

however, some who submit to the law of chance, and as a sequence they often reap the reward of the improvident. Long immunity from severe cold spells begets an optimism that spells financial disaster to the grower who yields to its seductive influence.

XII.

**FROST PROTECTION IN ARIZONA.**

By **ROBERT R. BRIGGS**, Section Director.

[Dated Weather Bureau, Phoenix, Ariz., Nov. 29, 1914.]

At present, except in a relatively small portion of the State, a special study of frost conditions, or the early advance information of the probable occurrence of frost or freezing temperature can serve no important interests in Arizona, for the reason that no protective measures are practicable for such agricultural products as are grown in marketable quantities. Only such observations of temperatures and frosts as may determine the average dates of killing frosts in spring and autumn, the length of the growing season, and the most favorable times for planting and harvesting various crops can be of advantage to most localities. Apples, peaches, and other fruits ordinarily grown in temperate climates can be produced in many of the valleys of the northern half of the State and of the eastern and southeastern counties of Arizona. Up to the present time such orchards have been principally confined to the small amounts needed for the personal use of the grower. In the high valleys of Yavapai County, near Prescott, apples have begun to be grown to a considerable extent for market, and with such success in yield and quality that the orchard acreage is increasing rapidly.

The only danger of damage from freezing lies in the possible occurrence of a decided cold spell after the buds are well along in the spring. Growers have to some extent provided themselves with fire pots for artificial protection. As many of the orchards are isolated and without telephone facilities, dependence is placed chiefly upon alarm thermometers and observations of local weather conditions, although the Weather Bureau furnishes warnings to Prescott for distribution to such growers as can be quickly reached. In the Verde Valley, in the eastern portion of Yavapai County, not only apples but peaches, apricots, and other fruits are grown in marketable quantities, but here the elevation is more moderate and injurious frosts seldom occur during the growing season.

This reduces the area in which a special study of temperature conditions is important for the introduction, culture, and protection of crops susceptible to injury from frost. The temperature of the southwestern lowland counties is generally favorable for the production of semi-tropical fruits and staples.

There is relatively but a limited portion of the lowland counties now under cultivation, owing to deficient rainfall and the impossibility as yet of economically supplying water artificially. The Salt River Valley lands, under the Roosevelt Project, is the most important section yet reclaimed both in extent of acreage and in diversity of products. What may be said of the importance of frost study and of frost protection to that section will apply largely to other sections of the lowland districts where reclamation has been effected or may be possible in the future. The Salt River Valley is typical of the topography of the entire southwestern portion of the State. It lies between two short ranges of low, barren mountains,

sloping gently from the foothills north and south to the river between.

In the colder months there is a considerable range in the Salt River Valley between the night or early morning temperatures of the higher slopes and those of the low bottom lands, amounting frequently to from 10° to 15°. This difference is so marked that in many seasons such tender plants as tomatoes and castor beans remain green on the higher slopes throughout the winter, while in the low sections they are killed in November or in early December. Citrus fruits can be grown without extreme hazard, but only in the sections having the most favorable temperature. For olives the possible acreage is considerably greater, as the trees are hardier than citrus, except when very young. Recent experiments with sugar cane seem to indicate that it can be grown successfully upon both the higher and the intermediate lands, while cotton is grown indiscriminately throughout the valley. Nearly all fruits, except apples, as well as most staples, except corn, are grown here more or less extensively, but protective measures during critical cold spells and the consideration of the relative temperature conditions of various areas are matters of first importance to citrus and olive culture.

The possible revenue from oranges, grapefruit, and ripe olives is greater than from other products; hence the lands upon which they can be grown must necessarily become more valuable than lands that are unsuitable. As the deciding factor is mainly that of temperature, one realizes the importance of an investigation into the determination of the line of demarcation beyond which it would be too hazardous to attempt their culture, even with provision for artificial protection. By an extensive distribution of recording instruments, extending on each side of the Salt River Valley from the bottom lands to the higher slopes, the Weather Bureau is now carrying on such an investigation, primarily to determine the extent of the acreage that may profitably be devoted to citrus and olives, and secondarily to gain a better knowledge of the temperature of the entire area under cultivation. If the relative temperature were dependent upon difference in elevation alone, it would be a simple matter to define the favorable areas, but proximity to the bare rocks of the mountain sides, receiving and storing heat during the daytime, and the air drainage at night, as affected by gaps in the ranges or by the gradient of the slopes, are complicating factors.

Growers are coming more generally to realize the advantage of artificial protection from frost. Practically no protective measures have been employed here until in recent years, but, while there are many old orange groves now bearing abundantly that have never received artificial protection, it is recognized that others have been killed that might undoubtedly have been successfully protected, and that without such protection the entire profitable area for the culture can not be utilized. Measures are now taken to protect nursery stock, and young orchards during the first two seasons, with cylindrical tubes filled with dry earth and by other devices, while older groves are variously protected by fire pots and by spraying. The fruit ripens early and can be mostly marketed before damaging cold spells are probable, with the advantage that in the event of freezing weather the trees alone remain to be cared for. The Weather Bureau is not only taking every precaution to give warning of the approach of dangerous cold spells, but it is also urging the growers, as an additional precaution, to install alarm thermometers or to take

other measures to observe any sudden fall in temperature approaching the danger point. With better protective facilities and a better knowledge of the requirements for successful culture confidence is increasing, resulting at present in a phenomenal extension of the acreage in young groves.

