PLANTCLIMATE ANALYSIS FOR LETTUCE

. . . introducing a new method for determining plant temperature requirements

M. H. KIMBALL · W. L. SIMS · J. E. WELCH

Most plants require differing day and night temperatures for optimum growth. Definite knowledge of day and night temperatures necessary for maximum yield of high quality crops is vital for intelligent agricultural planning. This applies to choice of crops for a single farm or for an agricultural community. It is also essential in determining potential soundness and ultimate economy of land- and water-development projects. Tremendous losses, both of money and time, often result from trial and error processes which eventually prove suitability of certain crops in a specific area. The study reported here describes a new method of phenological determination of temperature requirements for plants.

The need for precise data on plant temperature requirements has led to development of controlled-environment growth chambers (phytotrons) in which plants can be subjected to different day and night temperature combinations. The ideal day and night temperature relationship for top yield and high quality can be determined for each crop as well as the range of day-night temperatures that will result in 90% or 80% yield and quality.

Phytotron testing is costly and time consuming, however, and handling populations of tree crops could present almost insurmountable problems. Testing has been done on only a few of the vegetable, field and flower crops in the state. Phytotron results are not directly usable in the field, for they present a "square wave" rather than a sinusoidal curve for diurnal temperature fluctuations — making it necessary to convert the temperature data results from phytotron, or near-phytotron conditions to field conditions and vice versa.

It is possible to determine the optimum temperature range for most, if not all, commercial crops from field data of both crop behavior and temperatures. For any particular crop the following test conditions are necessary:

1. The crop must be grown in several different climates.
2. The same or similar varieties (similar behavior in the same climate) must be available for observation in all locations.
3. Adequate and detailed phenological data must be available from all locations.
4. Temperature data for each growing area must be available. Monthly mean maximum and monthly mean minimum temperatures, as reported by the United States Weather Bureau from local cooperative stations *in* growing areas—or extrapolated *for* the growing areas from station records in nearby towns—are satisfactory.

Great Lakes type varieties of head lettuce, *Lactuca sativa,* were chosen to illustrate the method. These varieties have been produced commercially throughout all seasons and for many years in California. They have been studied intensively in the field and have been successfully grown in greenhouses by plant breeders where temperature control approximates the precise conditions found in phytotrons. California growing conditions range from the Imperial Valley desert area, and the moderately warm coastal conditions of San Diego County on the south, to the moderate interior and cool coastal conditions of central California as far as 500 miles northward. Similar varieties are also grown in Arizona to elevations of 4300 feet and in Colorado to 7600 feet.

Climatographs were made of the yearly temperatures of each lettuce growing area in California, Arizona, and Colorado. These climatographs utilized the monthly mean minimum as the *night* temperature plotted on the ordinate, and the monthly mean maximum as the *day* temperature on the abscissa. Both ordinate and abscissa start with the same temperature at the axis, and both night and day temperatures increase with the same intervals. Each month is represented by a single point. Points represent approximately the middle of each month. Points are numbered "1" for January, to "12" for December. When all points are connected, a continuous line is produced diagraming the climate of the locality. Differences of climate become obvious by comparing climatographs.

Harvesting dates for each producing area were determined from reports of the Federal-State Market News Service and are indicated on the climatograph by a broken section in the line. The harvest season portion of each climatograph was transferred to one chart. All were found to be located within a narrow range of both day and night temperature. The area representing approximately 90% of potential yield and quality was enclosed. Harvest season extensions beyond the enclosed area are before, or after, the main season and are marginal in quality.

Boundaries of the enclosure indicate the range of day-night temperatures needed by lettuce. The range was from 63° to 83° F for day, and from 37° to 53° F for night. This indicates a desirable average of 73° F field temperature for day and 45° F for night.

Lettuce breeders have found through experience that greenhouse-grown head lettuce crops are similar to those grown under ideal field conditions, if the greenhouse temperature is kept at about 65° F during the day, and about 53° F at night.

The average day and night temperatures derived from field data convert to 66° F day- and 52° F night-equivalent in a controlled greenhouse, or near-phytotron conditions.

Climatographs shown as figures 1 through 6 are for lettuce producing areas of California with a composite in fig. 7.

