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Growing Seasons in Chile: Observation and Prediction

by
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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 ($r=0.995$, $P<.001$, for base 5°C and $r=0.984$, $P<.001$, 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.

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Different plant species have specific thresholds, but there is general consensus to set 5° C and 10°C as standard threshold for agricultural crops (Aspiazú 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:

$$y(t) = a_0 + A_1 \cos(t - \varnothing_1) + A_2 \cos(t - \varnothing_2) + A_3 \cos(t - \varnothing_3)$$

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 $\varnothing$ 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

Table 1: Location of analysed Chilean Meteorological Stations

Stations	Latitude S	Longitude W	Altitude (m)
Arica (L)	18°28′	70°22′	29
Iquique (L)	20°12′	70°11′	515
Pica (C)	20°30′	69°21′	1280
Antofagasta (L)	23°29′	70°26′	119
Chañaral (L)	26°20′	70°37′	9
Potrerillos (C)	26°30′	69°27′	2850
Caldera (L)	27°03′	70°58′	28
Copiapó (C)	27°21′	70°24′	370
Vallenar (C)	28°35′	70°46′	470
La Serena (L)	29°54′	71°15′	32
Ovalle (C)	30°36′	71°12′	220
Quintero (L)	32°47′	71°32′	2
Valparaíso (L)	33°01′	71°38′	41
Santiago (C)	33°27′	70°42′	520
Rancagua (C)	34°10′	70°45′	500
San Fernando (C)	34°35′	71°00′	342
Curicó (C)	34°58′	71°13′	225
Constitución (L)	35°20′	72°56′	7
Linares (C)	35°51′	71°36′	157
Chillán (C)	36°36′	72°02′	118
Concepción (L)	36°50′	73°02′	15
Los Angeles (C)	37°28′	72°21′	130
Victoria (C)	38°13′	72°21′	360
Temuco (C)	38°45′	72°35′	114
Loncoche (C)	39°23′	72°38′	112
Valdivia (L)	39°48′	73°14′	9
Osorno (C)	40°35′	73°09′	24
Puerto Montt (L)	41°28′	72°57′	5
Ancud (L)	41°52′	73°48′	20
Castro (L)	42°29′	73°48′	80
Futaleufú (C)	43°12′	71°52′	330
Río Cisnes (L)	44°45′	72°00′	700
Puerto Aisén (L)	45°24′	72°42′	10
Coyhaique (C)	45°29′	71°33′	140
Balmaceda (C)	45°54′	71°43′	520
Chile Chico (C)	46°36′	71°43′	342
Cabo Raper (L)	46°50′	73°36′	40
Puerto Edén (L)	49°08′	74°25′	6
Cerro Guido (C)	50°55′	72°30′	815
Evangelistas (L)	52°24′	75°06′	55
Punta Dungenes (L)	52°24′	68°26′	5
Punta Arenas (L)	53°10′	70°54′	8

(L) = Littoral
(C) = Continental

the distribution of temperatures in Chile was used. In the case of this country the function has only two terms, because the temperatures show only one maximum during the year. Therefore, the equation is:

$$y(t) = a_0 + A \cos(t - \varnothing)$$

the terms of the equation being similar to those defined before.

RESULTS AND DISCUSSION

The relation between mean annual temperature and accumulated degree-days (bases 5°C and 10°C) can be expressed in a simple manner by means of a linear regression (Fig. 1). The equation for the regression line appears in Table 2 (a and b). The correlation is highly significant, and therefore, it is possible to determine very precisely the amount of growing degree-days in one year from the mean annual values. Estimated values are closer to observed values when the mean annual temperatures are above 8°C (in Chile, about 80% of mean annual temperatures is above this value).

