatoes, melons, bush squashes, crook-neck pumpkins, cucumbers, garden peas, cabbage, lettuce, spinach, beets, carrots, turnips, radishes, asparagus, grapes, peaches, plums, apricots, almonds, pears, olives, dates and pomegranates.

The crops that can be grown fairly successfully, in addition to the above, are:— Indian corn, Kaffir corn, peas, beans, cowpeas, broom corn, tobacco, cotton, flax, canaigre, sugar beets, millet, squashes, cauliflower, onions, celery, strawberries, blackberries, figs, apples, quinces, oranges and pomeloes.

The crops grown in cooler regions that cannot be satisfactorily grown here are:— Perennial grasses, clovers, vetches, rhubarb, raspberries, currants, gooseberries and cherries. The crops adapted to warm moister regions of the United States that are not at present extensively grown here are:— Cowpeas, velvet-beans, tobacco, walnuts, pecans and pineapples.

WEATHER INVESTIGATIONS AT STATION FARM.

Advantage has been taken of the opportunity afforded at a farm located in an arid inland valley, as is the Station farm, to make observations upon the peculiar nature of the climate and its effect upon the various crops grown and attempted to be grown there, including as they do nearly all those grown in the temperate and semi-tropic zones. The work has consisted of keeping records of temperatures at various situations above and below ground, of keeping an evaporation record, and of carefully noting the effect of the weather on the various crops on the farm.

METHOD OF KEEPING WEATHER RECORD.

For several years a record has been kept of the temperatures registered by maximum and minimum thermometers situated at various elevations from the ground. Besides the thermometers furnished by the Weather Bureau and kept in a regular instrument shelter, three sets of instruments of the same grade have been located on the south side of a post in the full sunshine, and daily records made from them. One set is located within a few inches of the soil, the second is five feet above the ground, and the third is situated ten feet above. For a year and a half three self-registering thermometers have been located under ground upon a movable frame standing in a small shaft, one instrument being located five feet below the surface, one ten feet below, and one fifteen feet below. Records have been made from these instruments once a week.

Besides the above regular and continuous records, thermometers have been exposed among various growing crops, both above and under ground, and records made therefrom. By these various methods an attempt has been made to ascertain and accurately register the actual temperatures to which crops have been exposed, both at various distances above the surface and at various depths underground.

The records kept from the instruments located in the government shelter and from the set located on the post at five feet from the ground furnish a comparison between the temperatures "in the shade'' and those in the full sunlight. And as the instruments at the Phoenix Weather Bureau office only two miles distant are located fifty feet above the ground, the record reported from them furnishes data for quite a fair comparison between temperatures at that elevation and those under similar conditions five feet from the ground. The records kept from the instruments located underground furnish a comparison between the changes in temperature that occur there and the changes that occur in the air.

TABLES OF WEATHER RECORDS.

The three following tables give the principal features of the weather during the past four years, and incorporate into a tabular form the principal data concerning the weather collated during that time.

Explanation of Table I.

In Table I periods of what are in most cases one-third of a month are used as a unit of time. To give for three years tbe daily minimum and maximum temperatures would require more space than it would be advisable to use, and would result in the insertion of a table more cumbersome than useful. On the other hand, a table of mean temperatures for each month does not show the occurring fluctuations in temperature sufficiently well for the purpose ot the bulletin. Hence a period of intermediate length has been used as the unit. In all cases except the last one of those eight months having other than thirty days, this period is ten days. That is, each month is so far as practicable divided into ten-day periods, the last one of one month (February) being less than ten days, and of seven others, eleven days. For each of these periods are given the minimum and the maximum temperatures, and the mean minimum and mean maximum temperatures occurring near the surface in the open air, five feet from the surface both in the open air and in the Weather Bureau shelter, and ten feet from the surface in the open air, during the years 1901, 1902, and 1903.

In each case the column of figures giving the minimum temperatures percedes the column giving the corresponding maximum temperatures; this for the reason that the minimum temperature of each twenty-four hours occurs first—usually just before sunrise. In the first column of Table I is given the lowest temperatures recorded from a self-registering thermometer located a few inches above the surface, during each ten day period of the three years. In column five is given the minimum temperatures registered by the instrument located five feet from the ground in the government shelter, in column nine those registered at the same elevation in the open air, and in column thirteen those registered ten feet from the ground in the open air. In columns two, six, ten, and fourteen are given the averages of the minimum temperatures recorded during each period.

In the third column are the highest temperatures recorded from a self-registering thermometer located a few inches above the surface, during each ten day period of the three years, and in columns seven, eleven and fifteen are given the maximum temperatures recorded five feeet above the ground in the government shelter, and in the open air, and those recorded ten feet above the ground in the open air. Following each of these columns, are those in which the averages of the maximum temperatures occuring during each period are given.

The relative humidity figures were computed from the records of the Phoenix Weather Bureau office a record kept at the farm a part of a year indicating that the distance is so small that the humidity is practically the same at the two places. The mean is given of two observations, one made at half past five A. M. and one at half past five P. M., the former representing approximately the condition during the dampest part of each twenty-four hours, and the latter the approximate condition during the driest part.

The mean hourly wind velocity is also from the Phoenix records. While there would during some parts of the year occur winds of different velocity at Phoenix and at the farm, the difference in the means will probably not be great enough to materially affect conclusions drawn from them.

The evaporation given is from the surface of a tank of water sitting with the surface about on a level with the surface of the surrounding soil. It represents the combined influence of the temperature and relative humidity, as well as the movements of the atmosphere, and is, therefore, much of the time an index of the conditions that are affecting vegetation. The amounts given are the totals for each ten-day period.

The purpose of Table I is to represent as nearly as practicable the. general conditions of the atmosphere to which plants of various heights, and the different parts of tall plants, are exposed during the different seasons of year. The temperatures and relative humidity among different growing crops differ considerably at any one time of the same day, but they probably vary approximately with the general conditions given.

Explanation of Table II.

In Table II is given the weekly record from three self-registering thermometers situated underground, one five feet below the surface, one ten feet below, and one fifteen feet below. As it was found that there was very little difference during any one week between the temperatures recorded by maximum and minimum thermometers, and that an accurate record might be kept equally well from either, if they were removed for taking the record and replaced during the right time of the day, only minimum thermometers are now used. By raising the frame to which they are attached during the warm part of the day, and after making the record warming the instruments artificially if necessary, the minimum temperature during each week is thus registered. During the part of the year that the soil is cooling off, these temperatures would ordinarily be registered during the end of the week for which they are recorded; and during the part of the year that the soil is growing warmer, they would ordinarily be registered near the beginning of the week. But this discrepency does not materially lessen the value of the results.

TABLE I.

TEMPERATURE, RELATIVE HUMIDITY, WIND VELOCITY, AND EVAPORATION.

Period	Temperature near surface. In open air				Temperature Five feet above surface. In Gov't shelter				Temperature Five feet above surface. In open air.				Temperature Ten feet above surface In open air.				Mean relative humidity.	Mean hourly wind velocity.	Evaporation.
1901	Minimum	Mean Minimum.	Maximum	Mean Maximum	Minimum.	Mean Minimum	Maximum.	Mean Maximum	Minimum	Mean Minimum	Maximum	Mean Maximum	Minimum	Mean Minimum.	Maximum	Mean Maximum		Mls	Ins
January																			
1st period	15	28			20	33	76	65					18	30	79	68	44	4.0	
2nd "	15	26			20	31	78	71					18	31	79	73	34	3.7	
3rd "	29	41			34	43	75	68					32	42	79	70	63	4.4	
February																			
1st period	32	36			36	40	65	59					34	38	67	61	71	3.7	
2nd "	30	38			32	39	79	70					31	38	81	64	56	3.8	
3rd "	35	42			39	45	84	79					38	44	84	81	49	4.5	
March																			
1st period	30	41			33	45	89	80					32	43	92	83	49	3.1	
2nd "	27	35			32	40	84	77					31	39	84	81	29	3.1	
3rd "	26	36			30	40	77	71					33	39	80	75	39	2.8	
April																			
1st period	30	35			33	41	82	68					33	38	86	77	37	5.7	
2nd "	33	39			36	38	93	86					34	40	98	89	34	4.7	
3rd "	44	47			48	52	95	92					47	50	105	98	32	5.0	
May																			
1st period	40	45	108	101	45	51	98	91	42	48	108	100	41	48	108	96	30	4.7	2.16
2nd "	52	55	109	105	58	59	100	95	53	56	105	104	54	57	105	99	34	4.4	2.64
3rd "	42	51	107	100	47	55	97	90	42	52	102	97	45	52	100	93	28	5.8	3.24
June																			
1st period	52	55	112	108	56	60	101	98	52	55	110	104	54	57	108	102	22	5.0	3.60
2nd "	46	63	117	107	50	58	107	97	47	54	112	106	48	55	108	100	17	4.7	3.06
3rd "	52	54	121	117	58	64	111	107	56	58	116	113	56	61	114	109	16	4.2	3.06
July																			
1st period	61	68	125	120	65	72	114	109	61	65	120	115	62	68	117	112	22	4.5	2.70
2nd "	72	75	124	121	75	78	113	109	71	74	118	113	68	73	115	111	27	5.3	3.28
3rd "	72	76	118	116	73	77	107	104	72	75	115	110	70	73	113	103	48	5.1	2.70
August																			
1st period	71	75	118	115	72	77	108	104	71	75	114	109	71	75	112	108	45	4.4	3.28
2nd "	66	71	118	113	70	73	108	101	66	71	114	108	67	70	114	108	50	3.9	2.08
3rd "	58	68	123	116	63	71	111	105	58	68	120	111	60	68	119	109	35	3.9	2.34
September																			
1st period	54	58	117	113	59	64	105	102	54	59	115	109	57	61	113	107	28	4.0	1.98
2nd "	59	61	118	114	62	65	107	103	60	61	115	110	60	63	113	109	32	3.7	2.20
3rd "	43	48	112	105	47	55	101	95	43	49	107	102	44	51	106	101	25	4.4	1.73
October																			
1st period	44	52	111	103	50	56	100	93	45	53	110	102	47	53	109	102	36	3.7	1.89
2nd "	43	46	108	103	48	52	96	93	43	47	107	98	45	49	107	100	27	3.8	1.40
3rd "	36	48	100	89	40	53	88	78	38	50	100	88	38	50	106	88	52	4.5	1.32
November																			
1st period	38	42	96	89	45	47	83	79	40	44	95	89	42	45	95	90	51	3.1	.78
2nd "	34	39	90	85	39	44	79	75	36	40	90	85	37	41	90	85	56	3.1	.63
3rd "	32	37	95	88	38	41	85	78	34	38	96	88	35	39	96	89	42	2.8	.72
December																			
1st period	25	32	90	84	28	36	80	74	26	33	88	82	27	34	87	81	36	3.3	.59
2nd "	15	24	81	74	20	28	71	64	16	25	82	71	18	25	82	69	31	4.1	.57
3rd "	19	24	88	80	24	29	78	70	21	26	88	78	21	27	87	77	29	3.1	.66

TABLE I.—CONTINUED.

Period	Temperature near surface.				Temperature Five feet above surface.								Temperature Ten feet above surface				Mean relative Humidity	Mean hourly wind velocity	Evaporation
	In open air.				In Gov't shelter				In open air				In open air						
1902	Minimum	Mean Minimum	Maximum	Mean Maximum	Minimum	Mean Minimum.	Maximum.	Mean Maximum.	Minimum	Mean Minimum	Maximum.	Mean Maximum	Minimum	Mean Minimum	Maximum	Mean Maximum		Mls	Ins
January																			
1st period	24	29	96	88	31	34	81	77	28	31	91	85	29	32	89	84	28	2.6	.56
2nd "	22	29	90	82	25	34	77	70	24	32	86	78	24	33	84	77	42	3.6	.49
3rd "	21	28	75	69	26	32	65	58	23	30	71	65	25	31	69	63	58	4.0	.38
February																			
1st period	24	28	89	81	30	31	75	68	25	29	84	78	26	30	82	75	30	3.1	.50
2nd "	30	34	93	90	36	35	83	78	32	36	88	85	33	36	86	83	30	4.3	1.20
3rd "	31	37	86	78	35	42	73	70	32	39	79	74	32	38	78	71	42	6.0	1.32
March																			
1st period	27	34	91	84	33	39	77	72	29	36	86	79	30	36	84	75	32	5.2	1.31
2nd "	32	35	100	85	35	40	84	75	32	37	92	80	35	37	91	78	34	5.4	1.78
3rd "	30	36	94	83	33	40	82	71	30	36	88	77	31	36	87	76	44	4.3	1.56
April																			
1st period	38	42	105	97	43	48	93	86	40	44	99	91	41	44	97	88	29	4.3	1.74
2nd "	42	45	105	102	46	51	98	92	43	47	100	96	43	47	98	94	20	4.6	1.92
3rd "	39	43	103	96	42	48	92	86	39	44	101	91	39	45	95	89	24	5.4	2.28
May																			
1st period	45	52	110	105	51	56	99	95	47	53	105	99	48	54	103	97	21	4.1	2.58
2nd "	42	50	108	97	44	53	96	88	44	51	101	92	43	51	99	90	26	6.0	3.06
3rd "	43	50	113	105	45	55	104	95	44	52	107	99	44	52	106	97	22	4.9	3.30
June																			
1st period	44	55	119	111	48	60	109	101	45	57	114	105	45	57	111	103	16	4.7	3.54
2nd "	54	57	120	116	58	62	110	105	56	59	114	110	57	60	113	108	14	4.4	3.42
3rd "	53	63	136	121	60	68	119	109	56	64	122	114	56	65	121	113	18	5.1	3.90
July																			
1st period	55	59	128	112	60	64	110	100	56	61	114	104	57	61	112	103	20	5.4	3.84
2nd "	64	70	131	118	69	74	111	108	67	72	116	112	67	72	114	111	26	5.3	3.30
3rd "	64	69	133	117	67	72	113	105	65	69	119	111	65	69	117	109	35	4.9	3.78
August																			
1st period	72	74	134	120	73	78	114	107	70	75	119	111	70	75	118	110	34	5.2	3.66
2nd "	60	66	119	116	63	69	107	104	60	66	114	111	60	66	111	109	34	4.3	3.18
3rd "	62	69	119	114	65	72	106	102	62	70	113	110	63	70	111	107	40	4.0	2,64
September																			
1st period	58	68	123	117	62	71	108	105	58	69	118	112	58	69	116	110	33	4.2	2.64
2nd "	63	66	119	111	65	70	105	96	63	66	102	105	63	67	111	104	52	4.7	1.26
3rd "	45	54	114	108	50	58	100	95	47	55	109	103	47	56	108	102	34	3.1	2.16
October																			
1st period	43	46	116	108	47	52	98	93	44	48	110	102	45	49	108	101	24	3.4	1.56
2nd "	46	49	115	109	49	53	99	94	47	50	108	102	48	52	108	101	34	3.5	1.56
3rd "	39	48	111	103	44	53	95	88	40	49	106	97	41	50	105	96	38	3.6	1.56
November																			
1st period	40	46	102	96	46	50	86	82	42	48	95	92	43	49	94	89	39	3.8	1.02
2nd "	31	37	95	86	35	40	76	72	32	38	90	81	33	39	87	78	58	3.7	.72
3rd "	27	33	81	74	30	36	67	62	28	34	78	70	29	34	77	69	68	3.8	.42
December																			
1st period	24	30	91	80	28	34	77	68	26	31	87	77	27	32	86	75	48	3.4	.48
2nd "	29	35	79	69	31	38	65	60	28	37	75	66	28	37	73	65	76	3.9	.24
3rd "	26	53	88	79	31	35	76	67	28	33	85	75	30	34	83	73	56	2.9	.30

TABLE I.—CONTINUED.

