2. CLIMATE

The following information has been largely derived from publications of the Commonwealth Bureau of Meteorology "Climatic Survey Region 10 - Port Phillip" (1968) and "Rainfall Statistics of Victoria" (1966).

Rainfall

Average annual rainfall is given in Figure 3. The isohyets show an increase in rainfall to the north-west near Mt. Macedon (855 mm) and to the north-east around Kinglake (1200 mm). The dryest area is in the south-west.

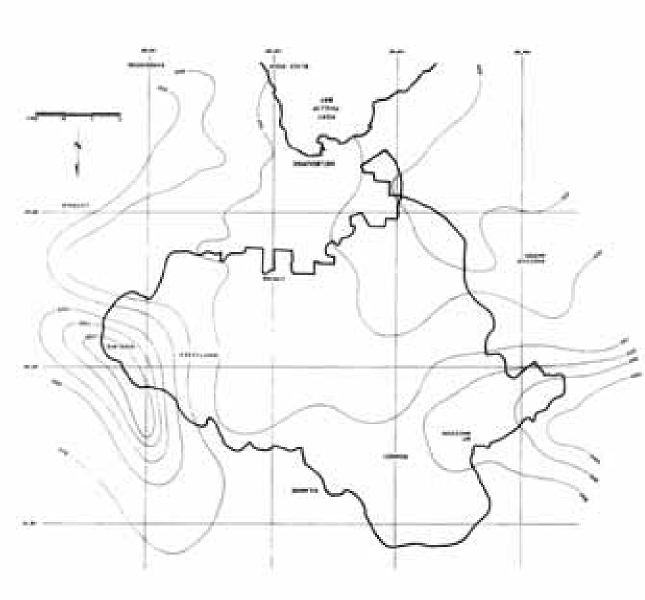

Figure 3 - Isohyets maps showing average annual rainfall.

The rainfall distribution throughout the year, at selected stations, is shown in Table 1. The rainfall is rather evenly distributed over the year.

Table I - Mean Monthly and Annual Rainfall - All years of records at each station to 1963 inclusive (mm)

(After : Climatic Survey Region 10 - Port Phillip, Victoria)

	No. of Years	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Year
ARTHURS CREEK	17	46	42	67	46	66	66	53	58	83	67	58	57	709
ARUNDEL	71	40	41	44	46	44	41	39	41	54	55	46	47	537
GISBORNE	40	45	56	49	61	70	69	69	74	78	76	67	51	765
GREENSBOROUGH	52	52	46	59	63	53	56	54	53	60	70	57	62	685
GREENVAIE	19	46	53	47	51	49	45	38	53	63	61	60	61	627
KINGLAKE	59	73	76	83	104	108	114	110	112	108	119	105	96	1208
LAVERTON	38	34	48	35	51	41	40	42	41	44	55	48	43	522
MELBOURNE	108	48	48	54	58	56	52	49	49	59	69	59	58	659
MICKLEHAM	60	47	51	49	51	55	52	51	53	66	73	59	53	660
MT. MACEDON	61	50	53	59	66	79	97	84	86	85	79	60	58	856
ST. ALBANS	40	35	37	48	40	39	43	42	40	50	51	46	43	514
SUNBRY	84	43	46	48	50	48	47	42	46	58	64	53	48	593
SYDENHAM	33	39	49	50	56	42	38		4'43	53	67	56	45	575
TOOLERN VALE	20	42	55	36	67	41	45	40	43	44	67	63	52	595
TOOROURRONG	71	55	56	70	64	69	68	65	71	76	84	67	65	839
WALLAN	72	43	48	50	55	59	62	54	61	65	68	57	52	674
WHITTLESEA	56	45	55	52	57	59	55	55	60	64	78	64	60	703
YAN YEAN	108	46	46	50	56	56	53	50	56	62	70	59	54	658

Temperature

Data for temperature is shown in Table II for maximum, minimum and mean values. The trend is for temperatures to increase towards the south-west.