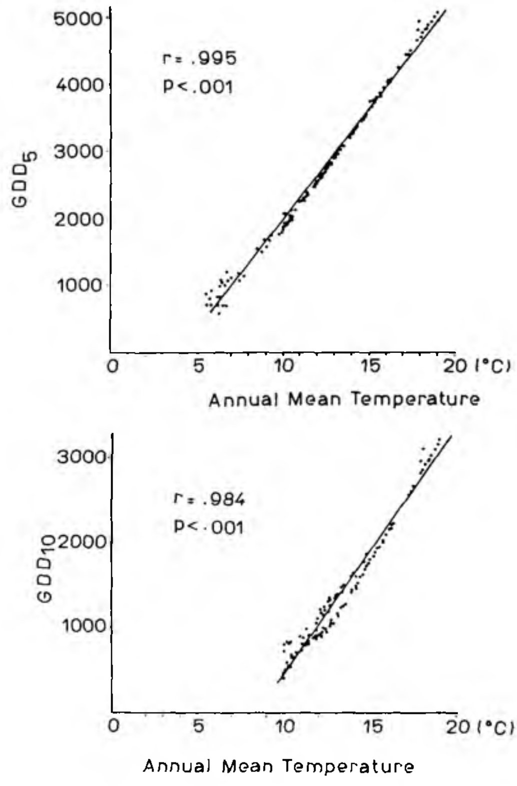


Fig. 1. (a) Relation of growing-degree days, base 5°C (GDD_5) and annual mean temperature.
(b) Relation of growing-degree days, base 10°C (GDD_{10}) and annual mean temperature.

Table 2: Equations defining the different relationships discussed in this study.

		r	P
a) ADD-5	= —1315.18 + 331.38 T	.995	***
b) ADD-10	= —1489.90 + 293.98 T	.984	***
c) ADD-5	= 196.56 exp (0.15TJ)	.76	***
d) ADD-10	= 13.33 exp (0.25TJ)	.78	***
e) LGS-10	= 6880.31 — 118.11 L	—.94	***
f) OGS-10	= —120.11 + 6.01 L	.92	***
g) EGS-10	= 556.21 — 6.61 L	—.85	***
h) ADD-5 (L)	= 6882.25 — 118.17 L	—.98	***
i) ADD-5 (C)	= 7413.90 — 130.13 L	—.98	***
j) ADD-10 (L)	= 4110.91 — 81.92 L	—.96	***
k) ADD-10 (C)	= 4548.54 — 92.11 L	—.96	***

ADD-5 = accumulated degree-days, base 5°C. ADD-10 = accumulated degree-days, base 10°C. T = mean annual temperature. TJ = mean temperature of January. LGS = length of the growing season, base 10°C. OGS = onset of the growing season, base 10°C. EGS = end of growing season, base 10°C. L = latitude south. (L) = littoral. (C) = continental. *** = $P<0.001$.

Since there also exists a significant correlation ($r = 0.91$, $P<0.001$) between the mean annual temperature and the mean temperature of January (Fig. 2) it is possible to predict the annual degree-days from this last variable. The data of mean temperature of January and accumulated degree-days, for base 5°C and 10°C fitted better to an exponential curve, and Fig. 3 shows the relation for both bases. The equations of the curves are tabulated in Table 2 (c and d). The correlation is significant in both cases. In spite of these relations, precautions should be taken to consider both equations for predictive purposes, due to great deviations of the observational data.

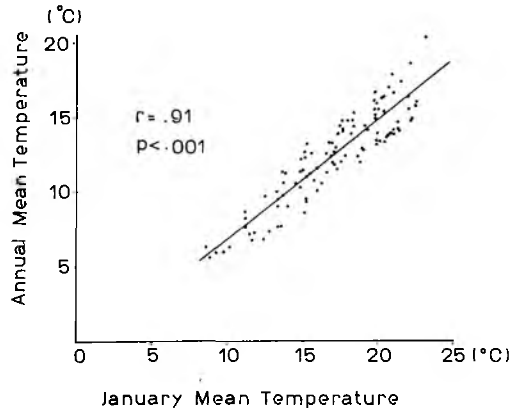
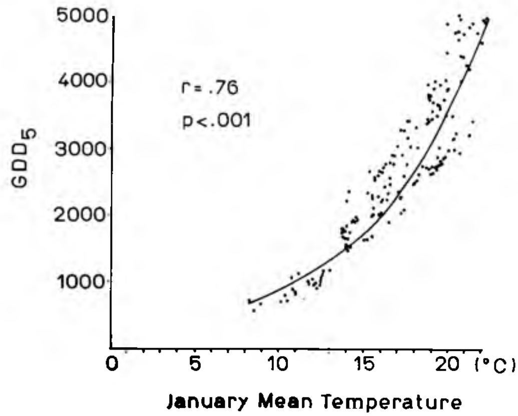


Fig. 2. Relation of mean temperature of January and annual mean temperature.



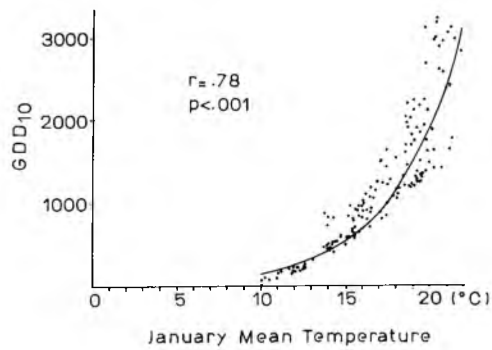


Fig. 3. (a) Relation of growing-degree days, base 5° C (GDD_5) and mean temperature of January.
(b) Relation of growing-degree days, base 10° C (GDD_{10}) and mean temperature of January.