Period.	Temperature near surface. In open air.				Temperature Five feet above surface. In Gov't shelter.				Temperature Five feet above surface. In open air				Temperature Ten feet above surface. In open air.				Mean relative humidity.	Mean hourly wind velocity	Evaporated.
1903.	Minimum.	Mean Minimum	Maximum	Mean Maximum.	Minimum.	Mean Minimum.	Maximum	Mean Maximum.	Minimum	Mean Minimum.	Maximum	Mean Maximum.	Minimum	Mean Minimum	Maximum.	Mean Maximum		Mls	Ins
January																			
1st period	25	28	92	80	28	32	77	67	26	29	88	76	27	30	86	74	54	3.3	.48
2nd "	24	29	81	76	28	33	69	63	26	31	76	72	26	32	74	70	53	3.8	.60
3rd "	27	33	85	79	32	37	72	67	29	34	80	75	30	35	78	73	52	3.6	.48
February																			
1st period	21	29	78	63	24	32	64	53	22	30	73	58	22	30	71	57	71	3.8	.42
2nd "	18	27	85	72	24	31	71	62	20	29	82	67	21	30	79	65	49	3.6	.78
3rd "	27	32	91	85	30	35	68	73	28	33	86	80	29	33	85	79	39	3.8	.78
March																			
1st period	27	34	94	85	32	38	77	72	30	36	86	79	30	37	84	77	45	4.2	1.14
2nd "	27	35	101	87	31	39	85	75	29	37	94	81	30	37	92	80	32	4.7	1.38
3rd "	29	43	101	91	35	46	89	79	31	34	95	86	31	45	94	85	47	4.2	1.02
April																			
1st period	35	44	102	92	39	46	89	80	37	45	98	86	37	45	96	84	35	4.9	1.32
2nd "	38	42	96	90	41	44	83	78	38	43	90	85	38	42	88	83	39	4.2	1.44
3rd "	36	45	108	101	40	49	97	90	37	46	102	95	37	47	100	93	26	4.7	2 28
May																			
1st period	44	52	108	105	49	56	97	93	45	53	102	99	46	54	100	97	25	5.0	2.52
2nd "	36	53	118	100	39	56	106	91	37	54	112	95	38	55	111	93	28	5.8	2.70
3rd "	42	50	122	103	45	54	107	91	43	51	117	97	43	52	115	96	25	5.5	3.30
June																			
1st period	55	60	117	113	57	63	103	101	55	60	111	107	55	60	110	105	26	5.0	3.24
2nd "	55	61	117	112	59	64	104	101	57	62	110	105	57	62	109	105	26	5.4	3.12
3rd "	56	68	123	118	59	66	114	108	57	63	116	111	58	64	115	110	16	4.9	3.60
July																			
1st period	55	66	122	118	60	70	110	107	57	67	115	111	57	67	113	110	22	5.0	4.08
2nd "	68	73	122	114	70	74	110	103	69	73	117	109	67	73	115	108	40	4.9	3.48
3rd "	63	68	121	116	65	71	110	106	64	69	116	110	64	70	114	107	33	4.6	3.36
August																			
1st period	65	70	122	114	66	72	109	103	66	71	116	108	66	70	114	110	38	5.5	2.64
2nd "	71	74	124	119	73	77	111	106	72	75	118	112	72	75	116	108	36	4.7	2.88
3rd "	64	70	122	116	69	73	111	104	64	70	117	110	63	70	114	107	38	4.3	2.64
September																			
1st period	65	69	124	117	68	72	111	103	66	70	118	110	65	69	118	109	44	4.5	1.80
2nd "	48	55	114	109	50	60	100	96	48	56	108	102	48	57	107	101	29	5.1	2.52
3rd "	56	59	115	101	56	61	98	89	56	60	107	96	56	60	106	95	56	4.5	1.82
October																			
1st period	44	49	109	101	46	52	96	87	44	50	104	95	44	50	104	94	50	3.5	1 32
2nd "	43	45	109	105	48	51	92	90	45	47	104	100	45	48	103	99	32	3.9	1.02
3rd "	33	41	114	105	37	45	94	87	35	42	106	99	35	43	104	96	34	3.6	1.26
November																			
1st period	34	37	103	96	38	41	85	81	34	37	96	89	37	39	95	88	40	3.3	.70
2nd "	31	35	100	94	35	40	83	78	38	36	92	85	34	38	92	88	42	3 6	.60
3rd "	32	35	104	97	37	40	85	80	34	37	97	89	34	38	95	88	38	2.9	.55
December																			
1st period	24	31	95	88	30	35	76	70	26	33	87	80	28	34	85	78	41	3 7	.50
2nd "	23	28	92	85	27	33	74	68	25	30	84	77	25	31	82	75	45	3.3	.50
3rd "	22	25	93	86	26	30	75	70	23	27	86	78	24	28	84	76	28	3 4	.65

TABLE II.—UNDERGROUND TEMPERATURES

1902				1903			
Week ending	5 ft	10 ft	15 ft	Week ending	5 ft	10 ft	15 ft
Jan. 6th	57	64	66	Jan. 5th	55	65	66
" 13th	55	62	66	" 12th	53	62	63
" 20th	56	62	64	" 19th	53	58	63
" 27th	56	62	64	" 26th	53	57	61
Feb. 3rd	57	63	64	Feb. 2nd	53	56	59
" 10th	58	63	64	" 9th	53	56	59
" 17th	59	64	64	" 16th	54	57	59
" 24th	59	64	64	" 23rd	55	57	59
Mar. 3rd	60	64	64	Mar. 2nd	55	58	59
" 10th	60	64	63	" 9th	60	58	59
" 17th	60	64	63	" 16th	59	58	58
" 24th	62	64	63	" 23rd	60	58	58
" 31st	62	64	63	" 30th	65	58	58
Apr. 7th	62	64	64	Apr. 6th	65	59	58
" 14th	67	64	64	" 13th	66	60	58
" 21st	68	65	64	" 20th	68	61	59
" 28th	70	66	64	" 27th	68	61	59
May 5th	71	66	65	May 4th	70	61	59
" 12th	71	67	66	" 11th	72	62	60
" 19th	72	68	66	" 18th	72	62	60
" 26th	72	69	68	" 25th	72	63	61
June 2nd	75	70	68	June 1st	72	63	61
" 9th	76	72	69	" 8th	76	66	62
" 16th	78	72	69	" 15th	80	67	62
" 23rd	82	72	70	" 22nd	82	68	62
" 30th	82	72	71	" 29th	83	69	63
July 7th	82	72	71	July 6th	83	70	63
" 14th	81	72	71	" 13th	84	71	64
" 21st	82	72	71	" 20th	84	72	66
" 28th	83	73	71	" 27th	84	72	65
Aug. 4th	85	73	71	Aug. 3rd	85	72	65
" 11th	86	74	71	" 10th	85	73	66
" 18th	87	74	72	" 17th	86	75	70
" 25th	87	74	72	" 24th	86	75	72
Sept. 1st	87	74	72	" 31st	86	76	72
" 8th	85	76	72	Sept. 7th	87	76	72
" 15th	86	76	72	" 14th	88	76	72
" 22nd	82	76	72	" 21st	86	76	72
" 29th	82	76	72	" 28th	86	76	73
Oct. 6th	81	76	72	Oct. 5th	82	76	73
" 13th	81	76	72	" 12th	78	74	71
" 20th	81	75	72	" 19th	78	74	71
" 27th	80	75	71	" 26th	77	72	68
Nov. 3rd	78	74	71	Nov. 2nd	75	72	68
" 10th	76	73	71	" 9th	73	72	68
" 17th	71	72	70	" 16th	69	68	68
" 24th	67	71	70	" 23rd	68	68	68
Dec. 1st	65	70	70	" 30th	67	68	68
" 8th	65	70	70	Dec. 7th	62	66	68
" 15th	61	68	68	" 14th	60	64	66
" 22nd	61	68	68	" 21st	56	62	66
" 29th	58	67	68	" 28th	56	62	66

TABLE III.—MEAN MONTHLY TEMPERATURES AT PHOENIX AND STATION FARM

1900	Phoenix		Station farm		1902	Phoenix		Station farm	
	Min	Max	Min	Max		Min	Max	Min	Max
January	42	71	36	70	January	38	67	33	67
February	42	71	35	71	February	41	71	37	72
March	51	80	44	82	March	43	70	39	72
April	51	75	46	78	April	53	85	49	88
May	62	93	56	95	May	60	90	55	93
June	70	102	63	104	June	69	103	63	105
July	78	105	74	106	July	74	103	70	104
August	71	101	67	102	August	76	102	73	104
September	64	94	60	95	September	69	98	66	99
October	57	85	52	86	October	58	90	53	92
November	49	77	43	76	November	45	71	42	72
December	39	69	33	70	December	39	64	36	65
1901					1903				
January	40	66	36	68	January	38	65	34	66
February	44	67	40	69	February	36	61	33	63
March	45	74	41	76	March	46	74	41	75
April	50	81	44	83	April	52	80	47	83
May	59	90	54	92	May	59	90	55	92
June	66	99	60	100	June	69	101	64	103
July	79	106	75	107	July	76	104	72	105
August	76	103	73	103	August	78	103	74	104
September	66	98	61	99	September	68	95	64	96
October	58	88	53	87	October	54	87	49	88
November	48	79	44	77	November	45	78	40	79
December	36	68	31	69	December	38	68	32	69

Explanation of Table III.

In Table III are given the monthly means of the minimum and maximum temperatures recorded in the government shelter five feet from the ground, and of these recorded from instruments in a like shelter fifty feet from the ground at the Phoenix Weather Bureau office. Although the latter are situated above a building and are about two miles distant, the comparison is thought to be an approximately fair one. The Phoenix instruments are located ten feet above the roof of the building, with no taller buildings about them, and are probably affected little, if any, by the local conditions; but would undoubtedly give approximately the same readings if located in a shelter fifty feet from the ground at the farm. This being true, the records kept from the instruments in the government shelter at the farm and those kept from the instruments in a like shelter at the Weather Bureau are fairly comparable.

DISCUSSION OF WEATHER DATA.

Before entering upon a discussion of the data presented in Tables I, II and III, it will be well to consider briefly some of the principles underlying weather conditions. For, like all other phenomena, the variations and conditions of the weather are the result of the operation of definite and fixed laws. To be sure* all the laws governing the changes and conditions of the weather are not fully known or understood, but the most of them are, being as a rule common-place laws that govern many other every day affairs.

Principles Underlying Weather Phenomena.

Most weather conditions and changes are due directly or indirectly to heat, heat being only a form of motion. The chief source of heat on the surface of the earth is the sun, from which it is constantly radiating. The earth and other bodies receiving this radiant energy, or form of motion called heat, in turn continually radiate it out towards space. Thus, the earth and all the objects upon it receive heat from the sun during the day only, but radiate it continuously.

Most transparent substances are not much heated by the passage of radiant heat through them The atmosphere, therefore, being at all times more or less transparent, permits the passage of the sun's heat rays without itself becoming much affected thereby. Heat radiated from the earth affects the air slightly more, being one of the minor causes of the raising of the temperature of the latter. Since pure air is only very slightly warmed by the passage of the direct rays of the sun through it, and is warmed to only a slightly greater degree by the radiation of heat from the earth, the changes in its temperature must be due principally to other causes.

Two bodies or substances in contact with one another tend to become alike in temperature, by the condition of one being transmitted to the other. The warmer body or substance tends to warm the other, and the cooler one to cool the other. Therefore, as the earth becomes warmed by absorbing heat radiated from the sun, some of its heat is conducted directly to the air lying in contact with it, and some of the heat received by the air is slowly conducted upwards. However, as the air is a poor conductor as well as a slow absorber of heat, it would become warmed upwards quite slowly by this process alone. But all gases expand and thus become lighter when they are heated; and since air is a combination of gases, it is governed by this law.

The air that has become warmer and therefore lighter next to the earth, by contact with it, is forced away and upwards by the cooler and therefore heavier air lying above. By this means a process somewhat analogous to the boiling of water is kept up during the day while the earth is receiving heat from the sun faster than it is radiating it. For it must be remembered that it is the heat that is absorbed by (and therefore raises the temperature of) the earth that most affects the air lying above it. Furthermore, the temperature of the air is affected only to a limited height by the earth, the temperature at the height of a few miles remaining constantly very low—over much of the earth being below zero Fahrenheit, The source of the heat of the air being the earth, during the day while the surface of the earth is kept warm by heat from the sun, the air is warmest next to the soil, and the temperature gradually decreases upwards. Thus, while the temperature of the air may be 100 degrees Fahrenheit next to the soil, it may be below freezing two miles above. During the night, however, after the surface of the soil, by the radiation of its heat, has become cooler than the air lying above it, the relative conditions change. The temperatures no longer decrease gradually upwards as during the day. The air in contact with the soil is cooled as the soil becomes cool, and this cooling extends higher and higher as the night advances. Cool air being heavier, it lies next to the earth unless mixed with the upper lighter air by a wind Thus, during the night, especially a still one. the air is coolest next to the soil, and for some distance upwards the temperature increases, the height at which it ceases to increase and then begins gradually decreasing as during the day depending upon many conditions.

Upon level land this cool layer of air remains spread uniformly over the surface, but upon uneven land the chilled heavier air flows downward just as water does, gradually filling up the valleys and other depressions Consequently night temperatures are lower at the same distance from the ground in low parts of a farm than on neighboring hills. The Station farm and the region about it are so nearly level, however, that there is little movement of the chilled air, and consequently comparatively little marked difference between temperatures of neighboring fields.

Any substance, such as clouds, smoke or vapor, floating in or mixed with the air checks the passage of radiant heat through it. In the day time these substances reduce the amount of heat received by the earth from the sun, and during either the day or night they check radiation from the earth and the objects upon it. Consequently, on a cloudy day the soil and the air lying above it do not become as warm as on a clear day during the same time of the year; and on a cloudy or damp night the soil and vegetation and the adjacent air do not become as cool as on a clear dry night during the same time of the year.

The atmosphere always contains more or less moisture in the form of vapor, the amount depending upon a variety of causes, and varying from hour to hour and from day to day. When the air contains all the water vapor that it is possible for it to contain, it is said to be saturated. The air in which dew is forming or from which rain is falling is necessarily saturated with moisture. But air can contain quite different amounts of moisture at different temperatures, the higher the temperature the greater the capacity for water vapor. A change in the temperature of the air therefore results in a change in the amount of moisture it can contain. For example, air at a temperature of 100 degrees can contain much more moisture than air at 50 degrees; and air that at the former temperature contained only a small part of the moisture it would be possible for it to contain, might be saturated if the temperature fell to the latter temperature.

The amount of moisture in the air is spoken of as its actual humidity, and the amount it contains compared with what it might contain at the existing temperature is called the relative humidity, the latter being expressed in hundredths or per cent. Relative humidity figures therefore express the relation that exists between the actual amount of water vapor in the atmosphere at any time and the amount it would be possible for it to contain at that temperature. For example, a relative humidity percentage of 25 means that the air contains twenty-five per cent, or one-fourth, as much moisture as it might contain. It is evident that the lower the relative humidity, the greater the capacity of the air for more moisture, and the greater the possibility of evaporation from the surface of the earth.

The water vapor of the air being the result of evaporation from the earth's surface, in perfectly still air the layer in contact with it would sooner or later become saturated and therefore incapable of receiving any more moisture. The movement of the air therefore favors evaporation. As already explained, the heating of the air by radiation from the earth causes an exchange of air that lies next to the earth with air lying above. The warmer moister air is thus replaced by air having a greater capacity for moisture. The movement of the air horizontally, called wind, also promotes evaporation, resulting as it does in the removal of the moisture-laden air and the bringing of a fresh supply of air with a lower relative humidity. The three principal factors effecting evaporation are therefore heat, relative humidity, and wind.

Wind is air in motion, being due principally to inequalities in its density. The lack of uniformity in density is caused chiefly by the unequal heating of the air. As already stated, as air is heated it becomes lighter and is crowded away by denser heavier air, the result being a current with a greater or less velocity. The unequal heating of the air over the land and over the water causes daily land and sea breezes; the unequal heating of the air of valleys and mountains causes daily valley and mountain breezes; and the unequal heating of the air over different parts of the land, or of the water, causes winds of various kinds and velocities. In all cases the cool, heavier air flows in to displace warmer lighter air. Near the coast, therefore, the air tends to flow from the sea to the land during the day and from the land to the sea during the night. Near mountains or hills the air tends to flow downward into the valley during the night and upwards during the day. Over the country in general, the temperature of the air becoming higher over one region than over another causes the air to flow towards (or in other words the wind to blow towards) the regions of lighter air.

To this movement of the atmosphere, indirectly caused by heat from the sun, is due most of the irregular changes in the weather. As a result of warm, moisture-laden air becoming cooled, water vapor is condensed into water and falls as rain, hail or snow. Precipitation is therefore closely connected with wind movement. Also, frosts and many other phenomena affecting agriculture are modified or caused by the movements of the atmosphere called winds. Evaporation is much hastened by them, sometimes becoming so rapid that crops wilt, though the soil be moist, and the temperature not excessively high.

Minimum Temperatures Recorded.

Examination of the minimum temperatures recorded in Tables I and III will show that there is a gradation upwards from tbe earth's surface, in accordance with the principles stated on a previous page. The minimum temperature near the soil is the lowest; that at five feet above a little higher; that at ten feet above a little higher still, and the minimum temperature fifty feet above, the highest of all. The difference is greatest in cool weather and least during July and August,

During January, 1901, for example, upon two nights the minimum temperatures recorded were fifteen at the ground and eighteen ten feet above. During December there was one night, however, when the same temperatures were recorded at these two places. During January, 1902, the differences between the minimum temperatures at the ground and at ten feet above were from four to five degrees most nights, and during February, 1903, the difference between the minimum temperature near the ground and at ten feet was eight degrees one night. The difference between the minimum temperatures at the soil and ten feet above is most of the year one to three degrees.

During the summer the difference is often very little, and some nights the minimum temperatures are higher at the ground than ten feet above. This was especially noticeable during the latter part of July, 1901, when for twenty days the minimum temperature at the ground averaged higher than at five feet and ten feet above, During July, 1902, for ten days during the latter part of the month the minimum temperatures at the ground averaged the same as at five feet and at ten feet above. During one night of the first ten of August, 1902, the minimum temperature at the ground was two degrees greater than at five feet or ten feet above, the average, however, for this period being one degree greater at the latter place. During the second period of August the average minimum temperature was the same at all three places, and during the third period of this month the average was again one degree greater at five and ten feet than at the ground. During the third period of August, 1903, the temperature was one degree greater at the ground one night and the average the same for the ten days at all three places.