Table II - Monthly maximum, minimum and mean temperature values (0 Celsius) for selected stations

(After : Climatic Survey Region 10 - Port Phillip, Victoria)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Year
Bacchus Marsh (Elevation 104 m) Means : 30 Years to 1940; Extremes : 54 Years to 1952													
Mean Monthly & Annual Maximum Temperature	28.7	29.0	26.2	21.5	17.8	15.2	14.8	16.2	18.8	22.1	24.8	27.4	21.9
" Minimum	11.4	12.0	10.1	7.5	5.2	3.5	3.0	3.6	4.7	6.6	8.5	10.6	7.2
Mean ½ (Max + Min) Monthly and Annual Temperature	20.1	20.5	18.1	14.5	11.5	9.3	8.9	9.9	11.7	14.3	16.7	19.0	14.6
Macedon Upper (Elevation 900 m) - 21 Years between 1887 and 1936													
Mean Monthly & Annual Maximum Temperature	21.9	22.1	19.5	14.6	10.6	7.4	6.7	8.2	11.5	15.1	18.2	21.2	14.8
Minimum	11.2	12.0	10.2	7.8	5.7	3.7	2.7	3.2	4.8	6.6	8.2	10.1	7.2
Mean ½ (Max + Min) Monthly and Annual Temperature	16.6	17.1	14.8	11.2	8.2	5.6	4.7	5.7	8.2	10.6	13.2	15.7	11.0
MELBOUNNE (Elevation 35 m) - 109 Years to 1964													
Mean Monthly & Annual Maximum Temperature	25.8	25.6	23.7	20.1	16.4	13.8	13.2	14.8	17.2	19.5	21.9	24.2	19.7
Minimum	13.8	14.1	12.7	10.4	8.2	6.7	5.6	6.3	7.6	9.1	10.7	12.5	9.8
Mean ½ (Max + Min) Monthly & Annual Temperature	19.8	19.8	18.2	15.2	12.3	10.2	9.4	10.6	12.3	14.3	16.3	18.3	14.7
WERRIDEE (Elevation 23 m) - 41 Years to 1955													
Mean Monthly'& Annual Maximum Temperature	25.7	25.3	23.3	19.6	16.5	13.7	13.3	14.6	17.0	19.4	21.7	24.4	19.5
Minimum	12.7	13.2	11.6	9.3	7.0	5.2	4.5	4.9	6.0	7.7	9.4	11.6	8.6
Mean ½ (Max + Min) Monthly Annual Temperature	19.2	19.2	17.4	14.4	11.7	9.4	8.9	9.7	11.5	13.6	15.6	18.0	14.1

Potential Evapotranspiration

Potential evapotranspiration is commonly defined as 80% of the evaporation from a free water surface and is an estimate of the amount of moisture lost by evaporation and transpiration from a fully vegetated area where soil moisture is not limiting.

No evaporimeters in the area have been read for long enough to be of value in calculating potential evapotranspiration, consequently approximations using Leeper's modification of Thornthwaite's formula (1950) have been used instead. See Table III.

The relationship between rainfall and potential evapotranspiration throughout the year for selected stations is graphed in Figures 4-8. The crossover points on the graphs mark the beginning and end of the growing season and the area enclosed by the two lines is a measure of the excess of rainfall over evapotranspiration. The graphs clearly illustrate the shorter growing seasons and drier conditions in the south-west.

Recently, results of measurements of evaporation from a free water surface using a Class A pan have become available. In Figure 9. they are graphed and compared to the potential evapotranspiration values of some stations in or near the study area. It is apparent that for the cool rainfall stations the agreement between measured (Ev) and calculated (PEt) values is quite good. In the case of warm and low rainfall stations, the measured evaporation consistently exceeds the calculated value by a factor of two or more. According to the measured values for the NNBW station at Werribee, there is no month in which the precipitation exceeds the evapotranspiration. This does not mean that no vegetative growth is possible but it implies that under average conditions continuous growth is possible only if irrigation water is applied as soon as the water from the previous rainfall is reaching exhaustion.

It can be concluded that while Class A pan evaporation is not necessarily identical to a real potential evapotranspiration, it may in certain locations be a better guide to it than values calculated from a formula based on many assumptions. Table III should be interpreted with due reserve.