Tables 3 and 4 show the data of onset and end of the growing seasons in Chile, for base 5° C and 10° C, and their corresponding length in days. With regard to base 5° C (Table 3) it can be seen that between the locations of Arica and Puerto Montt (18°28′ to 41°28′S) there is accumulation of temperature along the whole climatological year, exception made of high Andean or altiplanic regions. Comments on this situation have already been made in earlier studies (Hajek and Gutiérrez, 1978). From Puerto Montt southward the length of the growing season decreases, reaching its lowest value (175 days) in Punta Arenas (53° 10′S). The growing seasons computed on a 10° C base (Table 4) are shorter than 365 days only from Quintero (32°47′S) southward, exception made of Valparaíso. In the northern part of the country, Potrerillos accumulates temperature above 10° C only during 247 days probably due to its altitude (2,850 m). The relation between the length of the growing seasons in days (base 10° C) and the latitude is shown in Fig. 4 and Table 2 (e).

Fig. 5 shows the relation between latitude and the onset and end or the growing season, base 10° C computed from the first of July on from 33° latitude southward. The relation is described by the equation f and g in Table 2. The growing season for latitudes below 33° is 365 days, exception made of Potrerillos (discussed above).

Table 3: Onset and end of the growing season, base 5° C, for Chilean localities.

Localities	— 1 S	Mean	+ 1 S
Arica to Puerto Montt		All year	
Ancud	—	18 Jul	—
	20 Jun	24 Jun	28 Jun
Castro	5 Jul	14 Jul	23 Jul
	19 Jun	23 Jun	27 Jun
Futaleufú	13 Sep	19 Sep	25 Sep
	28 Apr	10 May	22 May
Río Cisnes	26 Oct	31 Oct	5 Nov
	19 Apr	27 Apr	5 May
Puerto Aysén	20 Aug	28 Aug	5 Sep
	24 May	30 May	5 Jun
Coyhaique	21 Sep	27 Sep	3 Oct
	24 Apr	2 May	10 May
Balmaceda	11 Oct	24 Oct	6 Nov
	12 Apr	27 Apr	12 May
Chile Chico	20 Aug	27 Aug	13 Sep
	13 May	24 May	4 Jun
Cabo Raper	1 Jul	8 Jul	15 Jul
	21 Jun	24 Jun	27 Jun
Puerto Edén	3 Oct	16 Oct	29 Oct
	23 Apr	8 May	23 May
Cerro Guido	27 Sep	8 Oct	19 Oct
	24 Apr	1 May	8 May
Evangelistas	14 Oct	24 Oct	3 Nov
	10 May	24 May	7 Jun
Punta Dungenes	5 Sep	24 Sep	13 Oct
	25 Apr	14 May	7 May
Punta Arenas	11 Oct	22 Oct	2 Nov
	4 Apr	17 Apr	30 Apr

Since the rate of accumulation of temperatures is different in littoral and continental sectors, it was considered convenient to analyse the two areas separately. The effect of the ocean tends to decrease thermal excursions, therefore tending to an increase in the accumulation of heat. The opposite is true for the inland, due to the distance from the coast and the altitudinal variations.

Table 4: Onset and end of the growing season, base 10°C, for Chilean localities.

Localities	—1 S	Mean	+1 S
Arica		All year	
Iquique		All year	
Pica		All year	
Antofagasta		All year	
Chañaral		All year	
Potrerillos	6 Sep 8 May	19 Sep 24 May	2 Oct 9 Jun
Caldera		All year	
Copiapó		All year	
Vallenar		All year	
La Serena		All year	
Ovalle		All year	
Quintero	6 Sep 31 May	18 Sep 15 Jun	30 Sep 30 Jun
Valparaíso		All year	
Santiago	16 Aug 14 May	30 Aug 29 May	13 Sep 3 Jun
Rancagua	8 Sep 23 Apr	18 Sep 9 May	28 Sep 25 May
San Fernando	12 Sep 29 Apr	19 Sep 3 May	26 Sep 7 May
Curicó	12 Sep 29 Apr	20 Sep 24 Apr	28 Sep 29 Apr
Constitución	14 Sep 27 May	22 Sep 9 Jun	30 Sep 22 Jun
Linares	14 Sep 24 Apr	20 Sep 5 May	26 Sep 16 May
Chillán	14 Sep 15 Apr	20 Sep 7 May	26 Sep 29 May
Concepción	18 Oct 16 May	24 Oct 22 May	30 Oct 28 May

