COLORADO FLOWER GROWERS ASSOCIATION

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DENVER WEATHER

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General climatic factors determine in large measure the initial capital investment for greenhouses, operational costs, and how efficiently they convert sunlight to plant yield and quality. Perhaps, in this era of increasing fuel costs and rapid inflation, we should reassess some of the questions formerly taken for granted. For example, we often design heating systems in Colorado for a zero F outside temperature, although a -20°F is not unknown. Is this a reasonable design parameter? Particularly, when a system to meet such a design may be used only once yearly? Most systems are designed to operate most efficiently at some maximum load. Are we getting best use of our money by running it at 50% of its maximum capacity 80% of the time? What might be cheaper alternatives to meet those few occasions when a larger heating capacity might be required? Allowances for wind along the front range are usually based on a 15 to 20 mph wind velocity. Is this realistic in our climate? Obviously, daily, monthly or yearly averages of such things as minimum temperatures, wind velocity and heating load are of little interest as they leave us without any means to realistically determine what is required. We need to determine probabilities in the manner that weather commentators now assess the chances for rain or snow. Each grower could then determine for himself how much risk he is willing to accept in design and operation, based upon reasonable probability.

As a start to answering some of these questions for Colorado growers, we examined the weather records from Denver, Stapleton International Airport for the past ten years, from September through April. One can appreciate, due to the characteristics of the Front Range, records at Stapleton may not be typical of what occurs at Golden or Lafayette, or in some small area with distinctive land arrangement. However, it is the only official weather station within reasonable distance of a major greenhouse concentration with records over several years.

We subjected: 1) minimum daily temperatures, 2) average daily temperatures, 3) daily degree-days of heating, 4) percent possible sunshine, 5) average daily windspeed, and 6) maximum daily windspeeds to a frequency analysis. Figures 1 through 3 depict the results graphically, and Table 2 shows the breakdown in terms of: 1) a lower limit for each class, 2) the number of occurrences with that lower limit, and 3) the percentage occurrence of a class with a particular lower limit.

Note, for example, that there were 10 days in the period between 1967 and 1977 when temperatures were between -14° and -19°F (Fig. 1). Or, one could expect, on the basis of this ten year analysis, an average of one day per year with a temperature below -14° and above -20°. Therefore, if a heating system were designed to maintain inside temperatures at -20°F, it would be used less than one percent of the time. Is the capital investment necessary for this design valid? If the design was for 17°F outside, we could expect maximum use of the heating equipment for 13.9 percent of the time. Can a grower accept some two or three days of inside temperatures approaching freezing? Or, are there alternative heating methods that could serve to meet these extreme conditions? The risk may not be acceptable, but sometimes it doesn't hurt to question conventional wisdom in the light of a different day. It might open some new ways of thinking.

Another way to look at the situation is to determine how much the heating system would be used by calculating the

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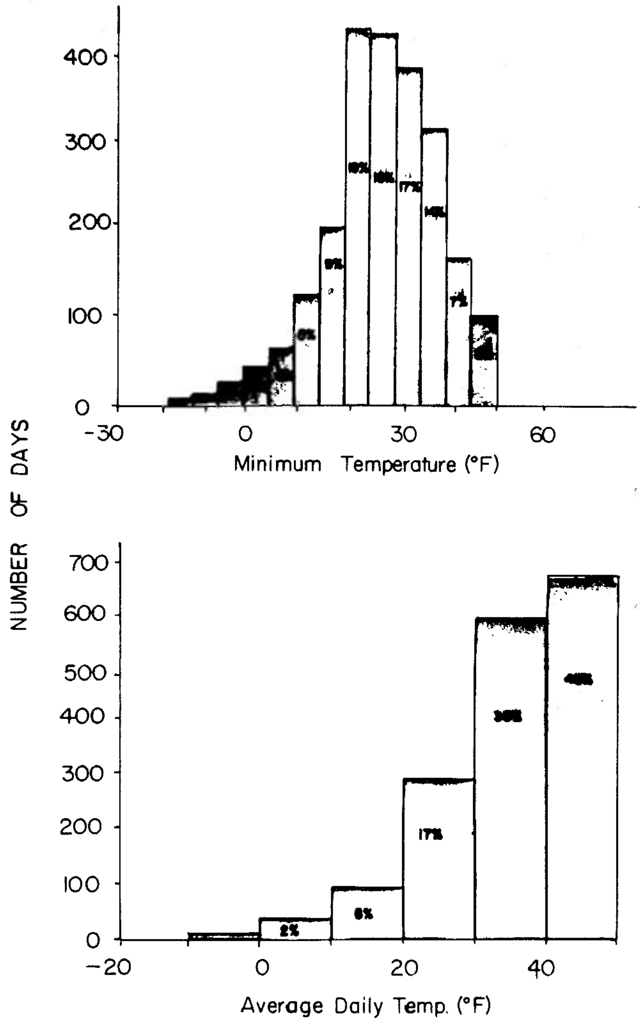