Table III - Calculated potential evapotranspiration values in mm

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Year
HEALESVILLE	94	82	73	48	33	20	19	28	38	54	69	86	644
IA.NCEFIELD	101	86	71	42	27	17	16	21	32	49	69	90	621
MACEDON	91	79	66	41	27	16	14	19	30	35	64	85	567
MELROU8RE	104	92	91	54	39	26	26	34	44	62	76	97	734
MT. ST. LEONARD	94	79	67	45	27	18	17	21	28	46	56	76	574
WERRIHEE	102	88	77	52	36	25	24	30	41	58	73	95	701

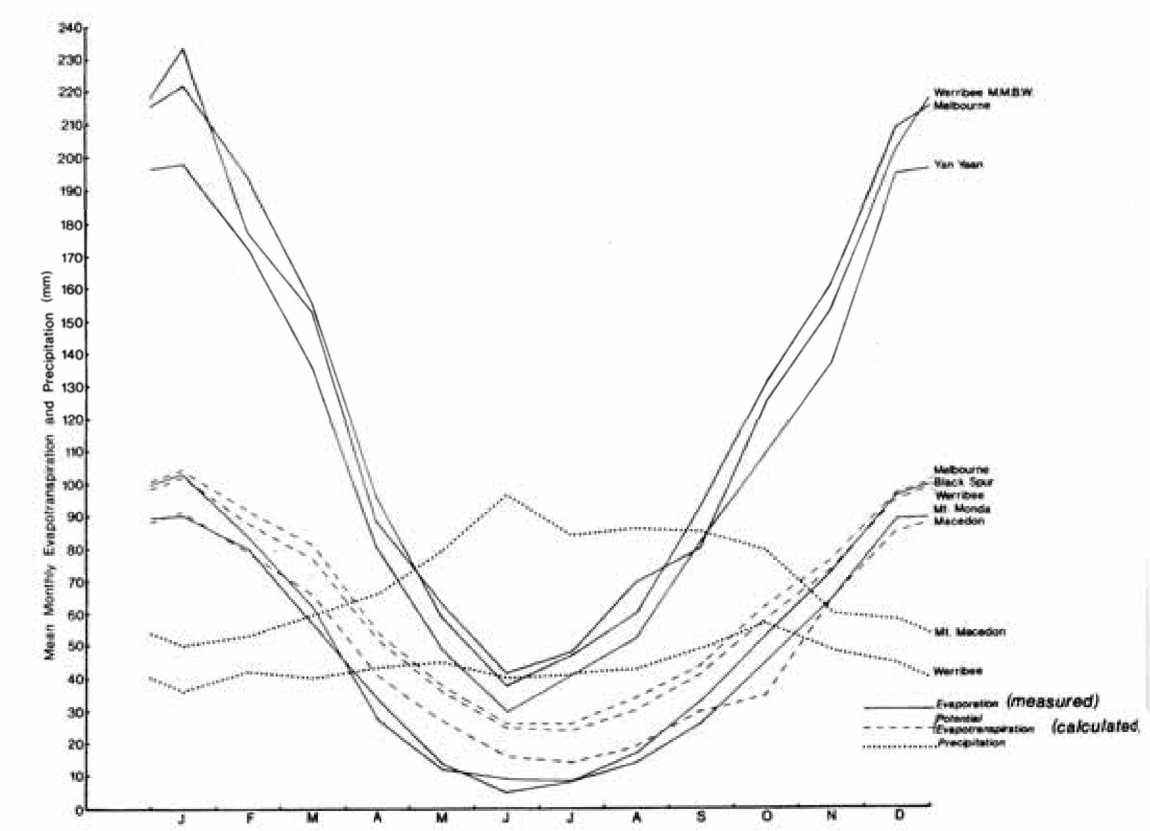

Figure 9 - Comparison of measured evaporation and calculated potential evapotranspiration for some selected stations.

Effective Rainfall

Effective rainfall, defined as the minimum amount of rain necessary to start germination and maintain growth above the wilting point, is calculated by the formula below. (Prescott 1949).

$$P = 13.72\ E^{0.7}$$

where P is the effective rainfall in mm/Month
E is the evaporation from a free water surface in mm/month.

The probability of receiving at least the effective rainfall in each month is shown in Table IV.