(Continuation) Table 4

Localities	— 1 S	Mean	+ 1 S
Los Angeles	29 Sep	14 Oct	29 Oct
	14 Apr	21 Apr	28 Apr
Victoria	1 Nov	7 Nov	3 Nov
	30 Mar	14 Apr	29 Apr
Temuco	22 Oct	29 Oct	5 Nov
	30 Mar	14 Apr	29 Apr
Loncoche	25 Oct	31 Oct	6 Nov
	13 Apr	22 Apr	1 May
Valdivia	24 Oct	28 Oct	1 Nov
	14 Mar	25 Mar	5 Apr
Osorno	26 Oct	4 Nov	13 Nov
	14 Mar	25 Mar	5 Apr
Puerto Montt	26 Oct	14 Nov	3 Dec
	26 Mar	7 Apr	19 Apr
Ancud	31 Oct	23 Nov	16 Dec
	22 Mar	12 Apr	3 May
Castro	23 Oct	14 Nov	6 Dec
	18 Mar	31 Mar	13 Apr
Futaleufú	15 Dec	3 Dec	21 Dec
	18 Mar	25 Mar	1 Apr
Río Cisnes	19 Dec	1 Jan	14 Jan
	27 Jan	5 Feb	14 Feb
Puerto Aysén	21 Nov	8 Dec	25 Dec
	13 Mar	31 Mar	18 Apr
Coyhaique	3 Nov	13 Nov	23 Nov
	4 Mar	17 Mar	30 Mar
Balmaceda	30 Nov	13 Dec	26 Dec
	27 Jan	5 Feb	14 Feb
Chile Chico	25 Oct	31 Oct	6 Nov
	14 Mar	31 Mar	17 Apr
Cabo Raper	5 Dec	23 Dec	10 Jan
	25 Mar	8 Apr	22 Apr
Puerto Edén	13 Dec	22 Dec	31 Dec
	23 Feb	5 Mar	15 Mar

Cerro Guido	17 Dec 4 Jan	21 Dec 23 Jan	26 Dec 8 Feb
Punta Dungenes	13 Dec 31 Jan	28 Dec 17 Feb	11 Jan 6 Mar
Punta Arenas	26 Dec 3 Jan	7 Jan 16 Jan	19 Jan 29 Jan

Evangelistas is not included

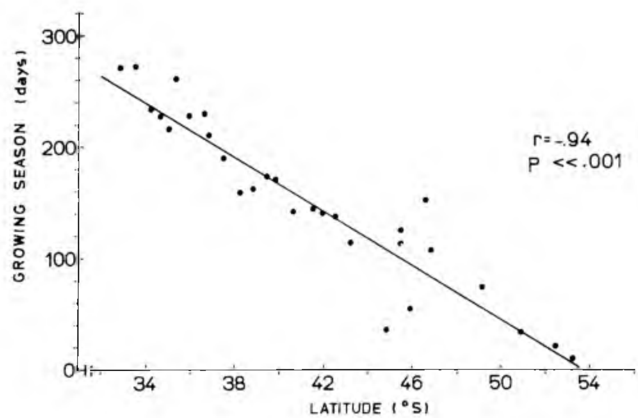


Fig. 4. Length of the growing season (base 10°C) as related to the latitude. For stations north of latitude 32, the growing season is 365 days.

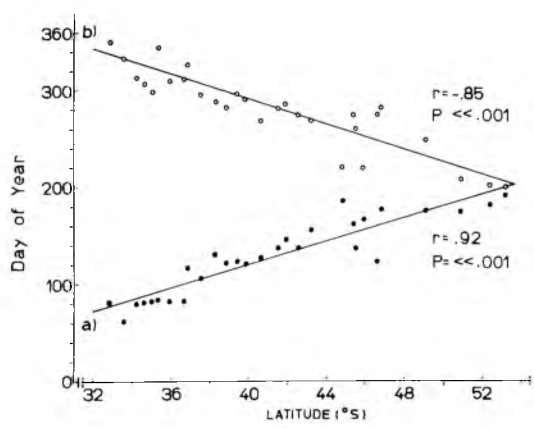


Fig. 5. Onset (a) and end (b) of the growing season (base 10°C) in relation to the latitude. First of July is day number 1 of the climatological year. North of latitude 32 the length of the growing season is 365 days.

