NSW GOVERNMENT Department of Primary Industries

primefact

Calculating heat units for citrus

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Plant and insect growth rate depends on the amount of heat they receive. Assuming no other factors (such as water) are limiting, there is an optimum temperature range for growth for each species. For citrus, the optimum temperature range for growth is 13–35 °C. The hours of heat within this range are referred to as heat units or growing degree days (GDD).

Heat units can be used to assess the suitability of a region for growing citrus, for estimating the length of phenological (growth) stages and predicting fruit maturity times.

It is also equally important to determine the incidence of cold temperatures (< –2 °C) and frosts when assessing an area for growing citrus. For oranges, root, shoot and fruit growth and development slow considerably below 13 °C (Bevington and Castle 1986). This value is then treated as the crop threshold and temperatures below it are discounted when calculating heat units.

The most common method for calculating heat units involves adding the maximum and minimum temperatures and dividing the total by two to obtain a daily average. The crop threshold for citrus of 13 is then subtracted from this average (Equation 1). The final value then represents the daily heat units useful for crop growth.

Results are then added to determine the accumulated weekly, monthly or yearly heat units. When calculating daily heat units, all results below zero (negative results) are not used and all maximum temperatures above 35 °C (≥ 35.1) are changed to 35. An example of how to calculate heat units using both winter and summer temperatures is in Table 1 and Table 2. This information can also be used to generate heat unit maps (Figure 1).

In Australia, accumulated heat units are often reported for the phenological (growth) period from bud break to harvest or annually from July to June to reflect the fruit growing season in the southern hemisphere. Table 3 and Figure 2 summarise the main phenological stages for citrus.

$$\text{Daily heat units} = \frac{(\text{maximum temperature} + \text{minimum temperature})}{\div\ 2} - 13$$

Equation 1. Calculating heat units for crop growth.

