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CLIMATOLOGY CAN IMPROVE AGRI-WEATHER ADVICE

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There are many ways that the meteorological discipline can serve or assist agriculture. The time-honored way is to issue a daily forecast. But, agricultural technology changes and the economy changes, and such changes make new requirements for the crop producer. We in the field of meteorology need to study the situation and be ready to change, too.

The changing economy of the nation and the world has put a burden on fruit production that is nearly more than the producer can bear. We need to examine the meteorological-climatological input to fruit production and determine whether or not one way of reduction of production cost can be found.

A large portion of the production cost of fruit in the northwestern United States is that of spring frost protection. We have, through the past 50 years or longer, been led to believe that a frost in the spring was a serious thing in fruit production and could reduce the harvest-time return to the producer. This is in general true but it is not absolutely true. Thee is real need to study the climatological situation of the various fruit production regions and learn the statistical probability of frost and of damaging frost. Not all frosts are damaging. How over-cautious are we in fruit frost work? Is the frost danger overstated? Climatological investigation can go far toward answering these questions.

Before a climatological investigation can be carried to completion, the temperatures critical to the fruit or fruits in question must be known. That is, the climatological-meteorological investigators must know what they are searching for.

There needs to be cooperative research between the meteorological and the horticultural specialists. Investigation probably is needed in three elements:

1. The general minimum temperature climate of the fruit production region
2. Critical minimum temperatures for the fruit at various stages of development from the cessation of rest to small green fruit
3. Meso- or microclimate within an orchard.

There have been critical minimum temperature values published for various fruits. These are a help, but it is believed that these are not well considered and used by the operational forecasters of minimum temperatures for fruits. Besides this, the critical temperatures are not well known, and some of the traditional values may be too high. "Because of the complex ... problem, critical temperatures are often wrong.... They usually are too high,... and as a result frost protection equipment often is operated unnecessarily." (Ballard et al, 1972)

To be of greatest service to agriculture, the fruit producer in this case, we need to know these critical minimum temperature values. Then we as meteorologists or crop specialists can advise producers at their various horticultural meetings or training seminars. We need to know the statistical likelihood of these critical temperatures occurring. What is the true probability of a producer suffering a damaging orchard temperature? Does he need to invest as heavily in protection as he does? We should be able to advise him.

Traditionally we speak of a "cold night" as one during which the minimum temperature descends to at least 32°F. The definition of cold night no doubt needs to be revised downward. Deciduous fruits aren't damaged by an overnight 32°F temperature.

Better knowledge of the difference between plant tissue temperature and that of the surrounding air at night is needed. The operational forecaster can forecast the minimum temperature, but the crop producer needs the knowledge of bud or small fruit temperature as it relates to air temperature. (A proposal has now been funded for this kind of research at the Southern Oregon Experiment Station near Medford, Oregon.) Such work will require microclimate investigation within an orchard and it surely must be cooperative research between the disciplines of meteorology and horticulture.

The time to start the operation of protection, by whatever method used, has historically been a question. No producer wanted to waste money or effort by starting too early in the night. Also, at what stage of crop, or date, in the spring should protection methods be started; and at what date in the late spring can the operations cease? Historically these problems haven't worried people greatly because costs were ususally not prohibitive. The cost of protection reduced the income but didn't render the crop entirely unprofitable. Today, costs are so high that the act of frost prevention may put some growers out of business.

At times, growers have lit orchard equipment to prevent frost at 32°F. "This is a sinful waste of oil and labor, particularly in the early part of the season. Then, too, if bud set is normal or heavy, some thinning by freeze damage is desirable." (Jones, unpublished USWB manuscript) Jones made two points in this statement. First, the "season" can be started too early; or, at least, protection is needed only for very low temperatures at early dates. Second, not all frost damage is a hazard to the crop.

It appears that by detailed study of climate and critical minimum temperatures for deciduous fruits, it would be possible to shorten the period during which frost protection needs to be considered. Also, it may be determined that certain frost nights need not be considered at all. The result would be a considerable saving of money for fruit producers.