The relation between latitude and accumulation of degree-days base 5° C in littoral and continental locations is expressed in Table 2 (h and i). The graphical representation of heat sum versus latitude for littoral and continental stations can be seen in Fig. 6.

In the computation of degree-days for continental stations Chile Chico and Potrerillos were not considered, since they deviate clearly from the general trend.

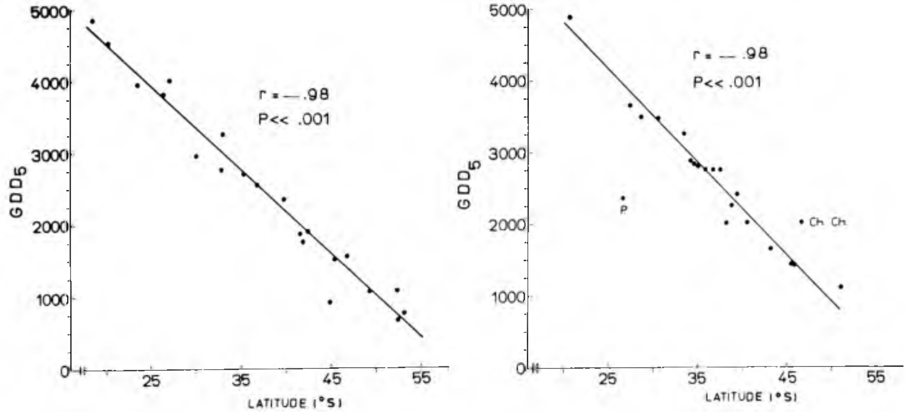


Fig. 6. (a) Growing-degree days base 5° C (GDD_5) in relation to the latitude for littoral stations.
(b) Growing-degree days base 5° C (GDD_5) in relation to the latitude for continental stations.
Potrerillos (P) and Chile Chico (Ch Ch) were not included in the determination of the regression line.

The accumulation, base 10° C (Fig. 7) for the littoral and continental stations relates to latitude by the equations appearing in Table 2 (j and k).

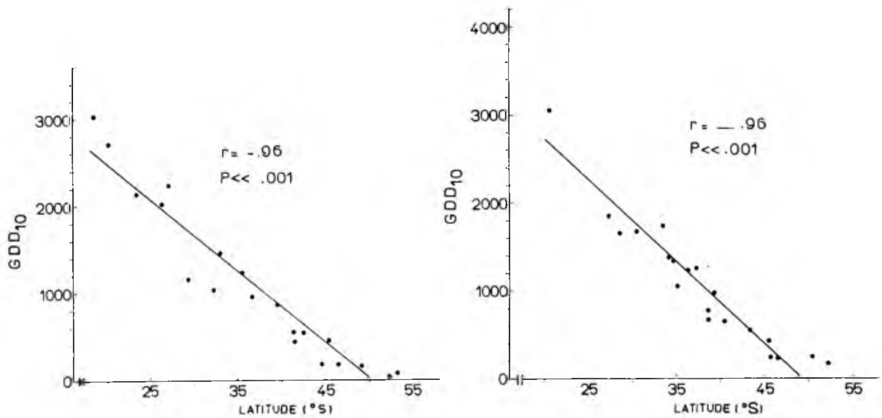


Fig. 7. (a) Growing-degree days base 10°C (GDD_{10}) in relation to latitude for littoral stations.
(b) Growing-degree days base 10° C (GDD_{10}) in relation to latitude for continental stations.

From these observations we can conclude that in Chile the onset, duration and end of the growing seasons, as also the accumulation of temperatures for different thresholds, are approximately linear functions of the latitude. However, there are some exceptions already mentioned in previous paragraphs that must be pointed out with further detail. These are locations with local climates, which makes them deviate strongly from the general latitudinal trends. These localities are, from north to south, Potrerillos, Valparaíso, Río Cisnes, Balmaceda and Chile Chico. In regard to Potrerillos, the reason for its divergence from the gradient seems to be related to its high altitude above sea level (2,850 m). Thermal excursions in Valparaíso are relatively small, and also the maximum temperatures are higher than other coastal localities. This would be due to local winds and upwelling phenomena of warmer sea currents in the Humboldt stream (Sievers and Silva, 1973; Silva, 1973) Río Cisnes shows lower values of the length of the growing season in relation to the gradient, probably related to its altitude (700 m) which for 44° latitude south in Chile is relatively high (IGM 1972). The same situation is observed further south, in Balmaceda (520 m). Chile Chico shows relatively higher values, which might be due to a "littoral effect" of Lake Carrera (di Castri and Hajek, 1976).