By comparing the minimum temperatures recorded by the instruments located in the open air, and the minimum thermometer located in the government Weather Bureau shelter, it will be seen that the recorded temperatures in the latter place are usually higher than at any of the out-door situations, showing that this shelter prevents as low registerings as would occur without it. The difference between the temperatures recorded at the Experiment Station Farm and at the Weather Bureau at Phoenix, are a matter of considerable interest. As has already been stated, the instruments at the two points are similarly located, except as to elevation from the ground. The difference between the minimum temperatures recorded at the two places is three to six degrees, the temperatures recorded at Phoenix being that much higher. This difference is evidently due entirely to the difference in elevation, and it is probable that instruments located at an elevation of fifty feet at the farm would show similar differences in minimum temperatures.

The lowest temperature that has been recorded at Phoenix during the past eight years is twenty-two degrees, while the lowest recorded at the farm during that period is seventeen degrees. There is then apparently usually a difference of two or three degrees between the minimum temperatures at the soil and ten feet above, and from three to six more degrees between the latter place and fifty feet above. This gradation of minimum temperatures continues upwards for some distance, to how great a height has not been determined here by experiment; but as has been already explained, a point would be reached somewhere above the earth where the temperatures would cease to increase as the elevation increased, and would begin decreasing, as they do during the day, in accordance with the law previously stated. The total difference between the minimum temperatures recorded near the soil at the experiment Station farm and those recorded by the Weather Bureau instruments at Phoenix is from five to ten degrees. This causes a great difference in the number of nights that freezing temperatures are recorded at the two places. At the Station farm freezing temperatures were recorded fifty-three nights during 1901, seventy-five nights during 1902, and eighty-four nights during 1903; while at Phoenix freezing temperatures were recorded but fourteen nights during 1901, four nights during 1902, and nine nights during 1903.

The lowest temperatures generally occur during January or December, although they are sometimes recorded during February. In 1897, the lowest temperature of the year, seventeen degrees Fahrenheit in the government shelter at the farm, occurred December 21; in 1898 the lowest temperature, eighteen degrees in the government shelter occurred January 24; in 1899, nineteen degrees, February 7; in 1900, eighteen degrees, December 31; in 1901, nineteen degrees, January 11; in 1902, twenty-five degrees, January 20; in 1903, twenty-seven degrees, December 19 and 25.

Maximum Temperatures Recorded.

By an examination of tables I and III it will be seen that there is quite a regular gradation of maximum temperatures upwards from the surface of the earth, the highest temperatures being recorded nearest the soil, and the lowest maximum temperatures of which we have a record fifty feet above The greatest difference between the temperatures at the ground and at some distance above are recorded during summer, and the least during winter.

Upon some summer days the temperature within a few inches of the soil rises to as high as 120 to 130 degrees Fahrenheit, and upon the 24th of June, 1902, the temperature rose to 136. The temperature of the soil itself during the warm part of many summer days is 140 to 160 degrees Fahrenheit. As has been explained before, it is this high temperature of the soil, caused by the absorption of the sun's heat, that produces the high temperatures of the air near the soil. As temperatures are less at greater distances from any source of heat, such as a stove, so the temperatures are less and less at greater and greater distances from the earth's surface.

The difference between the maximum temperatures recorded in the government Weather Bureau shelter at the Station farm and those recorded by instruments similarly sheltered at the Phoenix Weather Bureau office is from one to three degrees. This, as explained before, is due to the difference in the elevation from the soil of the two sets of instruments, the difference in the maximum temperatures at five feet from the ground and at fifty feet being usually about two degrees. The highest temperature recorded at the Phoenix Weather Bureau during the past eight years is 116 degrees and the highest temperature recorded by similarly sheltered instruments at the farm during that period is 119 degrees Fahrenheit The highest temperatures generally occur during July and August, but occasionally occur during June. It was during June (June 24, 1902) that the highest temperature that has been recorded at the farm or at Phoenix occurred. In 1898, the highest temperature recorded in the government shelter at the farm, 109 degrees, occurred July 24; in 1899, 118 degrees, July 1; in 1900, 112 degrees, July 11; in 1901, 114 degrees, July 9; in 1902, 119 degrees, June 24; in 1903, 111 degrees, August 20, 21, and 22.

Annual and Diurnal Range of Temperatures.

The difference between the annual and diurnal range of temperature near the soil and at different elevations from it are worthy of attention. It will be evident from what has been previously stated that the greatest range, that is the greatest difference between the lowest and the highest temperatures recorded during any one year, or during the same twenty-four hours, would be greatest near the soil and less and less at greater elevations from it The annual range of temperature at the soil is from one hundred and five to one hundred and ten degrees, and the daily range from forty-five to sixty degrees. The annual range of temperatures at five and ten feet from the ground is from ninety-five to one hundred degrees, and the daily range from forty to fifty degrees. The annual range of temperatures at fifty feet from the ground is ninety to ninety-five degrees, and the daily range twenty-five to thirty-five degrees. This decreasing difference in range continues upwards to where the yearly range becomes very small, the temperatures, as already explained, remaining constantly very low.

A consideration of the statements made and figures given will make it evident that the extremes of temperature to which small plants are subjected are much greater than those to which the upper parts of large plants are subjected. For example, strawberries and other small fruits must endure both lower temperatures during the winter and higher temperatures during summer than the foliage of orchard fruits. Unfortunately, the small fruits are less able to endure these extremes, especially the high temperatures, than are most fruit trees. Furthermore, plants that finally become tall endure greater extremes of temperatures during the earlier stages of their growth than they do as a whole during the latter stages For example, young date plants during the winter are subjected to temperatures lower than is the foliage of the older ones which have attained a height of twenty to thirty feet, and young corn plants during their earlier stages are subjected to considerable greater extremes of temperature than are the full grown plants as a whole,

From a consideration of the comparison that has been made between the temperatures recorded at the farm and those recorded at the Phoenix Weather Bureau office, it will be seen that the temperatures recorded at the latter place do not indicate sufficiently accuratel} for agricultural purposes the extremes of temperatures to which the various kinds of crops are subjected. The minimum temperatures recorded during winter are too high to indicate what crops may be safely planted in the region, and the maximum temperatures recorded during summer are somewhat too low to indicate what crops can endure our summer conditions, this difference in temperatures recorded by similarly sheltered instruments being, as has been stated, due to the difference in the situation of the instruments. Furthermore, the protective effect of the shelter prevents the recording of the temperatures to which plants are actually subjected. Careful observation has shown that frost occurs each night that thermometers a few inches above the soil record freezing temperatures, instruments thus placed giving therefore a more accurate record of the temperatures to which small or low vegetation is subjected, than do instruments that are sheltered and located some distance above the soil. It is important, therefore, in considering what crops may be grown in a region from which temperatures are reported, to take into consideration the location of the instruments from which the record is made.

Underground Temperatures Recorded.

The record of underground temperatures given in Table II shows that during winter the ground is warmer downwards and that during summer the ground is cooler downwards; that is, the temperatures recorded at five feet under ground are lower during the winter than those recorded at ten feet under ground, and those at the latter point lower than those recorded at fifteen feet under ground; while during the summer the temperatures recorded at five feet under ground are higher than those recorded at ten feet under ground, and the latter higher than those recorded at fifteen feet under ground, the change in the relationship of the temperatures recorded at these points takes place during the latter part of March, usually, in the spring, and during the latter part of November in the fall; that is, from the latter part of March to near the end of November; the temperatures are least at fifteen feet under ground and greatest at five feet under ground, while during the rest of the year the reverse is true, with the exception of a brief period during each March and each November when the temperatures are the same at each point.

It will also be noted that the annual range of temperatures decreases as we pass downwards; the difference between the lowest and the highest temperatures recorded at five feet under ground being twenty to twenty-five degrees each year; the difference between those recorded at ten feet under ground being fifteen to twenty degrees each year; and the difference between those recorded at fifteen feet under ground being but ten to fifteen degrees; that is, at the latter situation the change of temperature from winter to summer is each year less than fifteen degrees. At greater depths under ground the yearly range of temperature is less, until a point is reached where the temperatures would remain constant throughout the year. This is said to be below about fifty feet under ground.

A difference between the temperatures recorded during 1902, and 1903 will be noted. By reference to the temperatures recorded above ground during the winter of 1903 it will be seen that this season was considerably cooler than the previous one, and the effect under ground is quite marked. These underground temperatures being due to the combined effect of the above-ground temperatures, and being affected to only a slight degree by fluctuations in temperature, are a quite accurate index of the real weather condition above ground. While the minimum and maximum temperatures recorded above ground show fairly accurately the condition of the weather, nevertheless since they do not show for how long a time the mercury remains at either of the points recorded, they indicate less accurately than these underground temperatures the sum total of heat received and absorbed by the earth.

An examination of the temperatures recorded under ground will show that the roots of crops, especially of the deep rooted ones, are in quite different temperatures during most of the year than are their above-ground parts. During summer such plants as orchard trees and alfalfa, for instance, have the most of their roots where the temperatures are comparatively cool. On the other hand during winter the roots of these plants are in soil that is much warmer than the night temperatures of the air surrounding them.

It is also important to note how slowly changes in temperature take place deep underground, the conditions there lagging far behind those above ground. Though the warmest weather of summer occurs in July, the soil continues to grow warmer at five feet under ground until the latter part of August or the early part of September; at ten and fifteen feet under ground, until about the middle of September. And, while the coolest weather of the year occurs from the middle of December to the middle of January, the soil continues to grow cooler at fifteen feet under ground until March During March and September the temperature remains about stationary at ten feet and at fifteen feet under ground, though the weather above be quite changeable during those months.

Relative Humidity and Wind Velocity Record.

As already stated, the records of relative humidity and wind velocity are from the Phoenix Weather Bureau office. The figures given express for each ten-day period the average relative humidity as compiled from the two observations made daily, and the average wind velocity per hour as computed from a continuous record made by an automatic instrument. They undoubtedly represent very closely conditions at the Station farm, and as a rule can be safely used in considering the factors causing the total evaporation during any ten-day period.

It will be seen that the relative humidity varies irregularly, there being no time of the year when it is regularly high, although the average is higher during December, January, and February than during the rest of the year, the lowest averages being during May and June. The lowest average from any ten-day period of the three years is 14 per cent during the second period of June, 1902, and the highest 76 per cent. during the second period of December of the same year. During each June of the three years the average for one of the ten-day periods was 16 per cent., and according to the record for 1900 this was the average of the month for that year. June is usually the dryest month of the year as a whole, the first period of July, however, being usually nearly if not quite as dry as June. August is seldom as dry as May, June, or July. The high temperatures of the latter part of June and the early part of July, combined with the low relative humidity, makes the period a very trying one on most vegetation.

The wind velocity is seldom great in the valley, and is much of the time very low. There is no distinctly windy month, and no period when the velocity is regularly low. The lowest average hourly wind velocity during the three years was 2.6 miles per hour during the first period of January, 1902, and the highest average 6.0 miles per hour during the second period of May of that year. May is frequently the most windy month of the year, although the wind is seldom noticeably high during that month,

Evaporation Records.

The evaporation record is of special value in showing the combined effect of the weather conditions upon growing vegetation. The amount of water evaporated from the water surface or from the soil varies with the temperature, the relative humidity and the wind velocity. The higher the temperature the more rapid the evaporation; the higher the relative humidity the slower the evaporation, and the greater the wind velocity the greater the evaporation; hence evaporation from the water or from the soil takes place most rapidly during a high temperature, a low relative humidity and a rapid movement of the atmosphere. In this region the influence of temperature is the greatest factor.

The amount evaporated during ten days ranges from one-half inch during most winter periods to nearly four inches during several summer periods. During the second ten days of December, 1902, the total amount evaporated was less than one-fourth of an inch, this small amount being due to an unusual combination of weather conditions. The temperatures during that period were unusually low, the relative humidity was unusually high, and the wind velocity comparatively low. During the first period of July, 1903, the total amount evaporated was over four inches. This large amount was also due to a somewhat unusual combination of weather conditions, the temperatures being high, the relative humidity quite low, and the hourly wind velocity considerably above the average.

The total amount evaporated during any ten days shows, therefore, quite accurately the total effect of the weather on the plants. When the combination of weather conditions is such that evaporation is unusually rapid, some plants lose water through their foliage more rapidly than they can obtain it from the soil, and consequently either wither temporarily or succumb entirely, no matter how damp the soil may be about their roots. In other words, the weather conditions are such during a part of the summer that some plants do not endure them, no matter how much irrigation water is applied.

DATA BEARING ON FORECASTING THE WEATHER.

Causes of Weather Changes.

An understanding of the elementary principles underlying weather changes is of value to none more than to farmers. Not only does such knowledge aid in judging what the forthcoming weather is likely to be, but is helpful in appreciating the work of the government Weather Bureau. As previously stated, all conditions and changes of the weather are the result of the operation of fixed laws, and there are times when the results of the working of these laws can be quite plainly foreseen by the observant farmer. If all the established laws governing weather conditions were thoroughly understood, and the exact conditions existing elsewhere were definitely known, the forthcoming weather could at all times be accurately foreseen. But a lack of definite knowledge along these lines limits the forecasting of the weather by anyone. Only persons having an opportunity to keep constantly informed as to existing conditions in the surrounding country can at all times form definite opinions concerning weather probabilities; but at times the weather of the morrow is quite plainly indicated to any good observer.

The conditions and changes of the weather are, as already pointed out, influenced in a marked manner by movements of the atmosphere caused by heat. Were all the air of the earth to maintain the same relative position constantly, instead of being kept in continual circulation by heat from the sun, the weather would be influenced only by the rotation of the earth on its axis and by its revolution about the sun, The changes would be gradual and regular, instead of uncertain and irregular. At the same season of the year the weather would be approximately the same each year. Each spring the weather would gradually and regularly become warmer, until a certain maximum temperature was reached, when it would grow gradually cooler until a fixed minimum temperature was reached. The weather of the year at any particular place could be counted on with as much certainty as the occurrence of the tides and the changes in the phases of the moon are.

But through the effect of heat upon the atmosphere, great areas of different density constantly exist, and as a result irregular, and ofttimes sudden, changes in the weather occur. A great area of country becomes overlaid with air of comparatively low density, while a distant area is overlaid with air of comparatively high density. The difference is indicated by the barometer,—the denser the air the higher the column of mercury supported by It

The area of low barometer is for convenience designated as the "low," and the area of high barometer as the "high." As will be understood by what has already been stated, the air flows towards the center of the mass of air designated by the term "low." All of the air does not flow directly towards the center of the low, however, the air within the area having a whirling motion that causes the air currents to move more or less obliquely to the center of the low.

If these lows and highs remained stationary, the changes in the weather would be less marked. Through the rotation of the earth and other causes, the areas of low barometer progress from one part of a country to another, passing as a rule from west to east. The majority of those passing over the United States enter from the northwestern coast or from the Gulf of Mexico. Some originate within the western part of the continent itself. Wherever their starting point, the most of those that move over the United States pass out of the country over New England and adjacent British America.

Only a small percentage of these "lows," or storm centers as they are also called, pass over the Southwest. The most of those that enter from the northwest coast pass too nearly east to influence our weather, only a few (and these mostly during winter) veering far enough south to pass over or near Phoenix. Most of those entering from the Gulf of Mexico curve around to the east of us, rarely coming near enough to bring our atmosphere under their influence. A few entering from off the Pacific coast to the southwest of us or originating within the western part of the continent pass over our region. The result of being out of the path of so many of these storm centers is a comparatively small rainfall and less changeable weather.

Whatever the origin of these areas of low barometer, or wherever they are situated, the air within their limits, especially that at the center, is constantly rising and whirling through the pressure exerted by the surrounding heavier air. When this ascending air reaches the higher altitudes and becomes cooled, its capacity to hold moisture is reduced. The natural result is the formation of clouds from which rain may fall. Since the air flows from all directions towards the center of the area of low barometer, the location of a "low" is more or less definitely indicated in any locality by the direction from which the wind is blowing there. If the wind is from the south it would indicate that the "low" is to the north or northwest, if from the east, that it is to the west, and if from the north that it is to the south. Wherever the "low" is situated, there rain, or at least cloudiness, is likely to be resulting.

Since these storm centers commonly move eastward, a wind from southeast, east, or northeast commonly precedes the approach of one. The more pronounced the conditions in the "low," the greater the effect in the region over which or near which it passes. The most rainfall or cloudiness commonly occur at any point while the "low" is passing over or near. As the center passes to the eastward, the rain ordinarily diminishes, the clouds disappear, and clear weather follows. Since the air continues to flow toward the area of low barometer, as the center passes to the east the wind changes and now blows from some part of the west for a time. After the weather at any point has undergone all the changes due to the passage of a storm center, the atmosphere that overlies the region commonly differs from that that has been removed in containing less moisture and having a lower temperature. The water vapor has been condensed, and cooler air from the upper regions to the westward have flowed in and taken the place of the air that arose as the storm center passed. The air being clearer, heat from the sun warms it less and the earth more, and radiation is more rapid. This results in bright warm days and cool clear nights, the diurnal range of temperature being ordinarily greater than before the passage of the storm center. During each month several of these storm centers pass over some part of the United States, the greater number passing over the Great Lake region, and a comparatively small number passing over Arizona. According to the government weather reports, during the past five years but forty-five storm centers have passed over Arizona, as compared with 337 that have passed over the region of the Great Lakes, Of the forty-five, eleven passed to the south of Phoenix, and thirty-four to the north.