Fig. 1: *Upper:* *Frequency of minimum daily temperatures between September through April for ten years, 1967 to 1977, for Denver, Stapleton Airport.*

Lower: *Frequency of average daily temperatures, September through April, 1967 to 1977, for Denver, Stapleton Airport.*

degree-days of heating required. If we designed a heating system to supply 30 degree-days of heating per day, it would supply sufficient capacity for 87 percent of the time, leaving only 13 percent when capacity would be insufficient, or, on the average, 29 days per year. The outside design temperature would be about 13°F. In the light of present knowledge and thinking, 29 days, when one could not maintain adequate temperatures, is probably unacceptable. However, are there other ways of getting around this?

Note in Table 1, (Fig. 3) that the average daily wind speed was between 5 and 10 mph. The maximum windspeed recorded at Stapleton in the 10 year period was above 45 mph 5 times in the ten years. It is generally accepted that our maximum wind speeds occur with chinooks or close to the mountains, when temperatures are usually above freezing. So, while we might not be able to maintain inside temperatures at such high wind speeds (see CFGA Bul. 286), there is seldom danger of freezing. Would it be better to design the heating system for a maximum 5 mph velocity, which would take care of the situation 66 percent of the time? Again, the question is raised, but it is the individual grower who must determine the risk he desires to accept.

Recently, there has been much attention given to solar heating. Obviously, the more sunshine available, the better the possibility for solar heating. Table 1 and Fig. 2 show that there was an average of 19 days each year when the sky was completely overcast. In Colorado, minimum temperatures usually coincide with stable, clear conditions. A back-up system for the worst possible case might be for 13°F for 8 percent of the time. We can expect, in Colorado, 70 percent or more sunshine 60 percent of the time, or at least 50 percent of maximum possible 77 percent of the time.

Several other interesting relationships can be obtained from a study of frequencies. Only some of the relationships have been discussed, serving to point up some questions that we perhaps need to consider once more. Certainly, a 10 year survey of weather for a location may not be sufficient for reliable risk determination, but this preliminary study suggests the uses such information might have. Denver and Colorado Springs have first order weather stations which can provide the basic data from which this analysis was made. Temperatures and precipitation can be obtained for Franktown, Longmont, Brighton, Greeley, Boulder, Castle Rock, Fort Collins, Palmer Lake, and Byers. Some of these stations might better characterize your location.

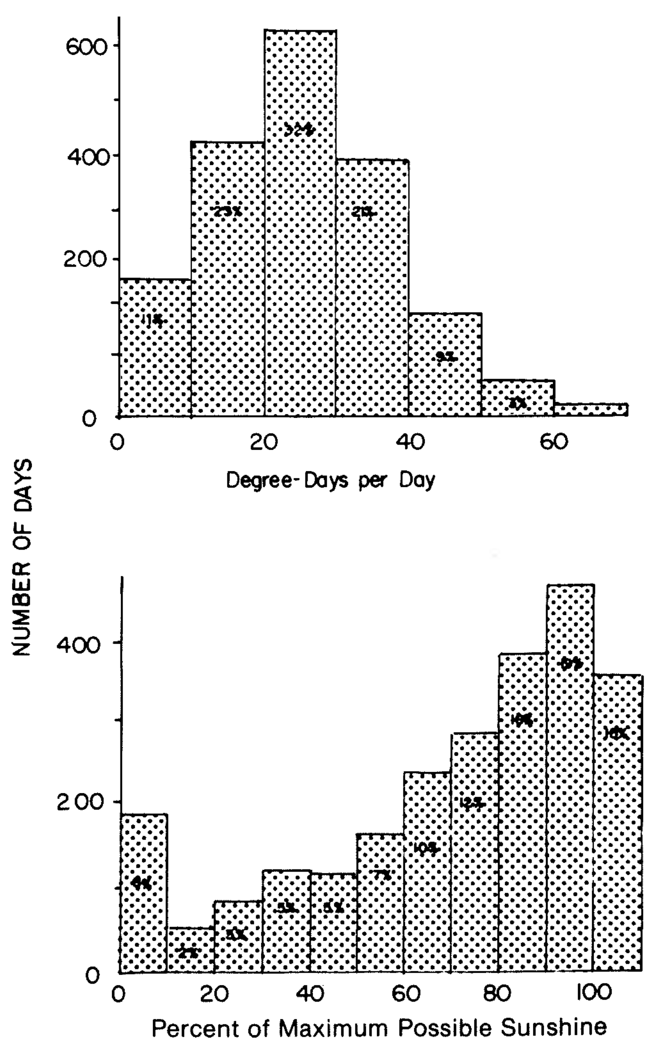

Fig. 2: *Upper:* *Frequency of degree-days, heating, September through April, 1967 to 1977, for Denver, Stapleton Airport.*