The annual course of temperatures shows a good adjustment to a cosine function for the analysed localities. Fig. 8 represents the distribution of mean temperatures (observed) for the climatological year, and the curve obtained by fitting the cosine function to data from some representative locations of Chile. Note the degree of adjustment between observed and calculated values. In all the cases, a X^2 test was used to determine the existence of significant differences between expected and observed values. Probabilities greater than 0.99 were obtained. The constants defining the cosine function for the analysed localities are shown in Table 5.

The constant a_0 decreases with increasing latitude, this relationship being similar to that obtained by Gutiérrez and Hajek (1979) in regard to maximum and minimum temperatures.

By knowing the seasonal course of temperatures it is possible to determine the amount of growing degree-days, as well as the onset, the end and consequently the extension of growing seasons in Chile by integrating the equations which define the temperature as a function of time. The following equation may be used for the calculations:

$$GDD = a_0 \int_{t_1}^{t^2} dt + A \int_{t_1}^{t^2} \cos (t - \emptyset) - t_b (t_2 - t_1)$$

where t is time in days and t_b is base temperature; t_1 and t_2 indicate the intercept points between the cosine curve and base temperature.

In Fig. 9 the values of accumulated degree-days, observed and predicted by this equation for some representative localities are shown. Table 6 shows the annual accumulated degree-days, bases 5°C and 10°C, observed and predicted by the cosine functions. No statistical differences between observed and predicted values were detected.

In Chile, despite the great existing diversity of physical environments, it is possible to establish meaningful relations between agriculturally important parameters and latitude. The onset and end of the growing seasons as well as the accumulation of temperatures change with the latitude.

On the other hand, it is possible to fit a cosine function to data for the different locations of this country, predicting the course of temperatures and consequently length of growing seasons and accumulated temperatures. So, by these means a direct practical use can be made for agricultural related activities or for avoiding tedious procedures in the calculations.