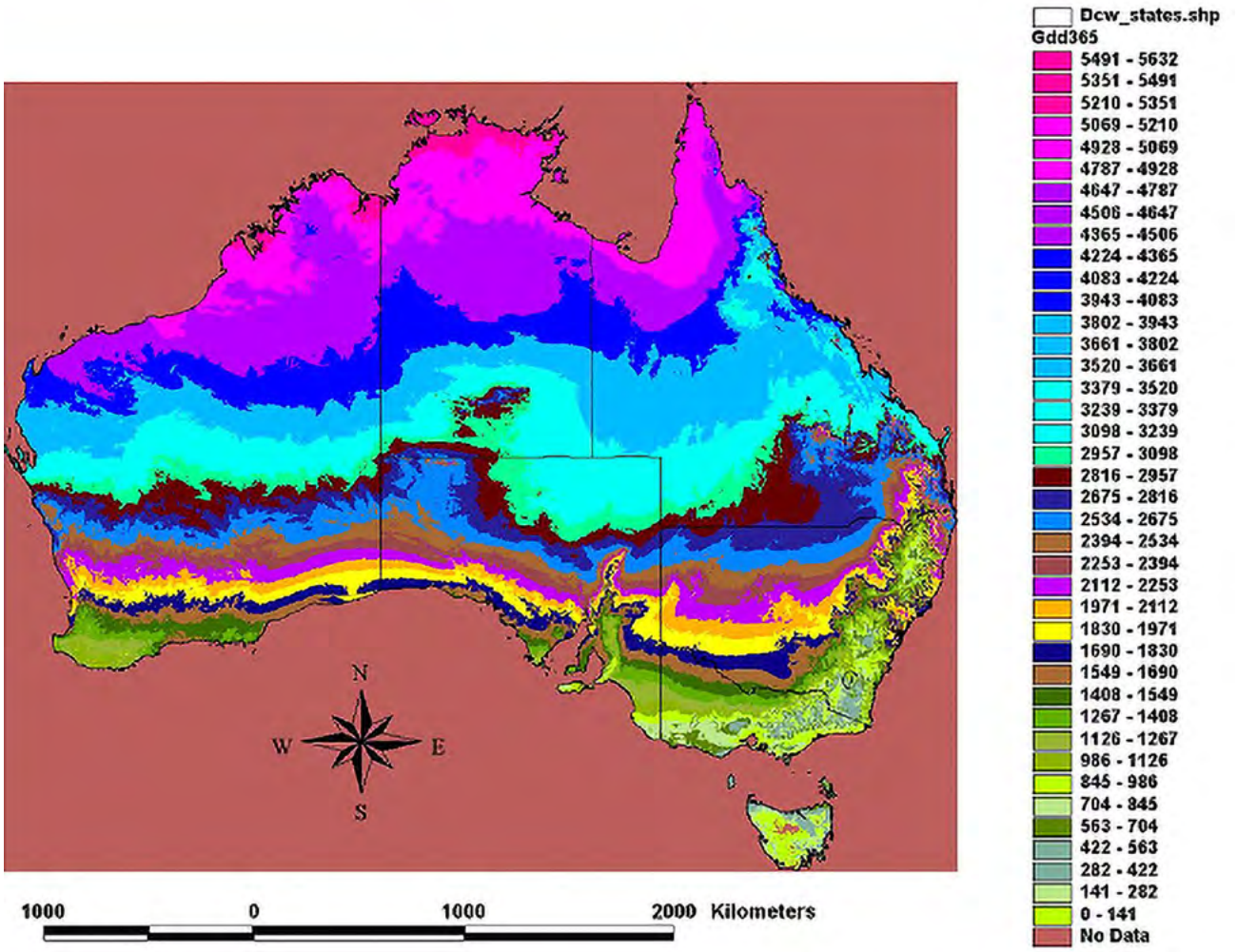

Figure 1. Map depicting various heat unit categories in Australia.

Table 1. Example heat unit calculations for winter temperatures.

Date	Max temp (°C)	Recalculated max temp (for temps > 35°C)	Min temp (°C)	Average temp (max + min ÷ 2)	Daily heat units (DHU) (average temp – base temperature of 13)	Accumulated heat units (negative values for DHU are not used)
1	11	11	4	7.5	-5.5	0
2	14	14	4	9.0	-4.0	0
3	14	14	3	8.5	-4.5	0
4	10	10	-2	4.0	-9.0	0
5	12	12	-1	5.5	-7.5	0
6	13	13	2	7.5	-5.5	0
7	15	15	4	9.5	-3.5	0
8	15	15	5	10.0	-3.0	0
9	16	16	6	11.0	-2.0	0
10	14	14	5	9.5	-3.5	0

Table 2. Example heat unit calculations for summer temperatures.

Date	Max temp (°C)	Recalculated max temp (for temps > 35°C)	Min temp	Average temp (max + min ÷ 2)	Daily heat units (DHU) (average temp – base temperature of 13)	Accumulated heat units (negative values for DHU are not used)
1	34	34	20	27.0	14.0	14.0
2	38	35	21	28.0	15.0	29.0
3	38	35	22	28.5	15.5	44.5
4	40	35	22	28.5	15.5	60.0
5	37	35	20	27.5	14.5	74.5
6	36	35	20	27.5	14.5	89.0
7	35	35	19	27.0	14.0	103.0
8	35	35	20	27.5	14.5	117.5
9	35	35	21	28.0	15.0	132.5
10	36	35	22	28.5	15.5	148.0

Table 3. Phenological (growth) stages of citrus.

Time (approximate)	Growth stage	Development phase
Mid-May to July	Floral induction and initiation	Transition of resting buds to floral buds
July/August to mid-September	Bud break/pre-bloom	Bud break and inflorescence development
Mid-September to October	Flowering	Flowering and initial fruit set
November to December	Stage 1 fruit growth	Fruit cell division and physiological fruit drop
January to April	Stage 2 fruit growth	Fruit cell expansion
May onwards	Maturation	Fruit maturity and harvest