CLIMATOGRAPHS FOR HEAD LETTUCE IN WESTERN PRODUCING AREAS

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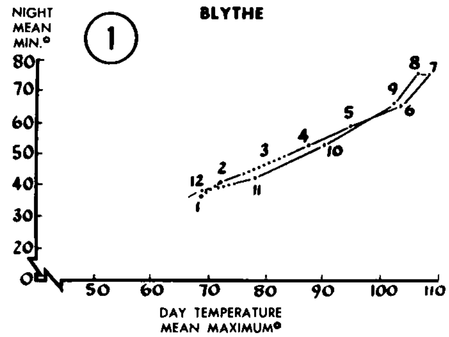
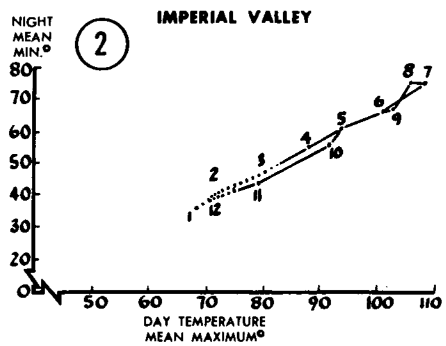
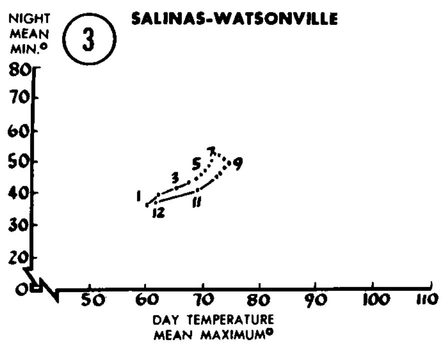
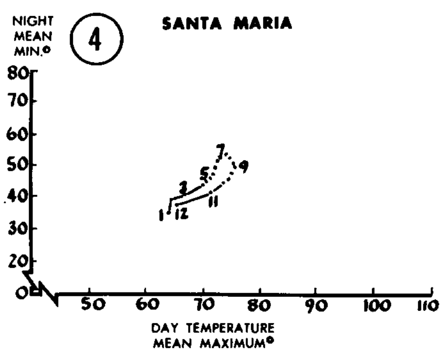
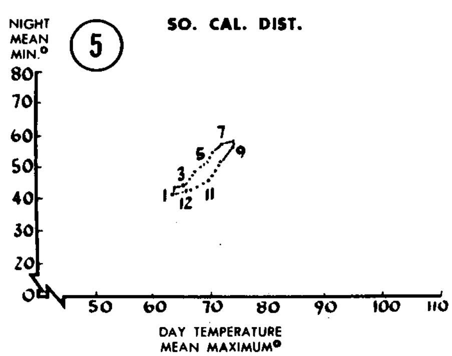
Monthly night-day temperatures are indicated by points 1 through 12 on graphs. Broken lines on graphs 1 through 11 indicate harvest periods. Dotted circles on graphs 12, 13, and 14 indicate optimum temperatures for lettuce production.