Besides these general atmospheric disturbances that traverse the continent, there develop local conditions that result in more or less pronounced weather changes, especially during summer. In valleys the air that overlies a certain area gradually becomes warmer and usually moister than the surrounding air. The result is an upward movement of the lighter air, the consequent formation of clouds and the occurrence of a wind of more or less velocity. Rain accompanied by lightning and thunder may follow. Where a valley is situated near mountains, the flowing of the warmer air up the mountain sides may result in the formation of thunderclouds and rain there. The sudden changes of weather in summer are frequently due to the development of these local storms.

It will be seen that in all cases the occurrence of a storm at any point is due to the rising and consequent cooling of warm moist air, the upward current of the atmosphere being due to inequalities in the density of the layer lying next to the earth. The force of the wind accompanying a storm depends upon the greatness of this inequality; and the precipitation depends upon the humidity of the ascending air, and the amount that its temperature is lowered. The length of a storm depends upon the area involved and the rate of movement of its center.

Indications of Rain,

One of the first indications of rain that would come under a farmer's observation, especially during our winter season, would usually be a wind from the east. As these east winds are commonly the movement of the air over the surface of the earth, and not from higher elevations, they are not usually cool. If from the southeast, they are often quite warm; from the northeast they are naturally cooler, but not usually as cool as winds that follow a rain or precede cool dry weather. It will be understood from what has been said on a previous page that a south or even a north wind, especially if moist, may precede and therefore indicate the approach of a rainstorm.

The increased moisture of the air that commonly precedes rain is indicated in various ways. Evaporation being retarded by presence of moisture in the air, perspiration does not dry oft as rapidly as usual, and therefore collects in drops on the skin, or unduly wets the hair of horses. On a moist day preceding rain the hair of a horse will often become wet as he stands in the shade, and slight exercise results in the hair becoming very wet. This is not because the animal is sweating more than usual but because the sweat evaporates slowly. In the Southwest, where ollas are in such general use for cooling water, slower evaporation and the consequent failure of the water to cool as rapidly as usual would indicate increased relative humidity and therefore the possibility of rain.

The increased humidity of the air is also indicated by a smaller diurnal range of temperature. Before a rain the early mornings are usually not so cool (as indicated by the thermometer and not necessarily by ones feelings) and the afternoon temperatures lower than they have been during preceding days. In summer, the nights often become unduly warm before rain, and in cool weather the night frosts are usually lighter just before a rain, the cause in both seasons being the checking of the radiation of heat from the earth by the moisture in the air. As long as the nights are normally or unusually cool, rain cannot be expected.

The comparative lightness of the air, and the consequent decrease in its buoyant power, is indicated before a rain by the behavior of smoke of chimneys. Instead of rising as usual, after ascending some distance in the upward current from the chimney, it floats off, usually to the westward, or even forms a descending streak towards the earth. After a rain, smoke seems in haste to leave the earth, before a rain it seems loathe to leave it. Just before a rain, as the storm center is at hand, outdoor fires burn briskly, owing to the upward movement of the atmosphere causing a draft favorable to combustion.

But, while the phenomena discussed above ordinarily precede a rain, their occurrence cannot be counted on as surely indicating precipitation. Rain does not usually fall without the occurrence of most of them, but it does not necessarily follow their occurrence. This is especially true in southern Arizona, where the rainfall is so light. The fact that all crops are grown by irrigation, little dependence being put upon the local rainfall to furnish the moisture to plants, makes the foreseeing of rainfall of somewhat less importance here than in many other sections.

Indications of Frost or Cool Weather.

The ability to foresee with more or less accuracy the probability of the occurence of freezing temperatures is of considerable value to farmers of the region during the cool portion of the year, especially during fall and spring. The conditions that exist before (and therefore indicate the coming of) cool weather, or at least low morning temperatures, are in most respects the opposite of those preceding rain. In considering the probability of frost, the principal factors that are to be considered are the direction and character of the wind, the condition of the atmosphere, and the existing temperature.

During December and January and February, light frost may occur at the ground any night, without being preceded by any unusual conditions, but during November and March when the most damage may be done by low temperatures, even light frosts do not usually occur without considerable warning, and during no part of the winter are very heavy frosts. likely to occur without premonitory conditions. One of the most marked of these is a wind from some point of the west. The earlier the wind begins in the morning and the heavier it blows, the more pronounced is the change in the weather conditions. During the five years that the occurrence of frost has been a matter of observation at the farm, no heavy frosts have occurred without being preceded by a west wind of considerable velocity. Several days, especially the first and second, following such a wind are as a rule considerably cooler than those that preceded it; and from the middle of November to the middle of March freezing night temperatures usually occur after them.

The conditions of the atmosphere favorable to the occurrence of low night temperatures are dryness and stillness. These usually follow the west wind just mentioned. The absence of moisture or cloudiness is favorable to rapid radiation, and in still atmosphere the cooled layer is not carried away and mixed with warmer air. If the air is very moist, if the *sky* is overcast with clouds, or if there is much wind, there is little likelihood of heavy frost during any part of the year in southern Arizona, and certain to be none during fall and spring when vegetation is in a condition to be most injured by frost.

After the time of year when freezing temperatures occur, cool weather usually follows abnormally warm weather more or less closely. The usual weather program throughout late spring and early summer consists of a repetition of cycles made up of a period of increased warm weather followed by a period of decid-edly cooler weather. For a certain length of time the days grow more or less regularly warmer until the temperature becomes ab-normally high for the time of the year, when a more or less sud-den change occurs, and the succeeding days are comparatively cooler. Again the weather grows gradually warmer, and again it becomes more rapidly cooler. As the the season advances, the warm periods become longer and more pronounced, and the cool days less in number. Throughout the summer, however, ex-cessively warm moist days are likely to be followed by much cooler ones.

EFFECTS OF WEATHER ON DIFFERENT CROPS.

FACTORS INFLUENCING RESULTS.

In considering the effects of the weather on different crops, some difficulty is experienced in distinguishing with certainty between the results caused by the different phases of the weather and those caused by soil conditions. Differences in the physical and chemical conditions of the soil, especially differences in the amount of alkali present, cause more or less marked differences in the ability with which crops resist unfavorable weather conditions. These facts have been given due consideration, and an attempt has been made to discriminate as accurately as practicable between those results due to differing soil conditions and those due to the effect of the weather.

In the study that has been made of the effects of the weather upon crops five factors have been considered—temperature, direct sunshine, relative humidity, rainfall, and wind. Of these five the first has the greatest influence, and the last the least influence. High temperatures limit crop production in southern Arizona considerably more than low temperatures. Relative humidity has a greater influence on crops than the local rainfall, the latter being too scanty most years to affect results very much. Most of the wind that occurs in the region affects vegetation principally by influencing the rate of the evaporation of water from it, the velocity seldom being great enough to directly damage crops.

General Effects of Temperature.

High and low temperatures affect crops in various ways, the principal ones being by preventing germination, by checking growth, by killing part or all of the vegetative parts, by injuring the blossoms, and by damaging the maturing product. The most pronounced effects are brought about in the first two ways, and the least injury through the last. Crops affect considerably the temperatures about and among them. Through the cooling effect of evaporation and radiation combined, the temperature becomes lower among growing plants during cool nights than it is over bare ground, the difference varying from four to eight degrees. During the day, also, the rapid evaporation of moisture from vegetation causes the temperature to be a few degrees lower among plants than elsewhere. The temperatures to which crops are subjected are, therefore, more trying during frosty nights, and less trying during hot days than thermometers situated outside of their foliage would indicate.

The seed of most crops will germinate only during one or more definite portions of the year while the temperature remains within certain limits. For the seed of some crops this period is during the cool part of the year, and for the seed of others it is during the warmer part of the year. Seeds of the former class either decay or remain dormant through the portion of the year during which the temperature is too high for germination; and seeds of the latter class behave similarly during the cooler portion of the year. The seed of a very few crops germinates here promptly during all parts of the year, if supplied with water; and of a few others the seed germinates during all of the year, except the hottest weather of summer and the coldest weather of winter-

Most crops make growth only during the portion of the year that the temperature remains within certain limits, maturing, dying, or becoming dormant when the temperature falls too low or rises too high. Most annuals grow continuously during a certain portion of the year, and either die or mature when the weather becomes too cold or too warm, as the case may be. A few become dormant as unfavorable weather comes, resuming and finishing growth when the weather again becomes favorable, Most deciduous perennials grow during one portion of the year only, while most evergreen perennials make fresh growth during two distinct periods of the year, remaining dormant or getting killed back during other portions of the year,

Of the eighty crops discussed in the preceding part of the bulletin, twenty are wholly killed by the lowest temperatures occurring during ordinary years. Of ten others the vegetative portion is partially killed during most years, the vegetative portion of the remaining five-eighths never being seriously injured by any low temperatures that occur at the farm. Of the eighty crops, twenty-five are ordinarily killed or brought to maturity by the hottest weather of the year, and of about twelve others the vegetative portion is more or less injured during summer, the remaining half ordinarily sustaining no definite injury from beat.

Of several crops whose vegetative portions are not killed by cold, the blossoms receive such injury from low temperatures that there is no further development of the reproductive portion, be it fruit, grain or vegetable, and of a few the blossoms are similarly injured by heat. In most cases the vegetative part continues growing, or at least keeps alive, until it matures or favorable conditions return. Of only a few crops is the maturing product alone injured by low or by very high temperatures.

General Effects of Direct Sunshine.

Direct sunshine has an effect upon plants different from the effect of diffuse sunlight at the same temperature. Any solid substance that intercepts the sun's rays becomes heated thereby to a greater or less degree, A shaded object does not become as warm as one exposed to the direct rays of the sun in atmosphere of the same temperature. This is due to the absorption of radiant heat from the sun by the exposed object, as previously explained, while the shaded object becomes heated only by contact with the warmer atmosphere. In the shade, therefore, not only is the temperature of the air lower, but absorption of heat from the direct rays of the sun does not occur. Hence, the difference between the temperatures of soil and of objects in direct sunshine and of soil and of objects in shade is considerably greater than the difference between the temperature of the atmosphere over or about the exposed objects and that over or about the shaded objects. Shutting off or admitting sunshine, therefore, has a double effect upon plants.

During weather too cool for the normal growth of a plant, direct sunshine promotes its activities and results in benefit, while shade has the opposite effect. The almost continuous bright sunshine of our winters is, therefore, a distinct advantage to vegetation, and results in more rapid growth than could take place in a cloudy region where other conditions (both of soil and of weather) are the same. It has the effect, however, of unduly warming during the day deciduous trees in their leafless condition, and causing some of them to bloom so early as to receive injury from frost.

During the warm portion of the year, parts of many plants become overheated in direct sunshine, and injury to tissue results. This is especially true of exposed stems, fruits, and vegetables. While the loss of a portion of the exposed leaves is more or less injury to a plant, injury to the stem is far more serious. Moreover, since the leaves are continually being cooled more or less by the evaporation of moisture from their tissues, they do not become as highly heated as do stems and tree trunks from which no evaporation is taking place. Hence a plant or tree with a heavy foliage that shades the other parts has a distinct advantage, other things being equal, over ones with slight foliage, provided they are supplied with sufficient water.

Not only does insufficient or improperly located foliage result in the overheating of exposed stems and other parts, but the soil immediately about the plants becomes so highly heated as not only to seriously injure shallow roots, but to radiate heat so rapidly that the effect of the direct rays of the sun is thereby much augmented. For two reasons, therefore, it is important that varieties of fruits, vegetables, and other crops be selected having a heavy foliage not sensitive to heat, and that trees and shrubs be headed low. Protection to stems or trunks, to roots, and to the maturing crop of fruit or vegetables is thus secured. Similar results are also obtained by the close planting of fruits and vegetables, one tree or plant thus shading its neighbor, and all shading the soil. The crops for which the above precautions are important are such ones as peas, beans, tomatoes, squashes, melons, strawberries, plums, peaches, apples and oranges.

General Effects of Aridity and of Rainfall.

Of the eighty crops discussed in a preceding part of the bulletin not over half a dozen grow better, (other conditions being equally favorable) in a climate having a very low relative humidity. The remaining seventy-four thrive best in an atmosphere having a somewhat higher relative humidity than prevails in southern Arizona, providing all other conditions are favorable; and the growth of many is seriously retarded by the aridity of the region. In some cases deciduous trees though abundantly watered, are so affected by the dryness of the winter and spring atmosphere that they put out their leaves very tardily and incompletely, presenting the appearance of having been injured by extremely low temperatures. Several crops, though the temperature be favorable, and though supplied with plenty of water, do not grow well during periods of low relative humidity. Very rarely is the atmosphere of the region too damp for the proper development of any crop.

The direct effect of the local rainfall is not great, comparatively little benefit or injury to crops resulting from the small amount of rain that falls. Indirectly, however, the local rains benefit many crops. The higher relative humidity that accompanies them is a benefit to most crops at any time of the year; and the lower temperatures that accompany the summer showers are a relief to most crops during that season. Local rains are ordinarily heartily welcomed, however, chiefly because as a rule rain falls at the same time in the region furnishing the supply of water for irrigation. Only occasionally is the local rainfall heavy enough to directly benefit crops; and then only shallow-rooted ones are much benefited, since the soil is rarely wet to as great a depth as one foot during any one storm. When it is considered that the total annual rainfall of the region is only five to eight inches, much of which falls in such small amounts as to fail to reach the roots of plants and that amounts ranging from twenty to fifty inches in depth are needed for the proper development of various crops, it will be evident that the effect of the local rainfall as a water supply is not great.

The combined effect of the factors discussed above—temperature, direct sunshine, relative humidity, and rainfall—together with that of the wind, is taken into consideration in discussing the crops whose relation to the weather is given in the pages that follow. Upon some crops the effect of one of these factors is greatest. upon others the effect of another is greatest.

GRAINS AND GRASSES HARDY TO FROST.

Wheat, barley, oats, rye-grass, brome-grass, blue-grass, orchard-grass, are not killed or seriously injured by the lowest temperatures that occur in southern Arizona. On the contrary, they continue to grow during most of the coolest weather of the year. Occasionally some injury is done to the bloom of grains during spring, but the loss from this cause is not great. It is the hot dry weather of summer that the small grains and most of the perennial grasses cannot endure, their growth being limited almost entirely by heat rather than by cold.

The season during which seed of the above grains and grasses germinates begins during September, after the mercury ceases to rise above 110 in the shade during the day, and begins falling as low as 50 to 60 at night, and continues until the next May when temperatures higher than the above recur. During the hot weather of June, July and August their seed will not start, though supplied with plenty of water either naturally or artifically.

Barley and the early varieties of wheat sown and irrigated during September sometimes head out during December, especially if the autumn be warmer than usual; but ordinarily all grains head out by the end of April, regardless of the time of seeding. Fall-sown winter varieties of wheat do not usually begin stooling until after the coolest weather of winter is over, but most other grains begin stooling earlier, if sown during early fall. Grain sown during the latter part of January and during February makes an uninterrupted growth from the time of germination, and matures before the weather becomes extremely hot. Grain sown later than February does not have sufficient time for full growth before the hot weather of May and June. November is ordinarily the most favorable month for sowing grain. Evaporation being comparatively slow during the weather that follows, grain sown in moist soil during this month usually needs no irrigation until February or March if there is an average amount of winter rainfall. All sowings of all varieties ordinarily ripen during May or during the few days that precede or follow this month. At this time of the year the weather is usually very favorable for the harvesting of the crop.

GRAINS AND GRASSES SENSITIVE TO FROST.

The grains and grasses sensitive to frost—Indian, Egyptian, and Kaffir corn, sorghum, and millet – are limited in their growth mainly by cold instead of by heat, as are those just discussed. In the early stages of their growth they endure differing amounts of cool weather, but all are killed by about the same degree of cold. All grow most rapidly during warm weather, the degree of warmth best suited to their growth not being the same for all, however.

Of those named, Indian corn is the least sensitive to cool weather, and the most sensitive to extremely hot weather. The period during which the seed of some varieties will germinate extends from February, when the mercury ceases to fall much below freezing at night at the ground, and begins rising to 85 to 90 during the day, until the middle of November when these maximum temperatures cease and night frosts usually return. Before the middle of March, however, germination is slow and more or less uncertain. Corn planted during February and early March is apt to be injured by March frosts, and all not matured by the middle of November is usually killed by the frosts of that month. Corn planted March 13, 1899, was injured considerably by a minimum temperature of 23 at the ground on March 26, and corn planted February 22, 1901, was injured March 23, by a minimum temperature of 24 Fahrenheit. Minimum temperatures higher than the above at the ground do little injury to young corn.