Table IV - Effective Rainfall - Probabilities

Probabilities (%) of receiving at least the effective amount of rainfall
(After : Climatic Survey Region 10 - Port Phillip, Victoria)

STATION	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
ARUNDEL	26	34	39	70	78	95	93	85	82	74	48	43
GREENNSBOROUGH	46	41	62	69	93	99	97	94	94	87	62	55
KILMORE	22	23	51	71	89	100	99	99	95	77	49	40
KINGLAKE	69	68	73	95	98	100	100	100	99	93	95	76
MELBOURNE	36	38	57	78	94	99	99	95	93	85	63	55
MT. MACEDON	44	47	51	92	96	100	100	99	99	95	70	58
SUNBJRY	31	39	49	73	84	97	97	94	89	81	58	43
WHITTLESEA	38	45	54	75	92	100	100	96	95	90	68	50
YAN YEAN	36	39	52	75	95	100	100	95	96	33	68	52

Snow

Snowfalls are generally restricted to the most elevated parts, such as Mt. Macedon and Kinglake area. Snow in the lowlands is very unusual, however two snowfalls in the region were recorded on the 19th July 1951 and on the 9th of August of the same year.

The main snow season is from June to September.

Frost

The occurrence of frost depends not only on the temperature and the humidity of the air, wind speed and cloudiness, but also on the surface of the ground, its slope and the slopes of nearby surfaces, its vegetation cover and water content. The susceptibility to frost of a particular piece of ground is peculiar to the site, so much so that the first step in frost protection in a region is site selection.

The frequency of temperatures falling to, or below, 0°C increases with distance from the coast. Frosts may occur as seldom as five times a year near the coast whereas in the higher country there may be as many as six light frosts per month in winter.

Frost data is given in Table V.

Table V - Occurrence of frosts as indicated by screen temperatures

(Average Number of days per month and year)

Source: Climatic Survey Region 10 - Port Phillip, Victoria (1968)

Light frost - screen minimum 2.2°C or lower but not as low as 0°C
Heavy frost - screen minimum 0°C or lower

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Year
BACCHUS MARSH 1943 TO1952		**ELEVATION 104 m**											
All frosts	..	0.1	0.2	1.9	6.1	12.8	10.3	11.2	7.0	2.6	0.3	..	52.5
Light frosts	..	0.1	0.2	1.8	3.8	7.2	5.2	5.2	4.9	2.0	0.3	..	30.7
Heavy frosts	..	..	..	0.1	2.3	5.6	5.1	6.0	2.1	0.6	..	..	21.8
BALLAN 1944 TO 1964.	**ELEVATION 442 m**												
All frosts	1.7	0.6	1.5	3.0	.6.0	9.7	12.9	11.3	8.7	4.7	2.5	0.9	63.5
Light frosts	1.5	0.6	1.3	2.6	4.1	5.7	7.1	7.5	6.[1]	4.0	1.9	0.9	43.3
Heavy frosts	0.2	..	0.2	0.4	[1].9	4.0	5.8	3.8	2.6	0.7	0.6	..	20.2
DURDIDWARRAH 1943 TO 1959		**ELEVATION 327 m**											
All frosts	..	..	0.1	0.7	3.4	7.1	9.4	8.3	5.8	1.8	0.3	0.1	37.0
Light frosts	..	..	0.1	0.7	3.0	4.2	5.6	6.2	4.6	'.6	0.3	0.1	26.4
Heavy frosts	..	..	..	..	0.4	2.9	3.8	2.1	1.2	0.2	..	..	10.6
ESSENDON 1944 TO 1964.	**ELEVATION 79 m**												
All frosts	..	..	..	..	0.8	3.5	5.0	4.4	2.1	0.4	0.1	..	16.3
Light frosts	..	..	..	..	0.8	2.7	3.4	3.4	1.8	0.4	0.1	..	12.6
Heavy frosts	..	..	..	..	..	0.8	1.6	1.0	0.3	..	..	..	3.7
LAVERTON 1944 TO 1964.	**ELEVATION 14 m**												
All frosts	..	..	..	0.3	1.7	4.1	6.4	5.[1]	2.8	0.[1]	3.1	..	20.6
Light frosts	..	..	..	0.3	1.5	2.6	4.3	3.7	2.3	..	0.1	..	14.8
Heavy frost	..	..	..	..	0.2	1.5	2.1	1.4	0.5	0.'	..	..	5.6
MELBOURNE 1944 TO 1964.	**ELEVATION 35 m**												
All frosts	..	..	..	..	0.3	2.4	3.1	2.3	0.7	..	..	..	8.8
Light frosts	..	..	..	..	0.3	2.3	2.5	2.0	0.7	..	..	••	7.8
Heavy frosts						0.1	0.6	0.3			..	..	1.0
WERRIBEE 1943 TO 1959.	**ELEVATION 23 m**												
All frosts	..	..	..	0.6	3.2	7.3	8.3	7.6	5.0	1.6	0.2	..	33.8
Light frost	..	..	..	0.5	2.3	4.8	5.6	5.2	3.7	1.3	0.2	..	23.6
Heavy frosts	..	..	..	0.1	0.9	2.5	2.7	2.4	1.3	0.3	..	..	10.2