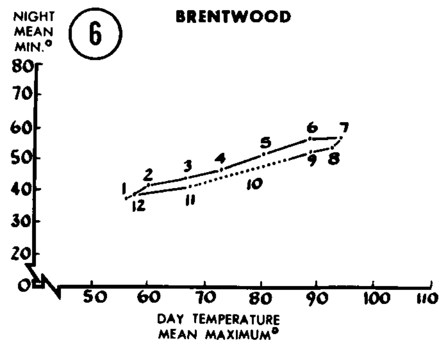


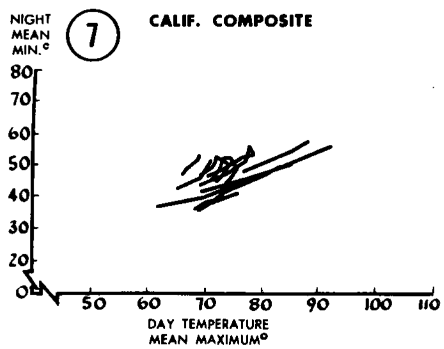


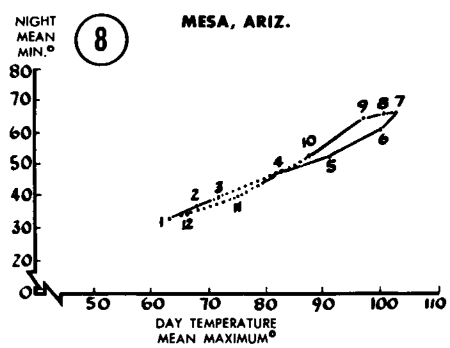


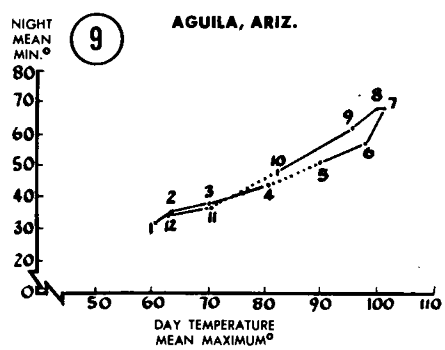


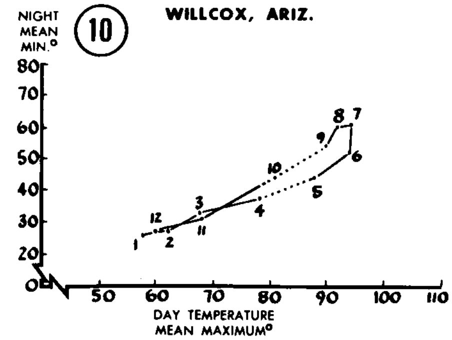


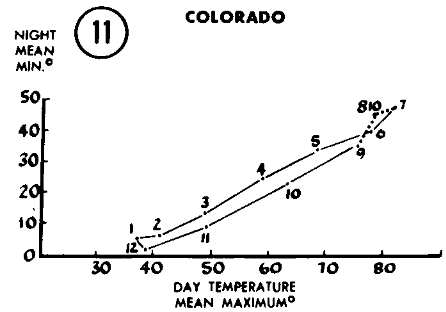


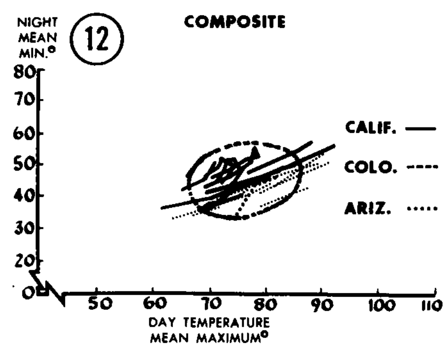


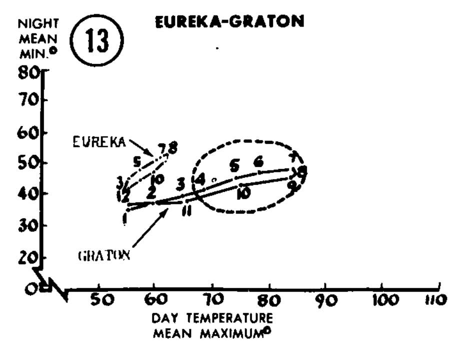


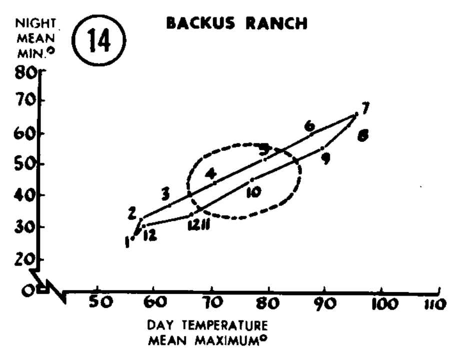












Figures 8 through 11 are climatographs for Arizona and Colorado. Fig. 12 is a composite of head lettuce producing areas of the three states with a line enclosing the 90% area—illustrating establishment of an ideal day-night temperature regime.

Application of this method to selection of prospective lettuce-producing areas can be illustrated by considering, for example, the climatograph for Eureka, California. This area lies entirely outside the ideal temperature zone because it is too cool, particularly during the daytime. Temperatures at Graton, California, on the other hand, indicate possible growing seasons in both spring and fall (see fig. 13). Records confirm this situation in part, because the Cotati Valley in Sonoma County was a lettuce seed producing area during World War I.

The Backus Ranch climatograph, fig. 14, represents the climate of south-sloping lands on the north side of the Antelope Valley in western Mojave Desert between Mojave and Gorman, California. This is an area in which no head lettuce had been grown. Inquiry concerning climate suitability was made as land was being prepared for trial plantings. Two possible crop seasons were indicated, and an encouraging prediction was made, particularly for a fall crop. A yield of 325 cartons per acre was considered necessary for a profitable venture. Two 10-day-spaced August plantings produced 400 cartons per acre in 70 days and 625 cartons per acre in 74 days, respectively, of exceptionally high quality lettuce. Low yield of the first planting reflects a poorer stand because of high soil temperature effects on seed germination. A rapid temperature rise in late spring, and the high level reached, make the quality of a spring crop doubtful.

