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**FROST AND FROST PROTECTION IN FLORIDA.**

By ALEXANDER J. MITCHELL, Section Director.

[Dated Weather Bureau, Jacksonville, Fla., Dec. 1, 1914.]

Many products grown in Florida have their natural habitat in lower latitudes; this, in conjunction with the efforts of fruit and vegetable growers to force production throughout the winter months, in order to realize the highest market prices, entails extra precaution in Florida as an essential to success.

The resistant power of products grown in most of the peninsular section of Florida ranges from that of the tomato, bean, and Irish potato (which are frequently damaged when thermometers, properly exposed, indicate temperatures in the thirties) to that of citrus fruits (which withstand temperatures well down in the twenties, provided the duration of the cold weather is not prolonged). A temperature of 25°F. and somewhat lower, during the first night of a cold wave, results in no damage to citrus fruit; but a two-night cold wave with a temperature fall to 25°F., or below, before midnight, will be attended by disintegration of some fruit—particularly in sections whose soil radiates heat freely, and where groves are remote from large bodies of water, or do not enjoy other factors that tend to sustain temperatures during abnormal conditions.

The growing period in Florida, which recognizes the necessity of protection, has no seasonal limitation. For some winter and spring crops, such as vegetables of various kinds, seeding begins during August or early in September; in order to circumvent possible disaster, resulting from unfavorable weather, seed beds are constantly being renewed, from which source fresh plants are drawn, as the exigencies of winter may require. Frosts occur occasionally over the interior of the extreme northern portion of the State during the last week of October, but the temperature is rarely low enough to damage any material crop before the second or third decade of November. It may be well to add, however, that radical departures from normal conditions have occurred over all sections of the State during the last two decennia, namely, December, 1894, and February, 1895 and 1899, resulting in destructive frosts throughout the mainland. These extreme conditions were epochs in the climatic history of the State. February 15, is an average date of the last dangerous frosts over most of the lower peninsula; the vagaries of the climate are indicated in the possibility of frost as late as the first week of April—fortunately so rare, however, as not to merit attention. March frosts damage fruit bloom over some northern counties; frost during March of the current year caused serious damage in Florida to vegetables as far south as the twentieth-seventh parallel.

The pressure distribution that results in the late spring frosts of these low latitudes is worthy of attention. Preceded, usually, by a shallow barometric depression over the lower valleys (and not infrequently along the Gulf margin) the area of moderately high pressure (the crest possibly not more than 30.2 inches) drifts slowly eastward over the northern half of the peninsula. Sluggishness is at times a characteristic of these "highs," vide March 9-10 of the current year, and when such conditions obtain the strong outward radiation results in temperatures of 15° to 20° below the seasonal average with frost southward to the prairies of the Everglades.

Paradoxical as it may seem, there are times when moderate damage from frost is not an unmixed evil. Mild winters (practically without decided damage to crops on the immediate Gulf and the south Atlantic coast sections) enable producing districts to the north and west to realize maximum crop yields. As a consequence of the favorable weather conditions there is overproduction—the concomitant of low prices. It is generally recognized that moderately cold winters (which result in retarded growth and more or less limited production) are conditions favorable to the Florida grower, so far as his vegetable crop is concerned. A corollary is seen in cotton production—a moderate crop being more remunerative to the farmer than a large crop, that may be in excess of current demands.

Methods for protecting crops from frosts vary with the kind of crop, its location, the period of frost occurrence, and the degree of cold expected. Lettuce, cabbage, and celery withstand quite low temperatures without serious damage, except at certain periods of growth. So, too, the strawberry, except at the time of bloom, or when the fruit has set, when a heavy frost results in damage. The most general method of protection is by covering plants with grass or straw. Some "truckers" have a system of subirrigation and others have surface irrigation. During periods of danger the various local ditches for drainage are easily flooded with warm artesian water, the temperature of which is from 60° to 70°. This process raises the temperature of the dew point and adds heat to the air, generally with happy results for the crop. The effectiveness of this method is somewhat impaired by high winds. Some plants are covered with dirt—"plowed under"—provided the plants are not too advanced; this method is effective with young tomatoes and Irish potatoes. Sugar cane is "windrowed."

The methods of protecting citrus trees and fruit multiplied after the cold waves of recent decades. Fundamentally, however, that of dry heat—raising the temperature of the lower layers of air—still predominates. Wood fires are built throughout the grove, preparation being made in advance by distributing cordwood in the centers of the squares. The wood is ignited when the temperature in thermometer shelters falls to about 26° or 28°, particularly if the tendency of the temperature is downward. During calm nights the temperature can be raised by 4° or 6° F. Should freezing weather be attended by high winds, the method is not so satisfactory, as the wind carries the heat from the grove. Succeeding the disastrous cold waves of 1894 and 1899, some groves were protected by sheds, which were simply a flat top of boards supported by posts. This provision retarded radiation, and, if the temperature fell dangerously low, the heat was increased by placing heaters throughout the grove. The method, while feasible and very effective, is expensive, and it is now more or less obsolete. The use of heaters is probably the most satisfactory plan at this present time. Various kinds of heaters are manufactured, and their use has been attended with success. Fuel oil of a low grade is used in the heaters with increasing favor. Irrigation of groves and the spraying of trees with artesian water have proven very helpful.

The low temperatures of winter, involving the safety of the citrus fruit, and the late frosts of spring which have to do with citrus bloom and vegetables, are discordant factors in the harmony of the grower's life. Action to negate the effects of damage from cold is recognized and, by many, is methodically carried out. There are,

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