All parts of the corn plant are usually injured more or less by the hot dry weather of June and July, and during a longer period of the summer the heat affects injuriously the tassels and silk. By the latter part of May the temperature is sufficiently high and the air sufficiently dry to so affect the pollen and the silk that fertilization does not take place. Consequently only varieties blooming before this hot dry weather produce corn from early spring plantings. The earliest dwarf varieties planted during February and March produce ears during May, but all ordinary field varieties bloom too late to produce ears from a spring planting. Of six varieties planted March 13, 1899, only Adam's Early produced well-filled ears. This variety bloomed May 15, before extremely hot weather, and produced ears suitable for the table May 28. The ordinary field varieties did not bloom until after the middle of June, while the maximum temperature was over 100 daily, and produced only partially-filled ears. Adam's Early planted February 22, 1901, produced an abundance of green-corn during the latter part of May, Dent corn planted on the same date did not bloom until June, and produced no well-filled ears, but gave a heavy yield of fodder.

The best results are secured from field corn planted during July and the early part of August. Such plantings bloom during September after the extreme dry heat of summer, and usually produce well-filled ears. Yellow Dent corn planted August 3, 1901, matured November 10, giving a yield of 2120 pounds per acre. A white dent corn planted the same date matured November 25, giving a yield of 3000 pounds per acre. Had the frosts been as early as they are some years, the early variety would undoubtedly have given the heavier yield.

Egyptian corn, Kaffir corn, and sorghum are each similarly affected by the weather of the region. The season during which their seed will germinate begins during March, and continues until November. Seed does not germinate promptly and the young plants grow thriftily, however, until April of most years. Little is usually gained by planting before the daily maximum temperatures begin to be 85 to 90 degrees, and the minimum temperatures are over 45. They are uninjured by the warmest weather of summer, ordinarily making their best growth then* They are all killed when the mercury falls below 30, this usually occurring during November. A good crop may be secured ordinarily by planting them any time from April to July.

Millet will germinate and make a good growth any time from the middle of April to the middle of October, but does not have sufficient time for full growth before the frosts of fall, if sown after August,

LEGUMES SENSITIVE TO EXTREME HEAT.

The legumes sensitive to extreme heat, including peas, bush beans, lupins, and the annual clovers, are limited in growth by heat more than by cold. However, the coolest part of the winter is too cold for the rapid growth of any of them, the most progress being made during the moderately warm weather of spring and fall. They are all killed or brought to maturity by the heat of summer, none of them continuing growth later than May.

The period during which peas will germinate extends from August to the hot weather of the following spring, but the months during which they start promptly and make a rapid growth are October, February and March. During August and September they germinate with uncertainty, but if early varieties get a start during these months, they bloom and produce some pods during November, blooming being terminated by the heavy frosts of December. Late varieties sown during autumn make considerable growth before the cool weather of December, grow slowly during the latter month and January, resume thrifty growth early in February, and begin blooming in February or March, The frosts of winter are seldom heavy enough to kill the vegetative parts, but all the heavy frosts injure the blossoms and young pods. Peas sown during December and January germinate slowly, but quite surely, and are ready for thrifty growth when the warmer weather of February comes. Early varieties sown during January and early February bloom and produce pods during the latter part of March and during April, seldom being seriously injured by frost, and usually coming to maturity before the heat of May. Late varieties sown during winter produce some green peas during April and May, but do not always have sufficient time to mature before their growth is checked by the summer heat. None sown after February have sufficient time for full growth.

Of the annual clovers, the only one that has been found to be thoroughly adapted to the weather conditions of the region is the so-called "sour-clover" (*Melilotus indica*), the winter being somewhat too cold for the others, as well as the summers too hot.

The growth of the Melilotus is confined to a definite portion of the year. Germination will not take place in the fall until the maximum temperatures cease to be greater than about 95 in the shade, and the mercury begins falling below 50 at night. This usually occurs about the middle of October. During the latter part of September, 1903, however, occurred a tain accompanied by weather sufficiently cool to cause Melilotus seed to start fully two weeks earlier than usual. From the time of autumn germination until the cool weather of December growth is quite rapid; but from the beginning of the heavy frosts of the latter month until the warmer weather of February growth is slow, though no part of the plant is killed by any low temperatures that occur in the region. From February until April growth is very rapid, full size being attained during the latter month, regardless of when the seed was sown. The heat of May terminates growth, the size reached before that time depending upon when the plants started. From the middle of November to the end of January the weather is too cool for prompt germination of the seed, and after the latter month there is not sufficient time for full growth before the heat of summer, Hence the best results follow seeding that occurs during October and the early part of November.

The period during which berseem, or Egyptian clover, germinates extends from August to December and from the first of February to May. However, plants that start during August soon succumb to the heat, and plants starting during November are soon checked in their growth or entirely killed by the frosts that follow. Plants that start soon after the middle of September make a fair growth during fall but are killed back when the temperature falls much below 30. The roots, however, usually survive the lowest temperatures that occur in the region, and send up fresh shoots when the warmer weather of February comes. After making considerable growth during the moderately warm weather of spring it succumbs to the heat of early summer. Being thus sensitive to frost as well as to extreme heat, it does not have sufficient opportunity for full development in this region. Where it is cultivated in Egypt, the mercury seldom falls below freezing.

COWPEAS AND COTTON.

The growth of these two distinctly warm-weather plants is confined to the frostless portion of the year. The seed of each will germinate as early as March; but the growth of the young plants is very slow from seed that starts earlier than April, when the mercury ceases to fall much below 40 at night and begins rising to 85 in the day time. Both grow thriftily during the hottest weather of summer, if supplied with plenty of water, and both are killed in the fall when the mercury falls below 30 degrees Fahrenheit.

Cowpeas come to maturity sown any time from early April to early August, but cotton requires all the season for full growth. Cowpeas that start during early April mature during August and September, and those sown as late as early August mature during the early part of November. Those sown later than August are apt to be killed by the frosts of November before coming to maturity. Cotton planted as early as it will germinate produces the first picking in September, and another of about the same yield about the time the first frosts come.

MELONS AND SQUASHES.

The relation of melons and squashes to the weather is similar to that of cowpeas and cotton just discussed, the former two differing in being somewhat less sensitive to cold and in being more or less injuriously affected by the extreme heat of mid-summer. Squashes and melons will start a little earlier in the spring than cowpeas or cotton, and will continue growth a little later in the fall. On the other hand, growth is checked and the ripening crop injured more or less during July and August.

Squashes are less sensitive to cold than melons and will germinate earlier in the spring. The bush varieties will start during February, and the remaining varieties will start nearly as early. As soon as the frosts that usually occur in March cease, growth becomes more rapid and continues until the hot weather of June, The bush varieties come to maturity at this time and cease producing squashes. The running varieties continue growing some longer, but growth is seriously interfered with, if not stopped entirely, by the heat of mid-summer. The bush varieties have ample time to produce a fairly heavy crop, but few of the standard running varieties produce sufficiently well to justify their culture, the Cashaw Crook-Neck pumpkin taking their place. The running varieties of squashes and the pumpkin mentioned do best if planted during June or early July. The plants start well during the weather of these months, continue growing through summer, and produce a crop during autumn. The bush varieties will start during July and August and produce squashes during autumn, but do not grow as thriftily as during spring.

The period during which melon seed germinates extends from March (the time m the month depending on the season) until October. Most of the early varieties germinate earlier in March than the later ones, the Augusta starting the earliest of any tested at the farm, but no varieties make much growth until the mercury ceases to fall below freezing at the ground. Seed planted before the latter part of March germinates very slowly, and during the early stages the young plants are sometimes injured by frost and usually give little promise of giving better results than those planted later; but the first planted are ordinarily the first to produce ripe melons Those planted during the early part of April ordinarily grow without interruption by cold, but usually ripen their melons a week or so later than those planted in March. During the warm weather of May and June while the maximum temperatures range from 90 to 105 growth is rapid, the first melons ripening usually at the farm during the last week of the latter month, but occasionally as early as June 20,

The melons produced are of prime quality until about the middle of July, if the vines are supplied with sufficient water, but from that on are apt to deteriorate, the early varieties first and the later varieties later. By the end of July the intense heat causes such early varieties as Augusta to be unfit for market, and a little later the Florida Favorite becomes affected by the heat. During the warm weather of August only the latest varieties or late-planted earlier varieties produce melons of good quality. If supplied with plenty of water, the vines continue growth throughout the summer, and will produce melons of good quality during September and October, especially if cut back and the soil between the rows cultivated and refurrowed.

As seed germinates promptly and young plants grow thriftily throughout the summer, plantings for the production of fall melons may be made during June and early July. The vines from seed planted at this time grow rapidly through August and September, producing ripe melons in abundance during the latter month As the cooler weather of October comes, growth and ripening are very slow and during November, or the early part of December, the vines are killed by frosts. In 1899, they were killed December 1, the minimum temperature at the ground being 28 degrees, in the government shelter, 32, and on the building of the Phoenix Weather Bureau, 37. In 1900, with the occurrence of the above minimum temperatures October 28, they were only partially killed, not being entirely killed until December 3, when the mercury fell to 28 at the ground, 32 in the government shelter, and to 35 at the Weather Bureau; in 1901, they were not injured by frost until December 8 and 9, the mercury falling to 25 degrees at the ground upon the latter date. In 1902, they were killed November 26 and 27, the minimum temperature the latter night being 27 degrees at the ground. The past autumn they were not killed until December 4, the minimum temperature being 25 at the ground, 34 in the government case, and 40 at the Weather Bureau. This last record furnishes an illustration of the fact that plants may be injured or killed when the thermometer in the government shelter five feet from the ground does not register a freezing temperature, and when the minimum temperature recorded at the Weather Bureau is many degrees above freezing.

GARDEN VEGETABLES HARDY TO FROST.

The vegetables of which the leaves, stems, or underground parts are eaten are, with few exceptions, hardy to frost. They include cabbage, cauliflower, lettuce, spinach, beets, carrots, parsnips, turnips, radishes, and onions. None of these are seriously injured by any low temperatures that occur here, and most of them make more or less growth through the coolest weather of winter. On the other hand, all are quite sensitive to heat, most of them being checked in their growth or killed by the heat of summer.

Seed of these vegetables will germinate from August to May, in most cases germinating quickly during the warmest weather of this period, and slowly during the coolest. During both the warmest and the coldest weather also, the young plants are apt to be injured, though injury by cold is less frequent and less severe than injury by heat. Well-established plants are not seriously injured by cold. They endure minimum temperatures of 12 to 14 degrees, Fahrenheit among their foliage, these being the temperatures registered there when those in the government shelter five feet from the ground were 18 to 20 degrees, and those over bare soil 14 to 16 degrees. The mercury fell to 12 to 14 degrees among low growing foliage November 23 and December 31, 1898, January 6 and December 14, 1899, December 31, 1900, and January 22, 1904, without serious injury to any of these vegetables Of the number, lettuce is the most subject to injury by cold, the ends of the leaves having been killed during the protracted cold of the past January. The coldest morning during this period was that of January 22, when the mercury fell to 25 degrees at the Weather Bureau, 19 degrees in the government shelter five fett from the ground, 16 at the ground over bare soil, and 12 degrees among low growing foliage.

SUGAR BEETS.

Sugar beets being, like garden beets, more sensitive to heat than to moderate cold, grow here better during the cooler part of the year than during the warmest part. In our climate, therefore, their growth is limited by heat rather than by cold. While neither the heat nor the cold is great enough to kill well established plants and young plants are sometimes killed by cold as well as by heat, yet it is the high temperatures rather than the low that interfere most with their culture in this region.

Beet seed will germinate sown at any time from August to May, the length of time lapsing between seeding and the appearance of the young plants varying with the warmth of the weather at the time. During weather that the maximum temperatures range from 95 to 105 the young plants appear within four or five days after seeding and irrigation, and during the coolest weather of winter they appear within ten days or two weeks. During midsummer some seed will sometimes start but the young plants in most cases succumb to the heat within a week or two after coming up; and during winter they are sometimes killed by frosts. During the part of the year that the maximum temperatures are much above 100 degrees in the shade at five feet from the ground young beets cannot get a start, and minimum temperatures below 26 degrees at the ground kill most beets that have just come up.

There are two periods during which beets may be sown in southern Arizona, with a reasonable prospect of securing a stand. One period is from the latter part of September to the end of October, and the other from the latter part of January to the end of April. During the first of these periods the seed must be irrigated just after being sown in order to bring them up. During the cool weather of winter the seed will germinate without irrigation if the soil has been thoroughly irrigated and the surface is still moist when it is seeded. The periods during which beets may be sown with a probability of securing a satisfactory crop are shorter than those given above. One period is very brief, covering only the latter part of September and the early part of October and the other extends from the latter part of January to the middle of March.

Beets that start during the latter part of September and during October make a rapid growth until checked by the cool weather of November, During December and Jannary they grow slowly but resume rapid growth with the return of the warmer weather of February. During the latter part of March or the early part of April autumn-sown beets ordinarily begin going to seed regardless of the time during autumn that they were sown or the size they have attained. Those sown in the fall after the early part of October, get so poor a start before their growth is checked by the cool weather that they are ordinarily very small when the time arrives in the spring when autumn-sown beets begin going to seed. Beets sown during November, December and January are liable to be killed by frost just after they come up. However, if they escape frost and get a start during December and January, satisfactory results usually follow.

Beets that start during or soon after the cool weather of winter grow with increasing rapidity until their growth is checked by the heat of summer. About the first of July they ordinarily cease growth, the size they have attained at that time varying with the length of time they have been growing, other conditions being the same. The size of those that start during January and February is usually about a half greater than those that start during early autumn and come to maturity during early spring. Those starting after February do not have sufficient time for full growth before being checked by the heat of summer.

After growth being suspended by the heat during most of July and August, a fresh growth of leaves usually starts as the weather becomes cooler, especially if the plants receive water either from rain or by irrigation. The roots do not ordinarily increase in size after their growth being once checked by heat, but become more fibrous and less sweet. The fresh growth of foliage takes place, therefore, largely at the expense of the sugar contained in the roots, the growth continuing until checked by the cool weather of autumn. Upon the return of warm weather the following spring they make a fresh growth of leaves and begin going to seed during March.

While being checked in their growth by heat interferes with the further formation of sugar and of an increase in the size of the roots, a checking of growth by cold is usually necessary to cause seed production. The amount of growth that takes place previous to being checked by cold seems to have little to do with the effect of the checking, all beets that start some time previous to the cool weather of late autumn and winter going to seed at about the same time.

POTATOES.

Potatoes differ from most of the vegetables discussed in the preceding pages in being sensitive to both heat and cold, being quite as sensitive to heat as most of the vegetables hardy to frost, and nearly as sensitive to cold as melons or squashes. They do not endure the low temperatures of winter, and are checked in their growth or killed by the heat of June, July, and August. Sprouts will start during both most of winter and most of mid-summer, but the young plants cannot endure the climatic conditions of either period.

With the exception of possibly a month in summer and about two months during winter, potatoes will germinate with more or less promptness after being planted in fairly moist soil. The usual planting season here is from the middle of January to the middle of February. Tubers planted during January send up sprouts nearly as rapidly as those planted later, but the young plants are apt to be injured by frosts. Potatoes planted December 23, 1899, and January 17, 1900, came up during February, and were slightly injured by frost that occurred February 24, when the mercury fell to 26 at the ground, 29 in the government shelter, and 37 at the Weather Bureau, no injurious frosts occurring during March of that year. Potatoes planted January 9 and February 1, 1901, were slightly injured March 13, when the minimum temperatures were 27 at the ground, 32 in the government shelter, and 37 at the Weather Bureau. They continued growing until March 25, when those planted in January had reached a height of six to eight inches, and those planted February 1, a height of two to four inches. Upon the above date the larger ones were nearly all killed to the ground, and the smaller ones considerably injured, the mercury falling to 26 degrees at the ground, 30 in the government shelter, and 35 at the Weather Bureau. Potatoes that were planted February 22, and were just coming up were very slightly injured.

During the past five years, potatoes planted during February have received no serious injury from frost, although some plants have been slightly injured each year. During April, potatoes that started in February or early March grow rapidly and early varieties begin forming tubers. Thrifty growth continues throughout most of May, if no unusually warm weather occurs. In 1902, an unseasonably warm period occurred between May 6 and 10, the maximum temperatures being 108 to 110 at the soil each day, ard 99 in the government shelter, and the mean relative humidity but 20. Potatoes planted January 20 and February 4 that were blossoming were considerably injured, and the crop was much lighter that year than usual. Some injury was also done May 12 and 13, 1903, when the maximum temperatures in the government shelter were 102 and 106 respectively

The increasing heat and aridity of June hasten the maturity or death of all potato tops, regardless of when they were planted or what the variety may be. Only early varieties have sufficient time to come to maturity before being overcome by the heat The varieties that are grown most successfully in the region are Early Rose, Triumph, and Burpee. These varieties usually mature about the middle of June, although a large share of the crop is often dug and marketed considerably earlier than this. Upon account of the weather, the tubers deteriorate rapidly after ripening, whether dug or left in the ground. For this reason, by July 4 all the crop of the season is ordinarily consumed, except a small amount that a few growers save as best they can for summer planting.