Haddock (1963) did some work regarding probabilities of number of years between freezes of several different severity levels, and he notes, "Risk-taking is an integral part of farming vegetables and other crops in the valley." Certainly there is risk in producing deciduous fruits in the northwestern United States; but the use of climatology can make the producer more comfortable with his risk and can make him better able to make decisions under uncertainty.

Some work regarding decisions in the problem of frost in fruits has been done at Medoford, Oregon. That work applied to deciduous fruits, and other spring frost problems; so, for example, let us take a broad view of climate near Medford, Oregon in relation to Bartlett pears.

Bartlett pears, like other fruits, can tolerate quite low temperatures (under 25°F) as it comes out of rest. As it progresses through springtime stages of development, it becomes less and less tolerant of frosty temperatures until by the small green fruit stage it is vulnerable to about 29°F.

The following table is extracted from a more complete table in Agricultural Experiment Station Technical Bulletin 136, Oregon State University, May 1977.

Probability of Occurrence of Certain Minimum Temperatures, by Date Increments, at Medford, Oregon

DATES	TEMPERATURES			
	24°F	28°F	31°F	35°F
Mar 14-31	1%	7%	4%	46%
Apr 1-15	0%	6%	3%	54%
Apr 16-30	>1%	4%	5%	49%
May 1-13	0%	1%	3%	76%

The table shows that in late March, when crop vulnerability ranges generally under 24°F, there is about a 1% probability of such occurrence. There is in this same time period only about a 50% likelihood of being down to 31°F, which is no problem to the fruit. This makes it seem statistically that a grower can not afford to consider frost protection earlier than April 1.

Through the month of April, the table indicates at least a 6% probability of the occurrence of temperatures which would be damaging to the crop in its various stages and a small probability exists that temperatures will go to 24 or below. Thus April is indicated as a period during which the risk of damaging freeze is too great to ignore. By May 1, the probability of a temperature as low as 28°F is about 1%, and this continues through May 13. Thus to a low risk taker, some expenditure for frost protection would be justified in the first two weeks of May. However, the producer who is willing to take some risk can see by the table that there is a 79% probability that temperature will only go down to 31°F in the first two weeks of May and he may feel justified in abandoning the costly frost protection program about May 1.

The following figure portrays graphically about the same information as the table just considered. The curve of the graph shows that in the last half of March the crop suffers only from temperatures in the lower 20's, but vulnerability increases significantly in April, and by April 30, the crop is subject to damage with temperatures about as high as 29°F. This vulnerability curve is general; it is not intended that a person be able to pick a particular date and then go to the curve and determine the critical temperature for that date. It is intended only to portray critical temperatures sufficiently for this discussion. The bars on April 1, April 15, May 1, and May 13 indicate the probability of getting the particular temperatures on those dates which are indicated by the vulnerability curve. The graph shows that though the critical temperature of April 1 is about 25°F, the probability of such an occurrence is only about 6%. By April 30 or May 1, the pear crop may have a critical temperature of 29°F and the probability of its occurrence is about 10%.

After May 1, the critical temperature of the crop hovers at around 29°F or slightly above, but the probability drops off rapidly. By May 13, the probability of 29°F is 3 or 4%, and the probability of such a temperature as 30°F is about zero by May 25. Thus, from the graph it can be seen that the greatest frost danger to the crop is in mid-April and it diminishes rapidly after May 1.

As meteorologists who may be involved in agricultural work, we have to advise and assist tender crop producers in reducing operational costs. It has been demonstrated with data from Medford, Oregon, that by detailed study of climatology, we can shorten the period through which producers need to use frost protective devices. It probably is not economically feasible to protect for frost in early stages of bud development prior to April 1 and probably not in the green fruit stage after about May 5 at Medford. A similar pattern of shortening the season can no doubt be demonstrated by climatological analysis in deciduous fruit districts of northwestern United States. This will require the cooperation of meteorologists, horticulturists, and economists. Such studies need to be undertaken to assist fruit producers in making decisions under uncertainty.

