Growing Seasons in Chile: Observation and Prediction

by

E. R. Hajek* and J. R. Gutiérrez*

ABSTRACT — Temperature data for 42 Chilean locations were analysed and heat sums calculated (for base 5°C and 10°C). Also, the length, starting and ending dates of the growing seasons were obtained. Temperature values normally found in Chilean climatological records, i.e. monthly and annual means, were related with temperature accumulations. In Chile it is possible to predict the accumulation of temperature from the annual mean temperature ($r=0.995$, $P<0.001$, for base 5°C and $r=0.984$, $P<0.001$, for base 10°C) or from the mean monthly temperature of January. In this latter case, a good adjustment with an exponential curve is found ($r=0.76$, $P<0.001$, base 5°C; $r=0.78$, $P<0.001$, base 10°C). For Chile, temperature courses along the year were approximated by using a harmonic analysis. No significant differences were observed between predicted and observed values. By integrating these equations as a function of time, it is possible to determine both the accumulation of temperature and the length of growing seasons for different threshold temperatures. A significant relationship was found between these variables and the latitude, and gradients were also obtained. Differences exist between littoral and continental stations in the extension of growing seasons and the accumulation of temperatures.

INTRODUCTION

A relatively well known and documented situation is the existing relation between temperature accumulations and the growth and development of plants (Holmes and Robertson, 1959). Thermic accumulation or growing degree-day is the accumulation of positive daily differences of mean daily temperatures and a threshold, which is usually set in relation to the studied plant or arbitrarily. Daily differences are added up until the plant has reached maturity or until the course of mean temperature approximates the threshold.

Computations usually begin when mean temperatures surpass the threshold that has been set and end when temperatures fall below the threshold again. These periods are called growing seasons and differ for different countries and plant species. In the northern hemisphere usually the first of March is defined as the beginning of the first climatological week (Dethier and Vittum, 1963). In Chile, Hajek, Rodríguez and Damm (1976) have defined the first of July as the starting date of the first climatological week and the 30 of June of the following year as the end of the last climatological week.

*Laboratorio de Ecología, Instituto de Ciencias Biológicas, Pontificia Universidad Católica de Chile. Casilla 114-D Santiago-CHILE.

Presented at the Eighth International Congress of Biometeorology 9-14 September 1979, Shefayim, Israel.
Different plant species have specific thresholds, but there is general consensus to set 5°C and 10°C as standard thresholds for agricultural crops (Aspiazu and Show, 1972; Holmes and Robertson, 1959; Mac Kay et al., 1967; Prine, Guilarte and Duncan, 1974).

In many countries (Boughner, 1964; Castillo and Giménez, 1966; De Fina and Ravelo, 1973; Dethier and Vittum, 1963; Hurst and Smith, 1967; Neild and Young, 1965; Pieslak and Przedpelska, 1966; Pochop, 1977) there exists a reasonable amount of knowledge about the duration, beginning and ending of the growing seasons, and the amount of accumulated temperature during these periods. Thus, some countries have been able to plan seeding seasons, determine the probable date of ripening of the products, make serial seedings, estimate the onset of agricultural pests and design adequate measures of control. Hence, the information on temperature accumulations has been used for practical purposes which have allowed the implementation of harvesting infrastructure, marketing, arrival of products to processing plants without accumulation that might lead to deterioration, etc.

The calculation of thermal units by daily accumulation is a rather tedious process and in the climatological statistics published in Chile normally mean daily temperatures are not specified, but only monthly and annual means. Hence, it would be of a great practical value to be able to predict thermic accumulations by using mean monthly, seasonal or annual temperatures.

Bingham (1963) has determined the distribution of temperature in Canada during the climatological year, showing that for practical purposes the temperature distribution may be considered to be statistically normal. This distribution may be specified by using a harmonic analysis, as described below:

\[ y(t) = a_0 + A_1 \cos(t - \varphi_1) + A_2 \cos(t - \varphi_2) + A_3 \cos(t - \varphi_3) \]

where \( y(t) \) is the mean temperature, \( a_0 \) is the mean annual temperature, \( A \) is the difference between the maximum value reached by temperature and the mean \( a_0 \), \( t \) is the time in days starting from the first climatological week, and \( \varphi \) represents the day in which the curves reach their maximum value.

The aim of our contribution is: (a) to relate observational data on growing degree-days (base 5°C and 10°C) (Hajek and Gutiérrez, 1979) with mean temperature of January, mean annual temperature, and latitude; (b) to relate onset, ending and duration of growing seasons with latitude, and (c) to determine the course of mean daily temperatures along the year, providing the values of the parameters that define their distribution. By assuming the validity of some of these relationships we could make predictions of practical value.

**MATERIALS AND METHODS**

For this study, information on temperatures for 42 Chilean locations between Arica (Lat. 18°28'S, Long. 70°22'W) and Punta Arenas (Lat. 53°10'S, Long. 70°54'W) was used. In Table 1 the analysed stations are listed, indicating whether they are littoral (L) or continental (C). Original data of daily temperatures at 08:00, 20:00 h, maximum and minimum of the period 1965-1970, were compiled from unpublished information of the Oficina Meteorológica de Chile. A computer program allowed to reduce the four values of temperature to get the mean daily temperature. From these daily temperatures annual accumulations for bases 5°C and 10°C were calculated.

Mean annual temperature, mean temperature of January and the latitude, were related to the accumulation of temperature. Also, the onset, ending and duration of growing seasons were related to the latitude, for both littoral and continental stations.

For each location, mean weekly values for the period 1965-1970 were calculated. These 52 mean weekly values for each location were plotted against time.

According to Bingham (1963) the cosine function, which describes in a fairly good way