From seed saved from the spring crop, a few potatoes are grown during autumn. They are planted during August or early September, and as a precaution against decay, are not cut. The sprouts sent up are usually distinctly slender, and the subsequent growth is of the same character. As the cooler weather of autumn comes, they grow somewhat more rapidly, and produce a small crop of tubers. They do not usually have time for full maturity before the frosts of late autumn. In 1899 they were partly killed December 2, when the ground minimum temperature was 26, in the government shelter, 32, and at the Weather Bureau, 38; and were entirely killed December 10, the minimum temperatures being 22 at the ground, 29 in the government shelter, and 34 at the Weather Bureau. The past season they were killed December 4, when the minimum temperatures were respectively 25, 34, and 40 at the above points,

As the heat causes the keeping of potatoes through the summer to be very difficult, the saving of a portion of the spring crop for seed for planting the next winter is not attempted; and as the fall crop is both very light and insufficiently matured, none of it Is ordinarily used for seed about Phœnix. Nearly all the seed used for winter planting comes from the Pacific coast. Attempts have been made at the farm to preserve seed from season to season, but without satisfactory results. Attempts have also been made to interest growers it) neighboring mountain valleys to produce seed for the warmer valleys, but the local demand near the former is so great that these attempts have met with no better success. The impractibility of preserving seed for succeeding plantings interferes materially with experiments with this crop, and renders the planting of varieties not grown near the region expensive.

TOMATOES,

Like potatoes, tomatoes are sensitive to both heat and cold, though not quite as sensitive to either. Tomatoes differ from potatoes in living through the summer and producing two crops on the same vines, instead of requiring replanting.

Tomatoes are propagated in two ways in this region: (1) By planting the seed in the usual way in protected seed-boxes and either transplanting directly from these to the field, or first transplanting to other boxes or to pots, and (2) by planting the seed in hills where the plants are to remain. As the latter method is the one that has proven the preferable one at the farm, and as it is in following this method only that the seed and plants are exposed to outdoor conditions from the first, it is the one that will be discussed most fully. The principal advantages of planting the seed in hills outdoors are that this method involves *less* labor, and usually results in" the production of an earlier and heavier crop. Though the seed may be sown much earlier in protected seed boxes than outdoors, the transplanting of the plants under our climatic conditions usually so checks their growth and renders them susceptible to disease that they are surpassed in growth and production by those planted in the field.

Tomato seed will germinate outdoors and the young plants start and make a continuous growth during most years from the middle of February to the first of May. In 1899, seed planted in January did not send up many plants until the end of February, but they grew continuously thereafter, tomatoes maturing earlier than on plants grown from seed planted in boxes January 3 and transplanted April 10. Some seasons the young plants receive some injury from frosts, but as a rule few young plants are killed, enduring a surprising amount of cold if planted in the field. During the spring of 1900 the young plants from seed planted out February 10 were not injured by cold. In 1901, about a fourth of the young plants from seed planted February 14 were killed March 25, the minimum temperature being 26 at the ground, 30 in the government shelter, and 35 at the Weather Bureau. They had been uninjured by a previous frost March 13 when the minimum temperatures were 27 at the ground, 32 in the government shelter, and 37 at the Weather Bureau. In the spring of 1902, tomatoes growing from seed that had lain in the ground over winter were uninjured March 4, when the minimum temperatures were respectively 27, 33, and 38 at the above points; but were slightly injured March 26 when the minimum temperatures were 30, 33, and 36 respectively at the same points. During the spring of 1903 tomatoes were uninjured outdoors, though March 19 the mercury fell to 27 at the ground, 31 in the government shelter, and 36 at the Weather Bureau.

After the early part of April the weather is sufficiently warm for tomatoes to begin making more rapid growth, and until the first of June most varieties grow with increasing rapidity. As the weather grows warmer, only the varieties with heavy foliage continue thrifty. All varieties with finely divided or thin foliage are seriously injured by heat during June, and none of them produce much fruit. Only the Dwarf Champion, and a few related varieties with heavy foliage, can be counted on to produce a crop regularly.

Fruit begins ripening during the latter part of June and increases in quantity until the middle of July. The vines continue to make some growth and to ripen fruit until about the middle of August. While they continue blossoming some through the summer, no fruit is ordinarily set after the middle part of July.

Hence none ordinarily ripens during the latter part of August, or during September. As the weather becomes cooler during the latter month, fruit again begins to set. It begins ripening during the latter part of October, the total amount of the crop depending upon the earliness of the fall frosts. The vines are usually killed during the latter part of November or the early part of December. In 1899, they were killed December 10, and in 1900 not until December 27. In 1901, they were slightly injured December 8, when the minimum temperatures were 27 at the ground, 31 in the government shelter and 36 at the Weather Bureau, and were nearly killed the next morning, when the minimum temperatures were respectively 25, 28, and 33 at these points. In 1902, they were slightly injured November 16, when the minimum temperatures were 31 at the ground, 35 in the government shelter, and 43 at the Weather Bureau; were considerably injured November 26, when the minimum temperatures were respectively 29, 32, and 34 at these points; were partially killed November 28, when the minimum temperatures were 27, 30, 34; and were killed December 3, when the mercury fell to 24, 28, and 33, at the above points. During the past season they were killed December 5, when the record shows minimum temperatures of 25 at the ground, 30 in the government shelter, and 35 at the Weather Bureau.

By comparing the records of spring and fall frosts it will be seen that young tomato plants endure quite as low temperatures as mature ones; and in some cases were uninjured by lower temperatures than seriously injured full-grown vines. In the fall, fresh growth is usually injured less than older growth, indicating that more vigorous action on the part of the plant renders it less susceptible to the effect of frost.

ALFALFA.

Alfalfa being a perennial, and therefore exposed to changes of the weather during the entire year, has a somewhat different relation to the weather than the crops already discussed. Instead of dying or coming to maturity with the change of the seasons, its growth is only temporarily interrupted when unfavorable weather comes. The relation of the growing vegetative part of alfalfa to the weather is much like that of tomatoes, being checked in its growth by the heat of summer, and killed to a greater or less extent by the cold of winter. Its growth, unlike the grass forage plants hardy to frost, is limited by cold to a greater extent than by heat.

Alfalfa seed will germinate any time from about the middle of September until the middle of May. During the remainder of the year, while the maximum temperatures are most of the time above 100, seed will not germinate. If sown during September, it germinates as soon as the mercury ceases to rise above about 105 in the shade during the day, and begins falling below about 60 at night. If sown during the latter part of September, or during October, it germinates very quickly, and begins making rapid growth, by the end of the fall usually having attained a height of four to six inches. The earlier it is sown after the latter part of September, the greater the growth that will be made before being checked by the cool weather of late autumn. Seed, however, will germinate satisfactorily and make a sufficient start to endure the cold of winter if sown any time before the middle of November. If sown after the latter date, the young plants are apt to be killed or seriously injured by frost. It is possible, however, to get a stand of alfalfa at any time during the winter, especially if advantage is taken of a warmer period. The young plants may be killed to the ground, but the roots are seldom killed. After about the middle of January, seed usually germinates promptly when sown, and the young plants are in comparatively little danger of being injured by frost* Seed sown during the early part of February is almost sure to give very satisfactory results, and it may be sown to advantage as late as the first of March. If sown after the latter date, the young plants are apt to be choked by weeds, and do not have sufficient time to get properly established before the heat of summer. After the first season, however, the plants having become thoroughly established, will survive all the heat of the region. Rapid growth continues until about the first of July, when it is checked by the increasing heat. During July and August growth is comparatively slow, and only a light crop of hay is produced. With the return of cooler weather in September, rapid growth is again resumed and continues until the cool weather of November. The amount of injury that is done to alfalfa during the winter depends upon the stage of its growth when a heavy frost occurs.

During 1899 the growing parts of alfalfa were injured considerably December 3, the minimum temperatures being 26 at the ground, 32 in the government shelter, and 35 at the Weather Bureau. December 10 more injury was done than on the preceding date, the minimum temperatures being respectively 22, 29 and 34 at the above points. The minimum temperature, however, among the alfalfa itself on this date was 17. On the 14th of December, growing alfalfa that had escaped the previous frosts was killed to the ground, the minimum temperatures being 14, 23 and 28 respectively at the above points. Subsequent warm weather started fresh growth that was badly injured February 9, when the mercury fell to 20 at the ground, 24 in the government shelter, and 29 at the Weather Bureau. It was again slightly injured February 24, when the minimum temperatures were respectively 26, 29 and 37 at the above points. In the alfalfa itself, however, the minimum temperature was 20. During the autumn of 1900, alfalfa was slightly injured October 30, the minimum temperatures being 28, 32 and 39 at the above points; was badly injured December 27 when the minimum temperatures were respectively 25, 28 and 33; and growing alfalfa was frozen nearly to the ground the 31st of that month, when the mercury fell to 14 at the ground, 18 in the government shelter, and 22 at the Weather Bureau. The following March, about 4 to 6 inches of the growing parts were injured on the 13th when the minimum temperatures were 27, 32 and 37 respectively, at the above points. December 9, 1901, alfalfa was injured considerably when the minimum temperatures were 25 at the ground, 28 in the government shelter, and 33 at the Weather Bureau, and was killed December 13 when the mercury fell to 17, 20 and 26, respectively at the above points. During the winter of 1902-3, alfalfa was not killed, but was somewhat injured December 3 when the minimum temperatures were 24 at the ground, 28 in the government shelter, and 33 at the Weather Bureau. During the past season alfalfa was considerably injured December 5 when the minimum temperatures were 25, 30 and 35 respectively at these points; and January 6, 1904, a field of alfalfa near the Station farm that had attained a height of two feet was killed to the ground, the mercury falling to 18 at the ground, 23 in the government shelter, and 27 at the Weather Bureau on that date.

The weather is especially favorable for the making of alfalfa hay, the time of cutting coming as it does during portions of the year when there is little or no rain. The first cutting is usually made during the last half of April or the early part of May, the date depending not only upon the weather, but upon how closely and how late the field was pastured during winter. The second cutting is usually made during the latter part of May or the early part of June, and a third cutting about a month later, if sufficient water to produce a growth has been available. During all this time the weather is ordinarily warm and dry. During May and June hay cut in the early part of the day can be raked into windrows before the end of the day. Whatever time of the day it is cut, it is usually raked within twenty-four hours during May, June and July and is usually put into shocks within forty-eight hours. In some cases it is baled or stacked directly from the windrows, within two days after cutting. Rarely is hay injured by rain during any part of the year. The fall cutting of alfalfa is usually made during the latter part of October.

STRAWBERRIES.

Like alfalfa, strawberries being perennials, are exposed to the climatic conditions throughout the year. Unlike alfalfa, however, they are very shallow-rooted, resembling in this respect the perennial grasses. Strawberries are less sensitive to cold than alfalfa, but are more sensitive to heat, resembling in this respect also the perennial grasses. The vegetative parts of none of the varieties of strawberries are entirely killed by any low temperatures that occur in the region, and some of them produce some fruit throughout the coldest weather. On the other hand, all varieties are more or less injured by the heat of summer, only a few varieties withstanding the summer conditions, and a large percentage of the varieties succumbing to the heat of midsummer,

As the varieties differ so much in their relation to the weather, it will be necessary to discuss each one separately. The varieties that have been experimented with most extensively and which seem the most promising ones for the region are Arizona Everbearing, Michel's Early, Excelsior, Texas, and Lady Thompson. The first variety mentioned has been grown in the region for many years, and is claimed by some to have originated here. The second variety named has been grown here nearly as long, and is now more extensively grown than any other. The last three named are newer varieties, and have been tested only a few years in the valley, mostly at the Station farm.

The period during which strawberry plants will grow if transplanted extends from the latter part of October to the first of April, the month of February being the one during which they are transplanted with the best success. During the fall months, while it is possible to get most varieties to make a start, in many cases they die during the latter part of tall or early winter. If transplanted during the cold weather of December and early January, while they will not start to grow for some time, the most of them will eventually make a good growth. Those set during the latter part of January and during February usually start to grow promptly, and their growth is continuous until the hottest weather of summer. Those set after February start to grow promptly, but usually do not get sufficiently established before the hot weather of summer. Of the varieties mentioned, Michel's Early makes the poorest growth if transplanted during the fall, and Excelsior usually the best. Texas and Everbearing also make a fairly satisfactory start if transplanted during the fall.

Michel's Early, set November 20, 1901, and supplied with plenty of water, died within two weeks, and most of those set December 6 of the same year died within a month. Michel's Early set November 24, 1902, made a much better start and grew fairly well the next spring. Plants of this variety set November 6, 1903, made a very poor start and have not since grown satisfactorily, while plants set December 2 became better established.

Arizona Everbearing set March 12, 1900, started well, and grew continuously until the hot weather of summer. Those not mulched with straw nearly all succumbed to the heat, while three-fourths of those mulched with straw survived. Those set February 16, 1901, grew well until the hot weather of summer, but few plants survived the trying conditions of July and August. Plants of this variety set October 27, 1901, did not make a good start; those set November 24 of that year started better, but a large percentage died before the end of winter. Those set February 12, 1902, started well and grew continuously until injured by the heat of August, only a small percentage surviving the summer.

Excelsior plants set December 2, 1901, started well, grew through most of the winter, and made excellent growth until the hottest weather of the following summer, when a large percentage of them succumbed to the heat. Only a small percentage ot the plants of this variety set October 27, 1902, made a good start, and some of those set November 24 of that year failed to start. Those that became established lived through the winter, grew well the following spring, and survived the heat of summer well. Excelsior plants set February 15, 1903, started promptly, grew vigorously throughout the spring, few of them dying until the early part of August. During this month about 75 per cent of them succumbed to the heat. Plants of this variety set upon several dates during October of the past season started quite well and made a fairly good growth during the fall. Plants set November 6 and December 1 started and became quite well established.

Lady Thompson plants set December 2, 1901, started fairly well, but did not become established and survive the winter well. The majority of the plants of this variety set October 27, 1902, failed to start, but the majority of those set November 27 of that year became well established, made a good growth the Following spring. and survived the following summer quite well.

Only a small percentage of Texas plants set October 27, 1902, started and became established, but nearly all those set November 24 of that year became well established, made good growth the following spring, and survived well the heat of the summer of 1903. Plants of this variety set February 16, 1903, started well, became well established, and made excellent growth until the hot weather of August. During the latter month a few of them succumbed to the heat, but the most of them resumed growth when the cooler weather of September came.

The plants of the different varieties mentioned produce fruit at quite different times of the year in this region. The fruiting period of the Arizona Everbearing is usually during April, May and June. While a few berries may be produced later in the summer than mentioned, and a few are sometimes produced during autumn, the amount is not sufficiently large to be marketed. The fruiting period of the Michel is of about the same length, but begins some earlier in the spring, extending from about the middle of March to the first of June. The Excelsior begins blooming during October, ripens some fruits early in November, produces a considerable quantity by the end of November, and, if the weather is not too cold, produces a fair crop during December. Some fruit continues to ripen throughout the coldest weather of winter, during March begins ripening in great abundance, and continues to ripen throughout spring until about the first of June. The Texas behaves similarly in this climate. It does not produce as much fruit during the winter but produces more during spring, the season during which it produces most abundantly extending from the first of April to the first of June. The fruiting season of the Lady Thompson is a little earlier than the Everbearing and not quite so early as that of Michel or Excelsior, being much the same as that of Texas.

The blossoms are injured by temperatures below 30 at the ground, but the young fruit endures temperatures as low as 24 at the ground and 28 in the government shelter without injury; and green fruit protected by the foliage endures temperatures several degrees below this. The ripening fruit endures less cold, being injured by temperatures below 25 at the ground. A good picking was taken from Excelsior plants December 24, 1903, although the mercury had fallen at the ground to 22 to 26 degrees during ten nights of the month. Some green fruit well-protected with foliage survived the past January, the mercury falling to 14 at the ground one night, 16 one night, 17 two nights, 18 one night, and 19 three nights; and a few berries ripened during the early part of the month.

For reasons all of which are not apparent, it is becoming more and more difficult to grow the Arizona Everbearing in this region, and its culture is gradually being abandoned in most of the valley. Its place is being taken by Michel's Early, a variety that produces a far inferior fruit. However, it endures well the heat of summer, and is the variety that is most easily carried through the first summer after setting. It is next in earliness to the Excelsior. The latter variety produces the most berries during winter of any variety that has been grown in the region, but does not endure summers as well as the Michel. The Lady Thompson gives promise of enduring summers somewhat better than the Everbearing, but not so well as the Michel. The most promising variety tested thus far is the Texas It fruits quite as early as the Michel, produces berries of excellent quality and endures the summer heat almost, if not quite, as well as the Michel. Unless some undesirable characteristics develop that are not yet apparent, it will probably be the variety that will be grown most extensively in the region in the future.

DECIDUOUS FRUITS.