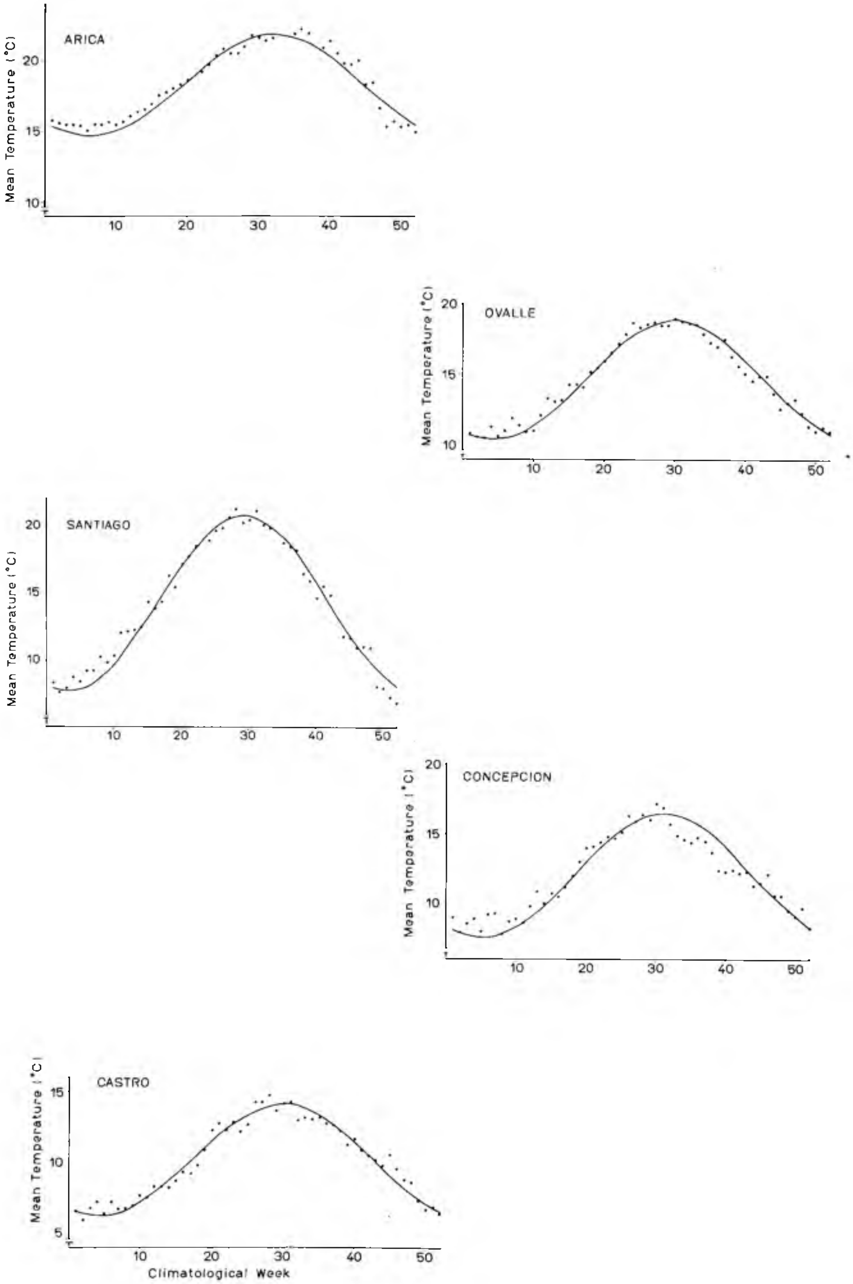


Fig. 8. Weekly mean temperatures observed (dots) and predicted (solid lines) by means of the cosine function for some selected stations. These are southwards: 1. Arica, 2. Ovalle, 3. Santiago, 4. Concepción, 5. Castro.

Table 5: Constants defining the cosine function for mean temperatures in Chilean localities.

Localities	a_0	A	Ø
Arica	18.30	3.6	224
Iquique	17.52	3.0	224
Pica	18.46	2.0	217
Antofagasta	15.88	3.6	224
Chañaral	15.53	3.9	217
Potrerillos	11.43	2.7	224
Caldera	16.25	4.0	294
Copiapó	15.04	4.2	217
Vallenar	14.63	4.2	203
La Serena	13.20	5.0	203
Ovalle	14.58	4.2	210
Quintero	12.64	3.5	217
Valparaíso	13.95	3.5	217
Santiago	14.18	6.5	203
Rancagua	12.88	6.5	210
San Fernando	12.70	6.5	203
Curicó	12.64	6.8	217
Constitución	12.50	4.0	217
Linares	12.54	6.5	210
Chillán	12.48	6.3	210
Concepción	12.03	4.5	217
Los Angeles	12.53	6.2	210
Victoria	10.35	5.5	210
Temuco	11.20	5.0	210
Loncoche	11.53	6.0	210

(Continuation) Table 5

Localities	a_0	A	Ø
Valdivia	11.40	4.6	210
Osorno	10.50	5.0	210
Puerto Montt	10.03	4.5	210
Ancud	9.78	4.0	210
Castro	10.16	4.0	210
Futaleufú	9.00	6.0	210
Río Cisnes	5.98	6.0	210
Puerto Aysén	9.18	4.7	210
Balmaceda	6.50	6.0	210
Chile Chico	10.13	6.2	203
Cerro Guido	6.70	5.5	210
Evangelistas	6.53	2.4	210
Punta Dungenes	7.45	5.0	196
Punta Arenas	5.80	4.8	217

Mean temperature $= a_0 + A \cos (t - \varnothing)$
Coyhaique, Cabo Raper and Puerto Edén are not included.

Table 6: Annual accumulated degree-days, bases 5°C and 10°C, observed and predicted by the cosine function for Chilean localities.

	Base 5°C		Base 10°C	
Localities	Observed	Predicted	Observed	Predicted
Arica	4858	4830	3026	3010
Iquique	4490	4548	2642	2728
Pica	4895	4893	3072	3073
Antofagasta	3951	3950	2125	2130
Chañaral	3833	3820	2008	2000
Potrerillos	2370	2332	816	602

(Continuation) Table 6

Localities	Base 5°C Observed	Base 5°C Predicted	Base 10°C Observed	Base 10°C Predicted
Caldera	4087	4101	2262	2281
Copiapó	3651	3641	1696	1821
Vallenar	3493	3490	1696	1670
La Serena	2962	3115	1188	1279
Ovalle	3481	3472	1690	1652
Quintero	2743	2769	1006	997
Valparaíso	3262	3246	1449	1426
Santiago	3335	3317	1706	1657
Rancagua	2884	2845	1370	1338
San Fernando	2825	2779	1340	1296
Curicó	2809	2759	1315	1314
Constitución	2722	2717	1022	1001
Linares	2774	2722	1267	1260
Chillán	2741	2700	1229	1225
Concepción	2547	2544	940	934
Los Angeles	2752	2719	1228	1226
Victoria	2005	1931	736	694
Temuco	2269	2239	795	805
Loncoche	2405	2356	920	985
Valdivia	2259	2314	742	798
Osorno	2016	1984	652	665
Puerto Montt	1867	1815	530	521
Ancud	1744	1726	413	419
Castro	1885	1864	516	487
Futaleufú	1642	1567	557	517