Climate of Individual Land Systems

Due to the fact that in the survey area there are only five meteorological stations for which data on rainfall and temperature are available, the polygon system (Theissen, 1911) has been adopted to characterise the climate for each land system. By this method it is inferred that the rainfall, temperature and evapotranspiration of all the landsystems in each polygon will be the same as the meteorological station of that polygon.

The temperature figures have been refined further by subtracting 1°C per 100 m increase in elevation (Byers, 1959).

It must be remembered that these results are generalizations and that the actual characteristics of specific areas may differ. However, it is considered that in the absence of extensive data, this is the most appropriate way to achieve a description of the climate of individual land systems.
Effects of Climate on Plant Growth

The rate of growth of agricultural crops, and in particular that of pasture species, is dependent on the moisture supply, nutrient supply, temperature and the amount of light received throughout the year. The growth factors of moisture and temperature are considered in more detail in Figures 4 - 8. Moisture supply over time is not characterized exclusively by the amount of rainfall and its distribution over the year, but also by the amount of moisture that is stored at any one moment in the soil beneath the crop. The horizontal bars showing growth patterns at the bottom of Figures 4 - 8 have been worked out for three assumed soil moisture storage capacities, 50 mm, 100 mm and 150 mm.

For Mt. Macedon (Figure 4), the precipitation starts to exceed the potential evapotranspiration in the last half of March, as shown by the crossing over of the two curves. From this moment on, the excess precipitation can be assumed to replenish the moisture stored in the soil. In the case of a moisture storage capacity of 50 mm, the soil can be "full" when the cumulative excess reaches the 50 mm level, which at Mt. Macedon occurs on the average around the middle of May. Subsequent excess precipitation drains away.

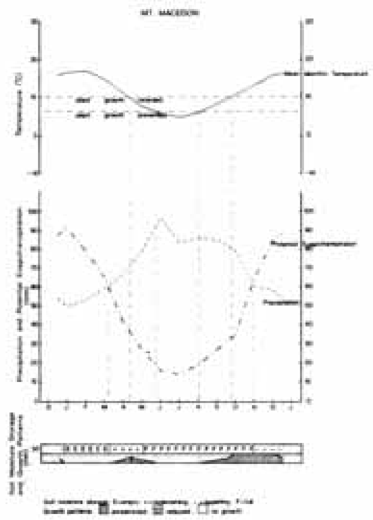

Figure 3 – Patterns of growth at Mt Macedon, as influenced by rainfall, potential evapotranspiration, temperature and soil moisture storage

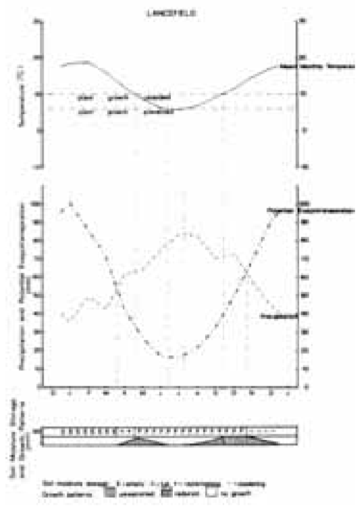

Figure 4 – Patterns of growth at Mt Macedon, as influenced by rainfall, potential evapotranspiration, temperature and soil moisture storage