The deciduous fruits, including apples, pears, plums, apricots, almonds, peaches, cherries, nectarines, grapes and figs, being both perennial and deep-rooted, have somewhat the relation to the weather that alfalfa has, differing from alfalfa in having woody rather than herbaceous stems. They also resort to the procedure of dropping their foliage as winter approaches, instead of permitting it to be frozen as alfalfa does. This shedding of their foliage, reducing as it does the surface exposed to the chilling and drying effects of the atmosphere, enables them to endure cold that the herbaceous part of alfalfa does not. The vegetative part of none of these trees are injured in our region by any low temperatures that occur, only the blossoms and young fruit receiving injury from frost. The trees, even in their leafless condition, however, are sometimes somewhat injured during winter by the dryness of the atmosphere, and consequently fail to start promptly when spring comes.

The growth of the above-ground parts of most deciduous trees begins during March, a few starting a little earlier than this month. The growth of the roots of most kinds, however, begins during January or early February. By the middle ot February many trees have put out fresh rootlets two to six inches long, several weeks before there is any appearance of growth above ground. The leaves and blossoms of a few almonds, and of some of the Chinese varieties of peaches, appear by the middle of February, Other almonds bloom during the latter part of February and early March. Most peaches do not put forth leaves or blossoms until March, some during the early part of the month, and others not before the middle. Apricots bloom from the tenth of March to the end of the month. Pears and plums bloom during the latter part of this month and the early part of April. Apples and cherries bloom from the first to the twenty-fifth, and grapes during the early part of April. The growth of all deciduous trees is rapid during April, May and most of June, the growth made during the season being completed most years by the end of the latter month. During the rest of the summer little growth is made, the tissue that has been formed ripening during this period.

While the trees are in a growing condition the foliage and young growth is more or less sensitive to hot dry air, and is sometimes considerably injured by it. As growth ceases, the leaves become less sensitive to heat, and during mid-summer endure much of it without injury. The trunks, however, unless the trees are headed very low, are apt to become over-heated during the warm part of the day, and the south and southwest sides seriously injured. This is especially true of apples, plums, and cherries, During the fall, deciduous trees make no fresh growth, the vegetative parts being little affected by the condition of the weather. The late varieties ripen their fruit in better condition than most of those that ripen during mid-summer.

None of the parts of an apple tree are ever injured in our region by cold, the blossoms appearing after the spring frosts are over; but the trees are considerably held back in their growth, and frequently injured seriously by the heat of summer. The fruit of most varieties is much affected by the heat, those that produce the best fruit maturing it during early summer before the extreme heat. Few varieties that ripen their fruit during summer produce satisfactory fruit, the latter being usually small and corky in texture. A few varieties that ripen their fruit during late autumn produce fairly good fruit; but, as elsewhere in the warm valleys of the Southwest, very few kinds endure well the heat of summer. The trees are as a rule short-lived, the trunks being apt to become sunburned on the south and southwest sides, and the trees sooner or later succumb to the results of the heat. Most varieties do not live over eight or ten years, a few that are better adapted to the climate living twelve to sixteen years.

Pears endure well both the cold and the heat of the region, the blossoms seldom receiving injury from frost, and the trees being little injured by the heat of summer. Most varieties set full of fruit, and a large number of varieties produce pears of excellent quality, regardless of the part of the season the fruit ripens. A proper selection of varieties gives a supply of ripe fruit continuously from the first of July to the first of March.

Plums are injured much more by the heat of summer than by the spring frosts, the buds, blossoms, or young fruit rarely being seriously injured by frost. The only season during the past five years when much injury was done was March 13, 1901, when the mercury fell to 32 in the government shelter, and 37 at the Weather Bureau, The different varieties of plums endure the summer conditions quite differently, the European varieties being most sensitive to heat. Those enduring heat best belong to the Japanese group, and most of those belonging to the American group endure summer fairly well. Unless the trees are headed low, the trunks are apt to become injured on the south and southwest sides, and the trees later to die, plums resembling apples in their relation to the climatic conditions of the region. The life of plum trees varies with the variety, that of desirable ones ranging from eight to twelve years.

Apricots receive comparatively little injury from either the frosts of spring, or the heat of summer, compared with apples and plums, being long-lived and well adapted to the region. During some springs some injury is done by frosts, but a fairly heavy crop of fruit usually sets.

Almonds endure quite well the heat of summer, but is the variety of deciduous fruits that receives the most injury from spring frosts. Some varieties receive injury when in bloom, and others after the fruit is formed. In 1898, the blossoms and young fruit were injured March 18, when the minimum temperature was 29 in the governraent shelter, and March 22, 23 and 27 when the minimum temperature was 30 in the government shelter. In 1899, they were seriously injured March 12, when the minimum temperature was 27 in the government shelter, and 32 at the Weather Bureau, In 1900, they received very little injury, the mercury not falling below 29 during February, and not below 34 during March, in the government shelter. In 1901, they received much injury March 13, when the mercury fell to 32 in the government shelter, and 37 at the Weather Bureau. In 1902, they received very little injury, the mercury not falling below 33 in the government shelter during March.

The different varieties of peaches differ considerably in their relation to the climatic conditions of the region. Some varieties escape injury from frost most seasons, and endure well the heat of summer. These varieties belong mostly to the Chinese type of peaches, blooming so early during the winter that the young fruit has attained sufficient size to endure quite low temperatures. As a result they set full of fruit every year. Other varieties not only receive considerable injury from spring frosts, but do not endure well the heat of summer. The fruit of most varieties that ripens during the heat of summer is of poor quality compared with that which ripens early in the season or during the cooler weather of fall. Peach trees are longer lived than apples or plums, but not so long-lived as either apricots or almonds, usually remaining productive ten to twelve years from time of setting.

The deciduous fruit that is the most sensitive to heat is the cherry. It usually blossoms late enough to escape the frosts of spring, but rarely sets fruit, upon account of the heat and aridity of the atmosphere at the time of blossoming. The trees are the shortest-lived and set the least fruit of all deciduous fruits that have been tested at the farm.

Suitable varieties of grapes are not seriously injured either by frost or by heat, but the summers are too hot and dry for most of these of American origin. Slight injury is done the first growth of spring some seasons.

EVERGREEN FRUITS.

The evergreen fruits, differing from the deciduous ores in carrying their leaves throughout the year, are fully exposed to all the conditions of the weather. Especially are they subject to the cold of winter. The texture of their foliage naturally has much to do with their power to resist climatic conditions.

The citrus fruits, including oranges, lemons, pomeloes, and tangarines, all bear foliage that is more or less sensitive to heat and to cold, and are the evergreen fruits that receive the most injury during extremes of temperatures here. It is with difficulty that they are propagated from seed in the region; hence either grafting stock or trees ready for setting are brought in from the outside, principally from California. They are set out during February and March, and except during especially unfavorable seasons, usually start quite promptly.

Citrus fruit trees grow well during spring and early summer, but grow more slowly, or rest from growth, during the hottest weather of summer. Fresh growth begins again as the weather becomes cooler during September, Throughout the fall growth is usually quite vigorous, but is checked by cold during November or December. From early December to March the trees remain nearly dormant. Thus they have two periods of growth each year, and two periods of comparative dormancy, resembling alfalfa in this respect.

The injury that citrus trees receive during the summer from heat and during the winter from cold depends upon many attending circumstances. If the trees are vigorous at the approach of winter, and if the change from the warm weather of fall to the cold weather of winter be gradual, much lower temperatures are endured than if the reverse be true. Most winters some injury is done to the foliage, and some winters most or all of the growth of the previous year is killed. The injury received during summer depends upon a variety of conditions, some seasons being slight and others quite pronounced. Lemons are the most sensitive to extremes of temperature, and pomeloes the least so. Only seedling oranges endure the frosts in the lower part of the valley, and lemons are not hardy enough to endure well the more favorable conditions of the upper portion of the valley.

Citrus fruits bloom during March and early April, usually escaping injury from spring frosts. Some injury seems to be done to the forming fruit, however, during some seasons, by too cool nights. The young fruit continues to make some growth throughout all parts of the summer, and during the cooler weather of early fall grows quite rapidly. The warm weather that continues during most of the time from the time of the setting of the fruit until well into the fall causes a rapid development of the fruit, and results in very early ripening. By the early part of November, oranges are distinctly sweet, and begin coloring as the weather grows cooler. So fully matured is the fruit when the heavy frosts of December occur, that comparatively little damage is done to that still on the trees, and fruit that remains on over winter is not seriously injured. This causes the oranges produced in the region to be of exceptionally good quality, and consequently to command a high price upon the market.

Olives are never seriously injured either by the low temperatures of winter or the high temperatures of summer, enduring well all the climatic conditions of the region. Occasionally a little injury is done to immature fruit hanging upon the trees during very cold weather, and some slight injury to young growth is sometimes done by the extreme heat of summer; but there is no injury from either heat or cold to interfere with the regular growth of the trees and the production of good crops of fruit.

Date palms endure the climatic conditions of the region nearly as well as olives, being injured somewhat more by cold than the latter tree, but less so by heat. Young seedling plants are sometimes considerably injured by the low temperatures of winter, and the foliage of older trees is sometimes injured some; but young plants have never been killed by frosts, and the older trees have never received injury that interfered seriously with their growth, or the production of fruit. The foliage and the unopened clusters ofmale bloom of the eight-year-old trees at the farm were considerably injured during December, 1897, when the mercury fell to 17 in the government shelter, but the trees grew thriftily the following season, all bloomed and several produced fruit. December 31, 1900, the foliage on all young seedling dates was injured, and some were frozen to the ground, the minimum temperature being 14 at the ground, 18 in the government shelter, and 22 at the Weather Bureau. Those frozen to the ground sent up leaves during spring, and by the end of the season showed little effects of the frost, No injury is done to dates by heat, the most rapid and luxuriant growth being made during the warmest part of the year, and the best time to transplant them being from April to June.

Date seed germinates any time from March to September, but the best growth of seedlings is secured by planting the seed during fall or winter. Seedlings and suckers usually fruit within five or six years, and at the end of ten years attain a height of 20 to 25 feet. Most varieties of dates bloom during April, and fruit ripens on the various varieties from September to January, At least one variety does not fully ripen its fruit in this region, the season not being warm enough or long enough, this being one plant requiring more summer heat than there is in the region.

EUCALYPTS.

Eucalypts being, like the fruits discussed above, evergreens, are exposed to the climatic conditions throughout the year; but they differ very much as to their relation to heat and cold. Some varieties endure much heat and little frost; some endure low temperatures but little heat; while others endure neither frost nor heat. Some species, on the other hand, endure both low winter temperatures and high summer temperatures. Species that thrive in this region must possess this characteristic and are *E. rudis*, *E. polyanthema*, *E. leucoxylon*, *E. tereticornis*, and *E. crebra*. These varieties vary considerably among themselves as to the amount of cold and heat they endure, all of them being more or less injured during extremes of temperatures. The injury to some ot them, however, is very slight during either winter or summer, and is not sufficient to interfere seriously with their growth. December 14, 1899, all Eucalypts being tested at the farm, except *E. rudis*, were more or less injured, the mercury falling to 14 at the ground, 23 in the government shelter, and 28 at the Weather Bureau. December 31, 1900, when the mercury fell to 14, 18, and 22 at the above points, *E. rudis*, *E. leucoxylon*, and *E. polyanthema* were slightly injured, one to four inches of the tips being killed. December 14, 1901, slight injury was done to the tips of *E. rudis* and *E. leucoxylon*, while yearling *E. rostrata* were nearly all frozen to the ground, the minimum thermometers registering 15 at the ground, 20 in the government shelter, and 24 at the Weather Bureau. All are more or less checked in their growth or injured by the heat of midsummer, *E. polyanthema* being affected the least of any of the species mentioned.

Some species of Eucalypts grow in a moist atmosphere, but most of them prefer a dry atmosphere, and do best during seasons when there is not excessive rain. If supplied with a moderate amount of water at their roots, a large percentage of them endure well a hot dry atmosphere.

The seed of Eucalypts germinates in this region from September to May, but it has been found very difficult to propagate the young plants, the dryness of the atmosphere interfering with their growth, regardless of the amount of water supplied to their roots. It has therefore been found better to bring in the young seedlings from California, and plant them during March, April, or August.

The Eucalypts, like citrus fruits, have two periods of thrifty growth, one from March to June, and the other from the latter part of August to the latter part of November. A little growth is made here by a few species during the hottest weather of summer, and a few make some growth during the coldest weather of winter.

The most rapid growing Eucalypt (*E globulus*) does no tendure our climatic conditions, but the growth of *E. rudis*, *E. tereticornis*, and *E. rostrata* is fairly rapid. Judging by their growth upon the farm and elsewhere, they can be counted on to attain a height of thirty feet and a diameter of six inches in four or five years, and a height of fifty feet and a diameter of one foot in six or eight years. A five-year old *E. rudis* at the farm is over a foot in diameter and forty feet high; an *E tereticornis* of the same age is thirty feet high and eight inches in diameter; and *E. rostrata* trees of this age are thirty-five feet high and ten inches in diameter. In Phoenix, an *E. rostrata* eleven years old is sixty feet high and over two feet in diameter.

RECAPITULATION.

From the foregoing discussion of the effects of the weather on the leading crops of the region it will be seen that a larger number endure the low temperatures that occur than endure well the high ones, a condition the opposite of that existing in the northern portion of the country. Instead of crops being grown between two winters, as is the case in the north, the most of them are grown between two summers, the number that grow through the summer here being about the same as live through the winter in the north.

Wheat, barley, oats, rye, peas, flax, canaigre, beets, alfalfa, clovers, lupins, vetches, cabbage, cauliflower, lettuce, spinach, carrots, turnips, radishes, onions, strawberries, olives, dates, oranges, lemons, pomeloes, tangarines, loquats and Eucalypts remain green throughout the winter, and make more or less growth. Of these the small grains, flax, canaigre, beets, clovers, cabbage, cauliflower, lettuce, spinach, carrots, turnips, radishes, onions, olives, and some species of Eucalypts are uninjured by the low temperatures of winter.

Besides those that grow through winter, beans, Indian corn, potatoes, and bush squashes grow only between the coolest weather of winter and the hot weather of summer, these being like those listed above sensitive to heat, but also sensitive to extreme cold.

The crops keeping green through summer are Egyptian and Kaffir corn, sorghum, millet, cowpeas, broom-corn, tobacco, cotton, alfalfa, tomatoes, melons, pumpkins, squashes, some varieties of beans, celery, strawberries, mulberries, persimmons, grapes, figs, plums, nectarines, peaches, apricots, almonds, apples, pears, quinces walnuts, olives, dates, oranges, lemons, pomeloes, pomegranates, loquats, cottonwoods, ashes, and Eucalypts.

Of the above, the following grow thriftily throughout the hot weather of midsummer: Egyptian and Kaffir corn, sorghum, cowpeas, tobacco, cotton, olives, dates, and some species of Eucalypts. Of these the date is the one that seems to enjoy the summer conditions best.

The crops liable to be injured by spring frosts are corn, potatoes, tomatoes, beans, grapes, peaches, apricots, almonds. The crops that are usually injured by autumn frosts are corn, sorghum, beans, cowpeas, cotton, potatoes, and tomatoes. Those liable to injury by the low temperatures of winter are peas, alfalfa, lettuce, strawberries, dates, oranges, lemons, pomeloes, and Eucalypts.

The crops that are killed or brought to maturity by the heat of summer are small grains, clovers, Indian corn, flax, bush beans, potatoes, summer squashes, cabbage, cauliflower, lettuce, spinach, turnips, radishes, onions, rhubarb, raspberries, currants, and gooseberries. In addition to the above the following are checked in their growth by the summer heat: Beets, alfalfa, tomatoes, melons, cucumbers, squashes, pumpkins, asparagus, strawberries, blackberries, deciduous fruits, citrus fruits, and Eulypts.

INDIRECT EFFECTS OF WEATHER ON CROPS.

Besides the direct effects upon crops produced by the weather of the region, there are indirect effects of no less importance. In some instances crops are attacked by insects or fungi as a result of being weakened by beat or cold, but the effect of the weather as a whole is to reduce such plant enemies. Melon plants are attacked and considerably injured by plant lice while their growth is slow during cool weather ot early spring, but as the heat increases, the lice become less active, and comparatively little permanent injury is done. During the cooler weather of autumn the lice usually again become abundant, injuring late melons to some extent.

As a result of the climatic conditions, the region is remarkably free from parasitic insects and fungi. The scale insects that are so destructive in many other parts of the country are almost unknown here. Some species have made their appearance on fruit trees, but most of them do not seem to be able to endure the dry hot summers, and hence do not become established. The only scale insect that has persisted at the farm is the date scale imported on trees from Africa, it having been necessary to destroy it by fumigation.

Diseases of plants caused by parasitic fungi are very few, only a small number of these fungi being able to reproduce themselves in our climate. Some injury is done by wheat smut, and a little by corn smut. Rusts are almost entirely absent from the region, no crops being injured by these fungi. As the native vegetation is nearly entirely free from attacks of rusts, it may be safely concluded that the climatic conditions are such that there is little probability of these fungi ever becoming established on cultivated crops.