Climatograph studies comparing quality of most annual crops at harvest time will be important. Optimum temperatures for both seed germination and growth can be studied by using other sections of the temperature diagrams. With perennials, entire climatographs are compared. The position, the slope or angle of the figure, its length and the interval (distance) between monthly points are all needed for relation to detailed phenology when studying plants exposed to year-around temperatures.

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PREDICTION OF FINAL FEEDLOT

. . . from observations at

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A NUMBER OF MANAGEMENT and economic decisions concerning feedlot practices and length of the feeding period could be made with more precision if it were possible to predict accurately a long-term feedlot gain from a short-term observation. The results presented here are from a correlation and regression analysis of 28- and 56-day rates of gains with overall average daily gain.

Data from 533 steers fed free-choice, high-energy rations capable of promoting maximum or near maximum gains were used. Additional criteria were availability of individual shrunk weights of all animals at 28-day intervals with a minimum

TABLE 1. INITIAL WEIGHT (IN GROUPS), AND AVERAGE DAILY GAINS FOR TEST ANIMALS

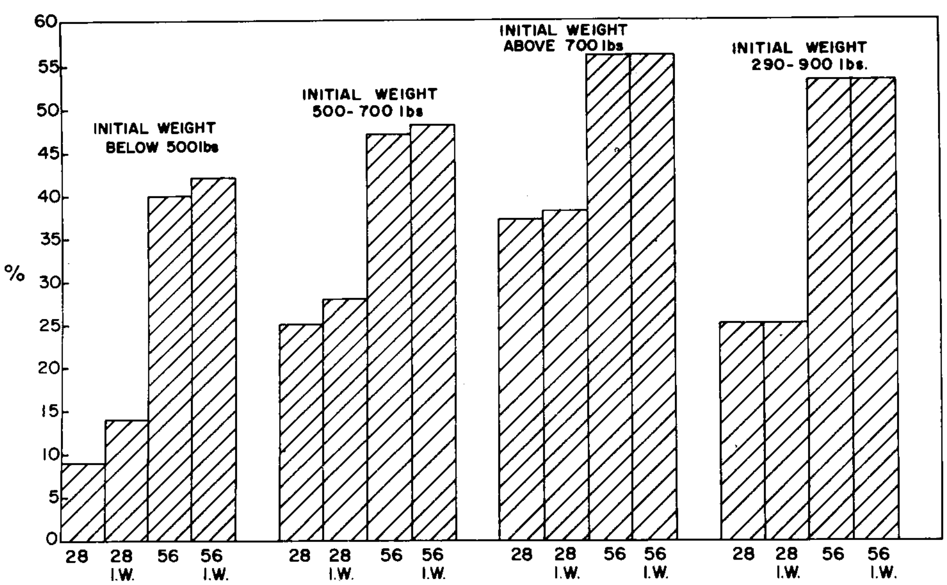
No. of animals	Initial weight, lbs		Average daily gain, lbs		
	Range	Mean*	28-day gain	56-day gain	Overall gain
174	290–499	422±4	2.02±.05	2.51±.04	2.55±.03
229	500–699	612±4	2.93±.08	2.83±.04	2.70±.03
130	700–900	757±4	2.29±.11	2.54±.06	2.69±.04
533	290–900	585±6	2.48±.05	2.65±.03	2.65±.02

* With standard error of means.

TABLE 2. ALL DATA—CORRELATION COEFFICIENTS (28- AND 55-DAY GAIN vs. OVERALL GAIN), THE PREDICTING EQUATIONS AND AN ESTIMATE OF THE ACCURACY OF THE PREDICTED GAIN

	Correlation coefficient	Predicting equation[a]	Precision,[b] lbs/day
28-day gain	.50	$Y = 0.20X_1 + 2.14$	±.40
56-day gain	.69	$Y = 0.48X_2 + 1.36$	±.28

[a] Y is overall average daily gain, X_1 is 28-day average daily gain and X_2 is 56-day average daily gain.
[b] The predicted gain will ordinarily be within these limits of the actual gain.



Percentage of variation in overall average daily gain that can be explained by feedlot gains made at 28- or 56-day intervals
(28I.W. and 56I.W. indicate the same comparison when initial weight was also considered as a factor influencing the variation.)