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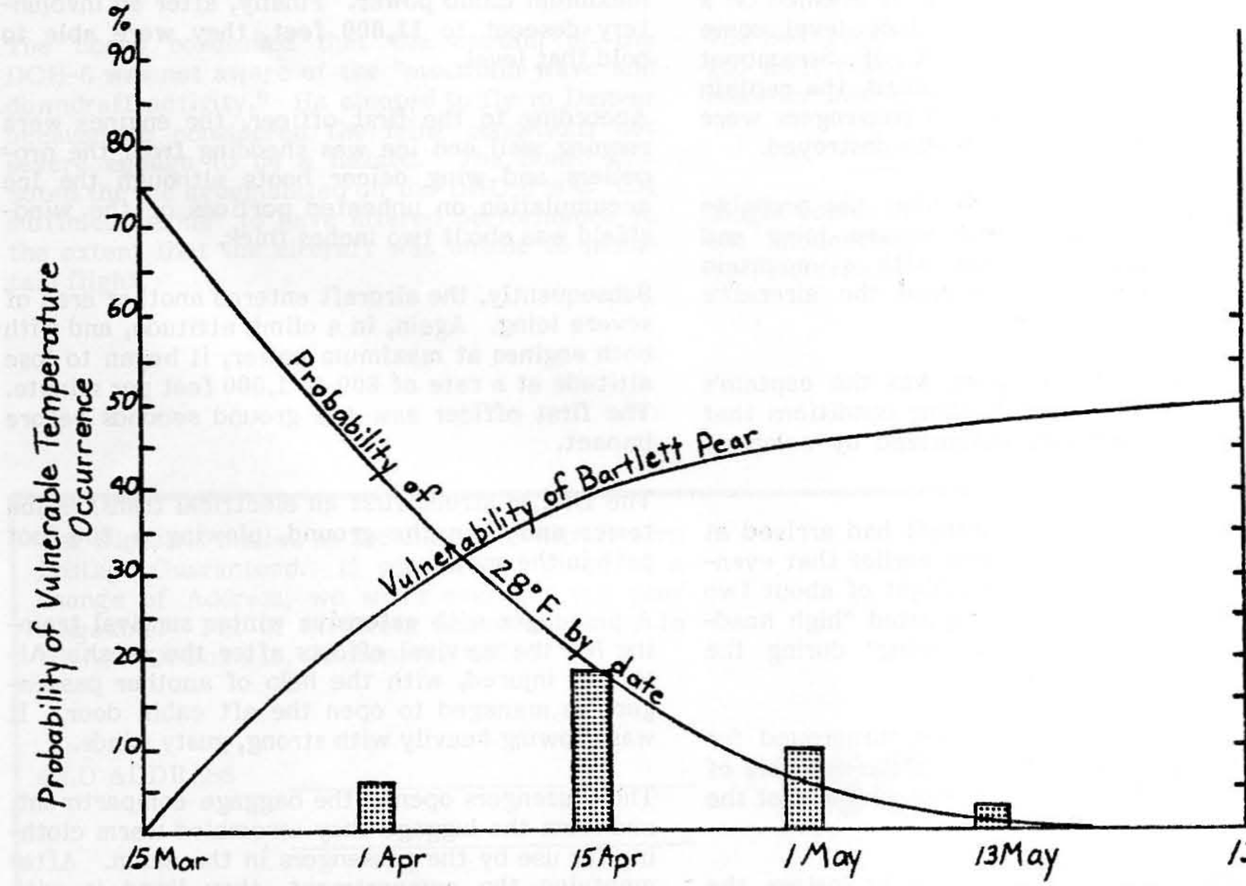

Temperatures at which Bartlett pear is vulnerable shown at right for typical phenological stages and dates. Bars show probability of occurrence of vulnerable temperatures on their dates.