XIII.

**FROSTS AND FROST PROTECTION IN TEXAS.**

By MALCOLM SPRAGUE, Observer and Acting Section Director.

[Dated Weather Bureau, Houston, Tex., Nov. 30, 1914.]

In considering the subject of frosts and frost protection in Texas, the great diversity of climatic conditions which exist within the limits of the State must be referred to.

In the coast section, which borders the Gulf of Mexico for a distance of 350 miles, climatic conditions are largely influenced by the warm waters of the Gulf. The winters are mild and short, the annual and diurnal ranges of temperature are small, and cold spells are followed by extended periods of damp, foggy weather. The cold periods are of short duration and are rarely severe enough to kill the more hardy vegetation. Truck growing is most profitably carried on during the winter months, and large areas are devoted to sugar cane, strawberries, and citrus fruits. In this coastal section an unexpected freeze causes immense loss and the growers are prepared to protect their crops. Strawberries and truck are injured by frosts, but sugar cane and citrus fruits will withstand a temperature several degrees below freezing.

In central and northern Texas there are some orchards, but, so far as known, little effort has been made to protect from injury by frost. Not much farming is done in this part of the State during the winter months. Corn, cotton, and small grain are the principal crops. A late frost in spring kills early planted corn and cotton, but the area devoted to these crops is so large that no protection can be given. Late cotton and the "top crop" are sometimes killed by unusually early frosts in autumn. Warnings of severe weather conditions are of great value to shippers and stockmen in this section, but are not so much used by farmers.

East Texas is wooded, and the climate is moist and well adapted to small fruits and early spring truck. There are large commercial peach orchards and tomato farms in this section. A late frost in spring may destroy the peach crop and delay the tomatoes so that they will reach northern markets too late to be sold at a profit. Many of the growers have made arrangements to protect against frosts and freezes; warnings are of greatest value from the middle of February throughout the spring months.

In west Texas and the panhandle the climate is continental in character, with hot summers and cold winters, and the cold waves are more frequent and severe. Stock raising and the growing of small grain are the principal industries. Commercial orchards are being developed in the Rio Pecos Valley and in portions of the panhandle, resulting in an increasing demand for frost and cold-wave warnings. Frost warnings are of greatest value after

March 1; warnings of cold waves are needed by stockmen throughout the winter.

In extreme northwest Texas the first killing frost of autumn usually occurs during the last decade of October, but has been recorded as early as September 26. The last killing frost in spring usually occurs in April, but has been recorded as late as May 7.

In going southeastward the growing season gradually lengthens, until in the lower coast section the average date of the first killing frost in autumn is late in December and of the last killing frost in spring early in February; but there have been winters without freezing temperatures. On account of the high winds and dry air that attend the cold waves that reach the coast, freezing temperatures are more frequent in this section than killing frosts.

Frosts in Texas rarely occur on the first morning of a cold wave, but are probable on the second and third mornings if the temperatures continue low and the winds become light. They occur at a higher temperature in east Texas and the coast section than in central and west Texas.

It is only recently that systematic efforts have been made to protect crops from cold waves and freezes. In the peach orchards and trucking districts of east Texas orchard heaters and smudge pots have been used to some extent with satisfactory results. The cane grower, upon receipt of warnings, cuts and windrows his cane, which would have been a total loss if allowed to freeze before cutting. Strawberries are usually protected by covering with a mulch of straw or hay which had been placed between the rows for this emergency. Between the cold spells the covering is removed. By using this precaution strawberries are marketed from the Houston-Galveston district from late in December to June 1.

In the trucking and citrus fruit district of south Texas smudge pots and heaters are used by many growers, while others build fires to the windward side of their fields. The great drawback in the use of artificial heat is the high wind that attends the Texas cold wave or "norther" during the first 12 to 36 hours after its arrival. It rapidly carries the smudge or heat beyond the limits of the area to be protected. To overcome this difficulty windbreaks are being planted in some sections. The smudge pots and heaters are effective, however, on the second or third night of the cold spells, when the wind has fallen and conditions are favorable for frost formation. Among other methods of protection against freezes are the covering of plants with soil and spraying and flooding. Flooding is found to be most efficient in the irrigated districts.

While the weather forecasts are published daily in the press and distributed by mail, telegraph, and telephone to our urban population, they formerly reached only a small percentage of the rural communities in time to be of benefit. Since the cooperation of the telephone companies of this State with the Weather Bureau, however, frost and cold-wave warnings are available to nearly every farmer, and the matter of protection is receiving increasing attention from the fruit and trucking interests. South Texas has a great future as a citrus fruit and winter truck-growing district, but to make these industries stable greater precautions must be taken to prevent the loss of a season's work by a frost or freeze.