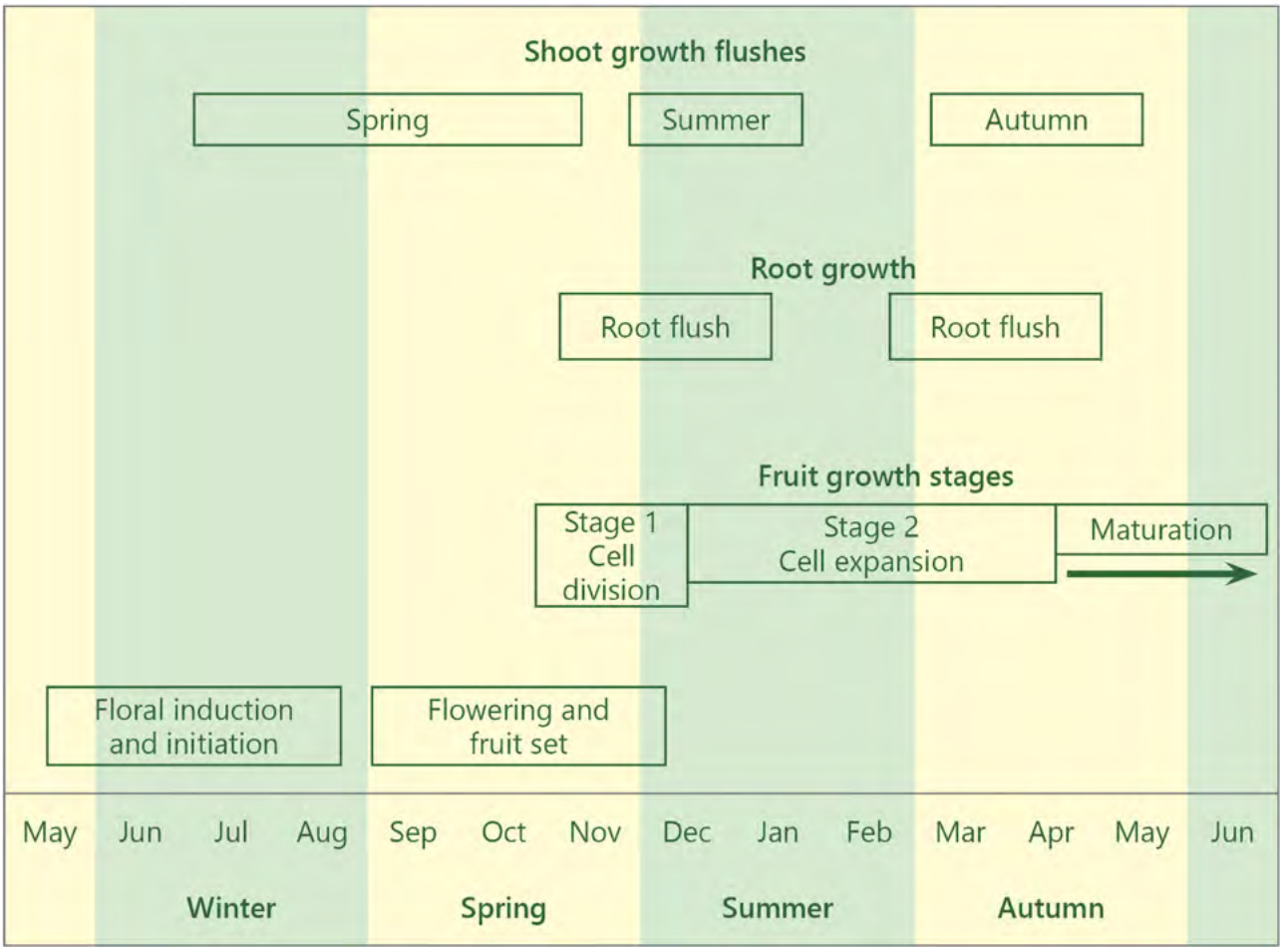

Figure 2. The citrus phenological cycle.

More information

Khurshid T and Hutton RJ (2005) Heat unit mapping – a decision support system for selection and evaluation of citrus cultivars, Acta Horticulturae, 694: 265–269.

Bevington KB and Castle WS (1986) Annual root growth pattern of young citrus trees in relation to shoot growth, soil temperature and soil water content, Journal of the American Society for Horticultural Science, 110(6): 840–845.

Bevington K, Hardy S, Meville P, Thiel K Fullelove G and Morrish P (2003) Fruit size management guide, part 1, an Australian Citrus Growers publication.

Acknowledgements

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