(Continuation) Table 6

Localities	Base 5°C Observed	Base 5°C Predicted	Base 10°C Observed	Base 10°C Predicted
Río Cisnes	901	873	194	125
Puerto Aysén	1620	1524	457	399
Balmaceda	1003	979	216	178
Chile Chico	2022	1895	797	734
Cerro Guido	1101	966	262	153
Evangelistas	645	605	7	0
Punta Dungenes	1072	1091	183	193
Punta Arenas	751	701	79	23

Coyhaique, Cabo Raper and Puerto Edén are not included.

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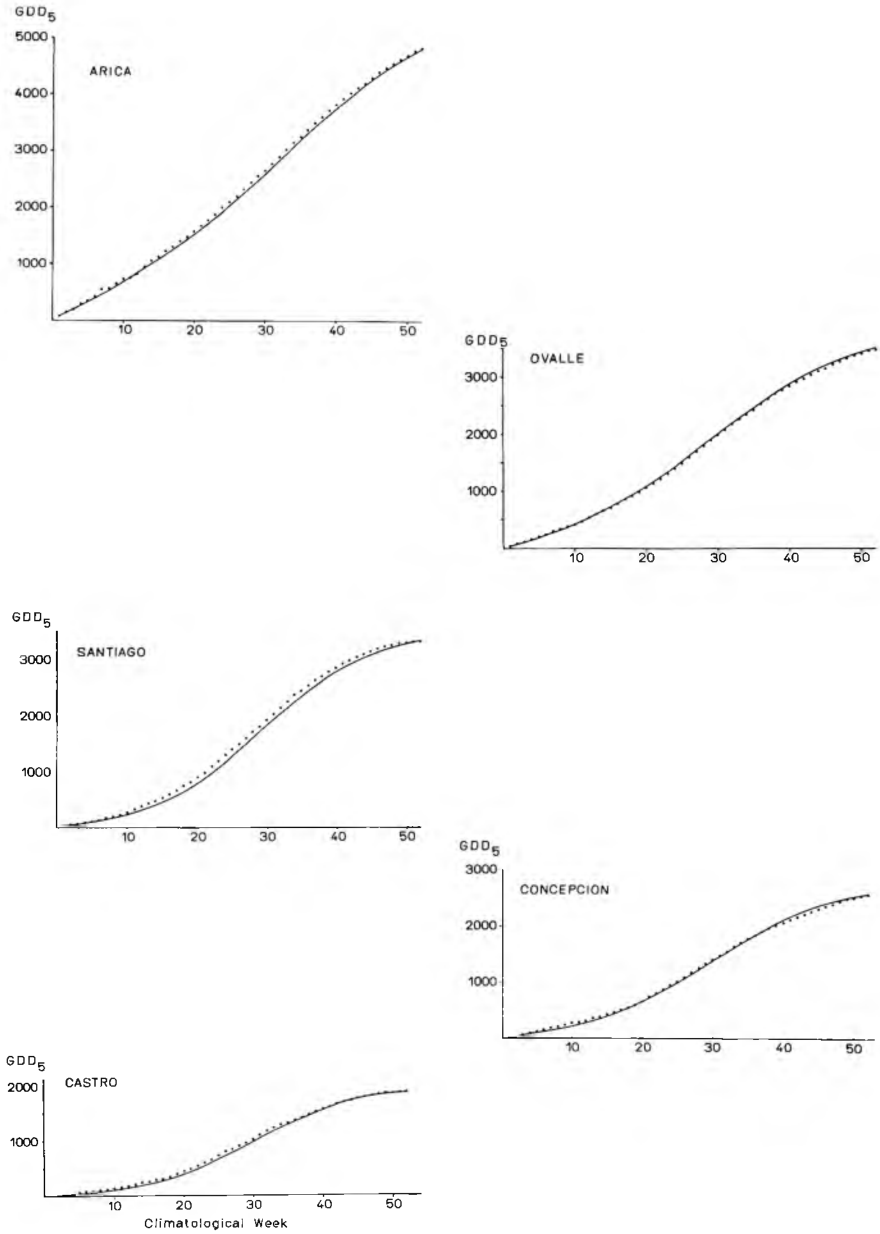

Fig. 9. Observed (dots) and predicted (solid line) growing-degree days base 5° C(GDD_5) for some selected stations. These are southwards: 1. Arica, 2. Ovalle, 3. Santiago, 4. Concepción, 5. Castro.

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