Lower: *Frequency of percent possible sunshine, September through April, 1967 to 1977, for Denver, Stapleton Airport.*

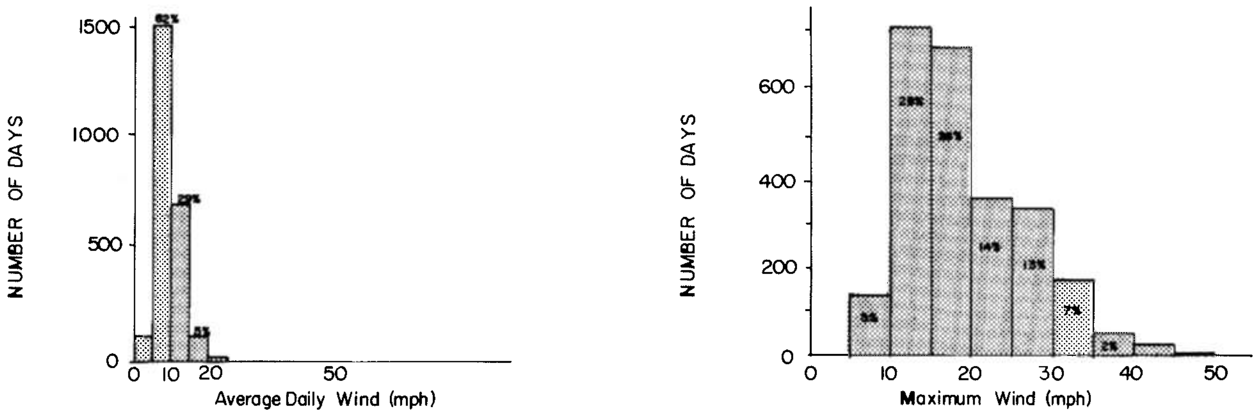

Fig. 3: *Left: Frequency of average daily windspeed, September through April, 1967 to 1977, for Denver, Stapleton Airport.*

Right: Frequency of maximum daily windspeeds, September through April, 1967 to 1977, for Denver, Stapleton Airport.

Table 1: Frequency analysis of weather at the Denver, Stapleton International Airport. Ten years, September through April, 1967 through 1977.

	Minimum temperature (°F)	Average temperature (°F)	Heating degree-days	Percent possible sunshine	Average Daily wind-speed (mph)	Maximum daily windspeed (mph)
Lower limit	-19.0	-10.0	0	0	0	0.0
Number of days	10	10	265	192	107	134
Percent	0.4	0.6	11	7.7	4.3	5.0
Lower limit	-14	0	10	10	5	10
Number of days	15	39	533	53	1525	730
Percent	0.6	2.2	23	2.1	62	29
Lower limit	-9	10	20	20	10	15
Number of days	29	99	747	85	712	684
Percent	1.2	5.6	32	3.4	28.7	28
Lower limit	-3	20	30	30	15	20
Number of days	46	305	498	123	113	350
Percent	1.9	17.3	21	5	4.6	14
Lower limit	2	30	40	40	20	25
Number of days	68	614	199	118	10	50
Percent	2.9	34.8	9	4.8	0.4	2
Lower limit	7	40	50	50	25	30
Number of days	128	696	70	166	1	170
Percent	5.4	39.65	3	6.7	0	7
Lower limit	13		60	60		35
Number of days	207		21	242		50
Percent	8.8		1	9.7		2
Lower limit	18			70		40
Number of days	436			289		25
Percent	18.5			11.6		1
Lower limit	23			80		45
Number of days	430			386		5
Percent	18.2			15.5		0
Lower limit	29			90		
Number of days	391			470		
Percent	16.6			18.9		
Lower limit	34			100		
Number of days	322			359		
Percent	13.6			14.9		
Lower limit	39					
Number of days	173					
Percent	7.3					
Lower limit	45					
Number of days	106					
Percent	4.5					

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