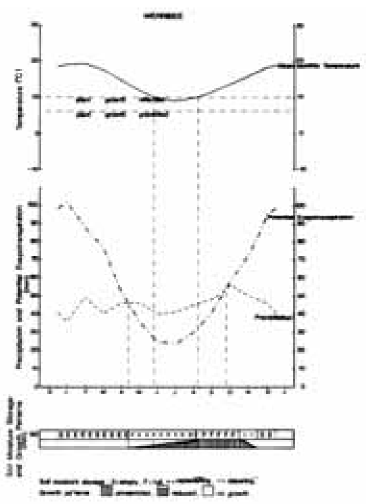

Figure 5 – Patterns of growth at Mt Macedon, as influenced by rainfall, potential evapotranspiration, temperature and soil moisture storage

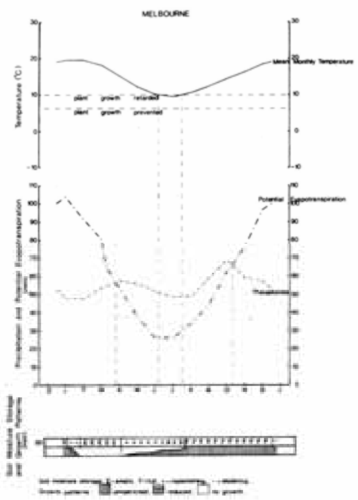

Figure 6 – Patterns of growth at Mt Macedon, as influenced by rainfall, potential evapotranspiration, temperature and soil moisture storage

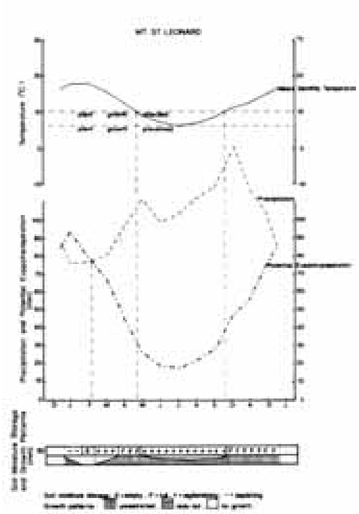

Figure 7 – Patterns of growth at Mt Macedon, as influenced by rainfall, potential evapotranspiration, temperature and soil moisture storage

This follows from an inspection of the differences between monthly rainfall and evapotranspiration in Tables I and III. The storage remains full until the end of October, when the precipitation curve dips below the evapotranspiration curve. The precipitation deficit causes depletion of the stored moisture in the soil, and by adding up the figures for this deficit it can be seen that by mid-January all the available water has been used up.

In this manner, an approximate plot of water availability can be constructed. By superimposing the period when low temperatures restrict or stop growth (assumed to be at average monthly temperatures of respectively 10°C and 6°C), plant growth patterns can be deduced.

The effect of soil moisture storage capacity on the length of the period of active plant growth is quite pronounced. By comparing the three soil moisture storage bars and the derived growth patterns, it is clear that as more moisture can be stored in the soil, the shorter becomes the period that the storage is empty. If 150 mm of water can be stored in the soil, there is never a period in an average year when moisture is restricting growth.

The procedure employed in drawing up the growth patterns is of necessity based on a simplification of a more complex natural phenomenon. However, it does enable one to compare different localities in terms of plant growth potential. The graphs for Mt. Macedon, Lancefield, Werribee, Melbourne and Mt. St. Leonard (Figures 4-8) allow such comparisons for the study area. For example, at 50 mm soil moisture storage, the growing period at Werribee is only three months compared with Mt. St. Leonard which has a growing period of nine months.

The length of the growing season for many horticultural crops is determined by the length of the period of frost-free days between the average date of the last frost in spring and the average date of the first frost in autumn. Some horticultural crops such as tomatoes are killed outright by a frost during their growing period, but in others damage can be caused by a killing of the flowers and a resultant reduction of fruit set. The median dates on which the temperature first falls to 2.2°C (light frost) or 0^{0}C (heavy frost) at Werribee are May 12th and June 11th respectively.

The median dates for the last heavy frost and light frost in the year at the same location are respectively October 27th and November 6th. For a very frost-sensitive crop, the growing season thus runs from November 6th to May 12th, a period of 176 days. By comparison, at Melbourne the growing season starts about two weeks earlier and lasts more than three weeks longer, for a total of 226 days. At higher elevations and in places where cold air ponding occurs, frosts could occur during most months of the year.