WHAT MAY BE PLANTED AND WHAT MATURES EACH MONTH.

Believing that information as to what may be planted each month with hope of success, and what commonly matures each month in the vicinity of Phoenix, will be of value, especially to new settlers, the following classified statement is inserted. *In* parts of southern Arizona having a cooler climate, planting is done later in the spring and earlier in the summer; and in the vicinity of the Colorado, planting takes place earlier in the winter and somewhat later in summer. In the first paragraph under each month is given the list of the crops that may be planted, and in the second paragraph those that mature or reach a stage suitable for use.

It will be seen from what follows that the time for planting the largest number of crops is during January, February and September, and that the greatest number of crops mature during May, June, October and November. During May and December comparatively few crops are planted, and January and February are the months during which comparatively few crops mature.

JANUARY.

Planted Wheat, barley, oats, alfalfa, peas, beets, potatoes, cabbage plants, carrots, lettuce, spinach, turnips, radishes, asparagus seed and roots, onion sets, strawberries, blackberries, grape cuttings and plants, deciduous fruit trees, date seed.

Mature Cauliflower, lettuce, spinach, table beets, turnips, radishes, oranges and pomeloes.

FEBRUARY.

Planted Wheat, bailey, alfalfa, Indian corn, peas, beets, tobacco, potatoes, tomato seed, bush squashes, lettuce, spinach, turnips, radishes, onion sets, celery seed, asparagus plants cabbage plants, strawberries, blackberries, deciduous fruit trees, citrus fruits, olives, date seed.

Mature Cauliflower, cabbage, lettuce, spinach, table beets, turnips, radishes.

MARCH.

Planted: Indian corn, cotton, beans, melons, cucumbers, squashes, pumpkins, citrus fruits, olives, Eucalypts.

Mature: Cauliflower, cabbage, lettuce, spinach, beets, turnips, radishes, carrots, green onions, asparagus, strawberries,

APRIL.

Planted: Egyptian and Kaffir corn, cowpeas, cotton, date plants, Eucalypts.

Mature: Grain hay, alfalfa, green peas, cabbage, lettuce, spinach, table beets, carrots, turnips, radishes, green onions, asparagus, strawberries, mulberries.

MAY.

Planted: Egyptian and Kaffir corn, cowpeas, date plants.

Mature: Wheat, barley, oats, alfalfa, table corn, peas, potatoes, bush squashes, string beans, cabbage, lettuce, table beets, carrots, turnips, asparagus, strawberries, blackberries, plums, apricots, peaches.

JUNE.

Planted: Egyptian corn, cowpeas, melons, squashes, pumpkins, date plants.

Mature: Alfalfa, Indian corn, potatoes, tomatoes, melons, cucumbers, bush squashes, beans, beets, carrots, onions, strawberries, blackberries, figs, plums, peaches, apricots, apples.

JULY.

Planted: Indian and Egyptian corn, millet, cowpeas, melons, squashes, pumpkins, date plants.

Mature: Cowpeas, sugar beets, alfalfa, tomatoes, melons, cucumbers, grapes, figs, plums, peaches, apples, pears.

AUGUST.

Planted: Peas, beets, beans, cowpeas, millet, potatoes, cabbage and cauliflower seed, carrots, celery plants, cucumbers, lettuce, Eucalypts.

Mature: Egyptian and Kaffir corn, sorghum, sugar beets. cowpeas, tomatoes, melons, grapes, figs, plums, peaches, apples, pears, almonds.

SEPTEMBER.

Planted: Wheat, barley, oats, peas, beans, potatoes, beets, cabbage and cauliflower seed and plants, celery plants, lettuce, spinach, radishes, beets, carrots, turnips, onion seed.

Mature: Egyptian and Kaffir corn, sorghum, cowpeas, cotton, melons, grapes, plums, peaches, apples, pears, dates, pomegranates.

OCTOBER.

Planted: Small grains, alfalfa, clovers, peas, beets, cabbage seed and plants, cauliflower plants, onion seed, carrots. radishes, turnips, lettuce, spinach, *Mature*: Cowpeas, cotton, Egyptian and Kaffir corn, sorghum, millet, alfalfa, tomatoes, melons, cucumbers, squashes, pumpkins, string beans, grapes, plums, peaches, apples, quinces, pears, dates, pomegranates.

NOVEMBER.

Planted: Small grains, alfalfa, clovers, peas, cabbage plants, radishes, beets, turnips, lettuce, spinach, strawberries, date seed.

Mature: Indian corn, Egyptian corn, sorghum, cowpeas, Alfalfa, potatoes, tomatoes, pumpkins, squashes, peas, beans, lettuce, spinach, table beets, turnips, radishes, celery, strawberries, grapes, peaches, apples, pears, quinces, olives, dates, oranges, pomeloes, pomegranates.

DECEMBER.

Planted: Small grains, peas, radishes, strawberries, date seed.

Mature: Lettuce, spinach, table beets, turnips, radishes, celery, strawberries, apples, pears, olives, dates, oranges, pomeloes.

WHEN EACH CROP MAY BE PLANTED AND WHEN IT MATURES.

For the further convenience of those desiring information concerning the planting of crops, the proper time for planting each and the time when each usually matures in the vicinity of Phoenix are given. Our seasons are so different from those in most other portions of the country, that those unfamiliar with the region are naturally apt to become somewhat confused as to the proper time for planting the great variety of crops that can be grown in the region. The times given are those when experience has shown that each crop should be planted in order to secure the best results. The time of maturity given is that when each crop reaches the stage when it is most suitable for the use for which it was planted. In the case of many vegetables this is while the plant is still in a green immature state; and in the case of such a fruit as pears it is some time after, not only the cessation of growth on the part of the tree, but of the removal of the fruit itself.

ALFALFA.

Planted: September 20 to November 10; January and February.

Mature: April 15 to August 15; October 15 to November 15.

ALMONDS.

Planted: January and February.
Mature: July and August.

APPLES.

Planted: January and February.
Mature: June 15 to December.

APRICOTS.

Planted: January and February.
Mature: May 10 to June 20.

ASPARAGUS.

Planted: January to March; October and November.
Mature: March and April of third year.

BARLEY.

Planted: September to March 1.
Mature: April and May.

BEANS.

Planted: March and first half of April; August 15 to September 15.

Mature: May 15 to June 15; October 20 to November 15.

BEETS, TABLE.

Planted: January to March 15; September and October.
Mature: January to July; October to December.

BEETS, SUGAR.

Planted: January 15 to end of February; September 20 to October 10.

Mature: July and August; March.

BLACKBERRIES.

Planted: January and February.

Mature May and June of second year.

CABBAGE.

Seed planted: August 15 to November.

Plants set. January and February; September 15 to October 20.

Mature: February to June.

CARROTS.

Planted: January and February; August 20 to October 15.

Mature: January to July; November and December.

CAULIFLOWER.

Seed planted: August and September.

Plants set: September and October.

Mature: January to April.

CELERY.

Seed planted: January to March.

Plants set: August 15 to October 15.

Mature: November and December.

CLOVER, "SOUR."

Planted: October 15 to November 20.

Mature: March.

CORN, EGYPTIAN.

Planted: April 15 to July 15.

Mature: September and October.

CORN, INDIAN.

Planted: February 20 to March 15; July 10 to August 5.

Mature: May 15 to June 15; October and November.

CORN, KAFFIR.

Planted: April, May and June

Mature: September and October.

COTTON.

Planted: April.

Mature: September to December.

COWPEAS.

Planted: April to August.
Mature: August to November.

CUCUMBERS.

Planted March and April; June and July.
Mature: June and July; September and October.

DATES.

Seed Planted: November to March.
Plants set: April to August.
Fruit Mature: September to January.

EUCALYPTS.

Seed planted: August to January.
Plants set: March, April, and August.

FIGS.

Planted: January and February.
Mature: June and July.

GRAPES.

Planted: January and February.
Mature: July 10 to December.

LETTUCE.

Planted: January, February, September and October.
Mature. January to May.

MELONS.

Planted: March and June.
Mature: June 20 to November.

MILLET.

Planted: August.
Mature: October.

OATS

Planted: October to December.
Mature: April and May.

OLIVES.

Planted: February and March.
Mature: October to January.

ONIONS.

Seed planted: September 15 to October 15.
Sets planted: November to February.
Green onions: February to April.
Mature: June and July.

ORANGES.

Planted: February and March.
Mature: November to January.

PEACHES.

Planted: January and February.
Mature: May 25 to November.

PEARS.

Planted. January and February.
Mature: July to January.

PEAS.

Planted: January and February; August 20 to November 20.
Mature: April, May, and November.

PLUMS.

Planted: January and February.
Mature. May 10 to October.

POMEGRANATES.

Planted: January and February.
Mature: October and November.

POMELOES.

Planted: February and March.
Mature: November to January.

POTATOES.

Planted: January 15 to February 15 and August 20 to September 10.
Mature: May 20 to June 15; November.

PUMPKINS.

Planted: March and June.
Mature: July and October.

QUINCES.

Planted: January and February.
Mature: October.

RADISHES.

Planted: January to March; August to October.
Mature: January to August; October to December.

SORGHUM.

Planted: May and June.
Mature: September to November.

SPINACH.

Planted: January, September and October.
Mature: November to May.

SQUASHES.

Planted: March, June, and August.
Mature: May, June, and October.

STRAWBERRIES.

Planted: November 20 to February 20.
Mature: March to July; December.

SWEET POTATOES.

Planted: March to May.
Mature: September to November.

TOMATOES.

Planted: February and March.
Mature: June 20 to August, and October 20 to December.

TURNIPS.

Planted: January, February, August, September and October.
Mature: October to May.

VARIETIES ADAPTED TO REGION.

It being very important that varieties adapted to the climatic conditions of the region be planted, the following list is given for the benefit of those who have not ascertained the facts by experience. The aim is to give those varieties that have succeeded and should succeed under average conditions in southern Arizona. In many cases only those listed will thrive. Much of the failure to grow vegetables and other crops in the region has been due to planting varieties entirely unsuited to the peculiar conditions prevailing. Of some crops one or more varieties give excellent results, while all others fail almost entirely. Hence knowledge as to suitable varieties is of the greatest importance.

Almonds.

Ne plus ultra, I. X. L., Nonpariel, Commercial, Languedoc.

Apples.

Early Harvest, Red Astrachan, Gravenstein, Maiden's Blush.

Apricots.

Newcastle, Royal, Moorpark, Blenheim, Montgamet.

Asparagus.

Conover's Colossal, Palmetto.

Barley.

All varieties.

Beans.

Long Yellow Six Weeks, Pink.

Beets.

Early Blood Turnip, Long Blood, Klein Wanzlebener.

Cabbage.

Early Jersey Wakefield, All Seasons, Succession, Surehead, Drumhead, Flat Dutch, Brunswick.

Carrots.

Danver's Half-long, Ox-heart, Shorthorn.

Cauliflower.

Burpee's Best Early, Burpee's Dry-Weather, Early Snowball.

Celery.

Giant Pascal, White Plume, Golden Self-Blanching.

Corn.

Adams Extra Early, Black Mexican, Yellow Dent, Leaming.

Cucumbers.

Long Green, Boston, Pickling, White Spine.

Dates.

Seewah, Rhars, Amrai, and other early and medium early Old World varieties.

Eucalypts.

E. rudis, *E. tereticornis*, *E. rostrata*, *E. polyanthema*, *E. hemiphloia*, *E. leucoxylon*, *E. crebra*.

Figs.

Mission, White Adriatic, Calimyrna, Bulletin Smyrna.

Grapes.

Thompson Seedless, Almeria, Muscat, Rose of Peru, Black Hamburg, Mission, Zinfandel.

Lettuce.

Hanson, New York, Boston Market, Denver Market, Iceberg, and many other varieties.

Muskmelons.

Netted Gem (Rockyford), Nutmeg, Hackensack, and many other varieties.

Oats.

Texas Red.

Olives.

Nevadillo, Manzanillo, Rubra, Pendulina, Uvaria, Sevillano, and many other varieties.

Onions.

Prize Taker, White Portugal, Silver King, Australian Brown, New Queen.

Oranges.

Washington Navel, Valencia, Jaffa, Ruby, Blood, Mediterranean Sweet.

Peaches.

Alexander, Briggs May, Late Crawford, Muir, Picquet's Late, Salway, Wheatland, St. John, Sylphide Cling, Columbia.

Pears.

Bartlett, Le Conte, Beurre Clairgeau, Patrick Barry, Winter Nellis, Beurre Diel, Clapp's Favorite.

Peas.

American Wonder, Little Gem, Yorkshire Hero, Horsford's Market Garden, Stratagem, Champion of England.

Plums.

Red June, Doris, Mariana, Damson, Burbank, Botan, America, Chalco.

Potatoes.

Early Rose, Triumph, Burpee's Extra Early.

Pumpkins.

Cashaw Crookneck.

Sorghum.

Club-head, Amber.

Squashes.

Mammoth White Bush, Mammoth Yellow Bush.

Strawberries.

Michel, Arizona Everbearing, Excelsior, Texas, Lady Thompson.

Sweet Potatoes.

Shanghai, Southern Queen, Nansemond.

Tomatoes.

Dwarf Champion.

Turnips.

All varieties.

Watermelons.

Augusta, Florida Favorite, Sweetheart, Rattlesnake, Fordhook First, Blue Gem, Kleckley Sweets.

Wheat.

Sonora, White Australian, Canadian Club, Ruby.

Of the foregoing crops, the following seem especially well adapted to the climatic conditions of the region, usually giving good yields and very satisfactory returns:

Alfalfa, Gravenstein apples, Newcastle and Royal apricots, asparagus, barley, dates, Thompson Seedless grapes, Rockyford muskmelons, olives, Bartlett pears, Red June and Doris plums, sorghum, Augusta, Florida Favorite, and Sweetheart watermelons, and Sonora and White Australian wheat.

SUMMARY.

1. The climate of an arid inland region is characterized by greater extremes of heat and cold than that of a humid coast region in the latitude, the winters being cooler and the summers warmer, and the difference between the temperatures of day and night greater.

2. The climate at the Station farm is a typical inland climate, and very trying on a large number of crops grown in the same latitude in a moist climate.

3. If planted at the proper time, nearly all the crops grown in the temperate regions may be grown here more or less successfully.

4. The small grains do well during winter, Indian corn fairly well during spring and fall, and Egyptian corn does well during summer

5. Few legumes are profitably grown here, peas doing fairly well during winter and cowpeas fairly well during summer.

6. Cotton and sugar beets grow fairly well, but require a great deal of water at a time of the year when it is ordinarily scarce.

7. The forage crops grown most successfully are alfalfa, small grains, and sorghum, the three furnishing green feed throughout the year.

8. The most useful green-manuring crop is what is known here as "sour clover," and to botanists as *Melilotus indica*.

9. Most garden vegetables can be grown here quite successfully during winter and spring, those for which the climate is especially unsuited being winter squashes, beans, and rhubarb.

10. No small fruits are generally grown with success, though strawberries were formerly grown in abundance and are still grown to a limited extent.

11. Of deciduous fruits, grapes, peaches, apricots, plums and pears are successfully grown, while cherries and apples are grown with difficulty.

12. The only nut-producing tree that thrives here is the almond.

13. Citrus fruits do fairly well, but have not proven to be a reliable crop for profit.

14. Olives and dates seem especially well adapted to the climate, and promise to be profitable crops.

15. The cottonwood is the most easily grown timber tree, though the ash and a few species of Eucalypts grow quite well.

16. Records from instruments located at different elevations from the ground show the importance of taking the situation of instruments into consideration in judging of the effect of recorded temperatures upon crops.

17. Minimum temperatures average four or five degrees lower in government shelter five feet from the ground than in the same shelter fifty feet from the ground, and about three degrees lower at the ground than at the former point.

18. Maximum temperatures average about three degrees higher five feet from the ground than at fifty feet from the ground and ten to twelve degrees higher a few inches above the ground than at former location.

19. The annual and the diurnal range of temperature is greatest at the surface of the ground, and decreases from there upwards and downwards.

20. The lowest recorded temperature at five feet underground has been 53; at ten feet underground, 56; and at fifteen feet, 58. The highest temperatures at these points have been 88, 76, and 73.

21. Evaporation from a water surface ranges from a little over an inch per month during the coolest, dampest part of the year to over ten inches during the warmest and dryest part.

22. Weather changes that are not periodic are clue to inequalities in the density of the atmosphere.

23. The indications of rain are: East or southeast wind, decreased diurnal range of temperature, slower evaporation, sinking of smoke or vapor.

24. The indications of frost or cool weather are: West wind, increased diurnal range of temperature, rapid evaporation, clear sky.

25. Grains hardy to frost are grown from October to June and grains sensitive to frost from March to November,

26. Melons grow from March to November, potatoes From February to June, and from August to December; tomatoes from March to December; corn from March to June and from July to November.

27. Alfalfa grows some all the year, but makes the most growth from February to July and from September to November.

28. Deciduous fruit trees grow from February to July, and evergreen fruit trees from March to July, and from September to December.

29. Owing to the warm dry climate, insect pests and fungus diseases of plants are rare in the region.