

# Calculating heat units for citrus

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The growth rate of both plants and insects depends on the amount of heat they receive. For each species there is an optimum temperature range for growth, if no other factors (such as water) are limiting. For citrus the optimum temperature range for growth is commonly considered to be 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 in citrus to assess the suitability of a region for growing citrus, for estimating the length of phenological (growth) stages and for predicting fruit maturity times. NB. It is also equally important to determine the incidence of very cold temperatures (< -2°C) and frosts when assessing an area for growing citrus.

For oranges, root, shoot and fruit growth and development slows considerably below 13°C (Bevington and Castle, 1986). This value is then treated as the crop threshold and temperatures below 13°C are discounted when calculating heat units.

Table 1. Example Heat Unit calculations for both winter and summer temperatures.

Date	Max temp	Recalculated max temp (for temps above 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)
<b>Example winter temperatures</b>						
1	11	11	4	7.5	-5.5	0
2	14	14	4	9	-4	0
3	14	14	3	8.5	-4.5	0
4	10	10	-2	4	-9	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	-3	0
9	16	16	6	11	-2	0
10	14	14	5	9.5	-3.5	0
<b>Example summer temperatures</b>						
1	34	34	20	27	14	14
2	38	35	21	28	15	29
3	38	35	22	28.5	15.5	44.5
4	40	35	22	28.5	15.5	60
5	37	35	20	27.5	14.5	74.5
6	36	35	20	27.5	14.5	89
7	35	35	19	27	14	103
8	35	35	20	27.5	14.5	117.5
9	35	35	21	28	15	132.5
10	36	35	22	28.5	15.5	148



Table 2. 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

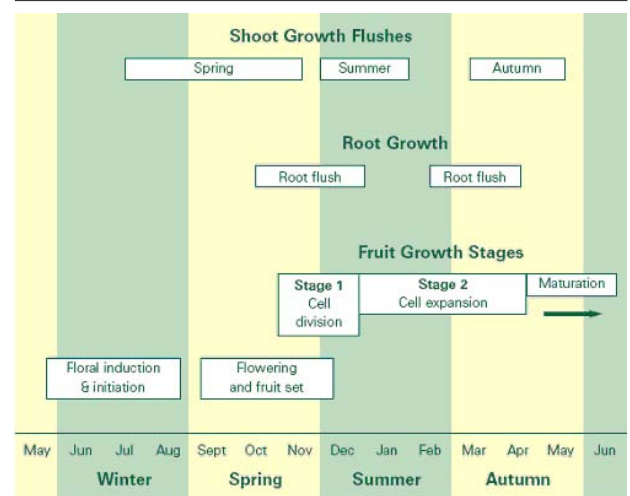
There are several methods used to calculate Heat Units. The most common method is relatively straight forward. The heat accumulated each day is determined by adding together the maximum and minimum temperatures and dividing the total by two to obtain a daily average. The crop threshold for citrus of 13 is then subtracted from this average. The final value then represents the daily heat units useful for crop growth.

$$\text{Daily Heat Units} = [(\text{maximum temperature} + \text{minimum temperature}) \div 2] - 13$$

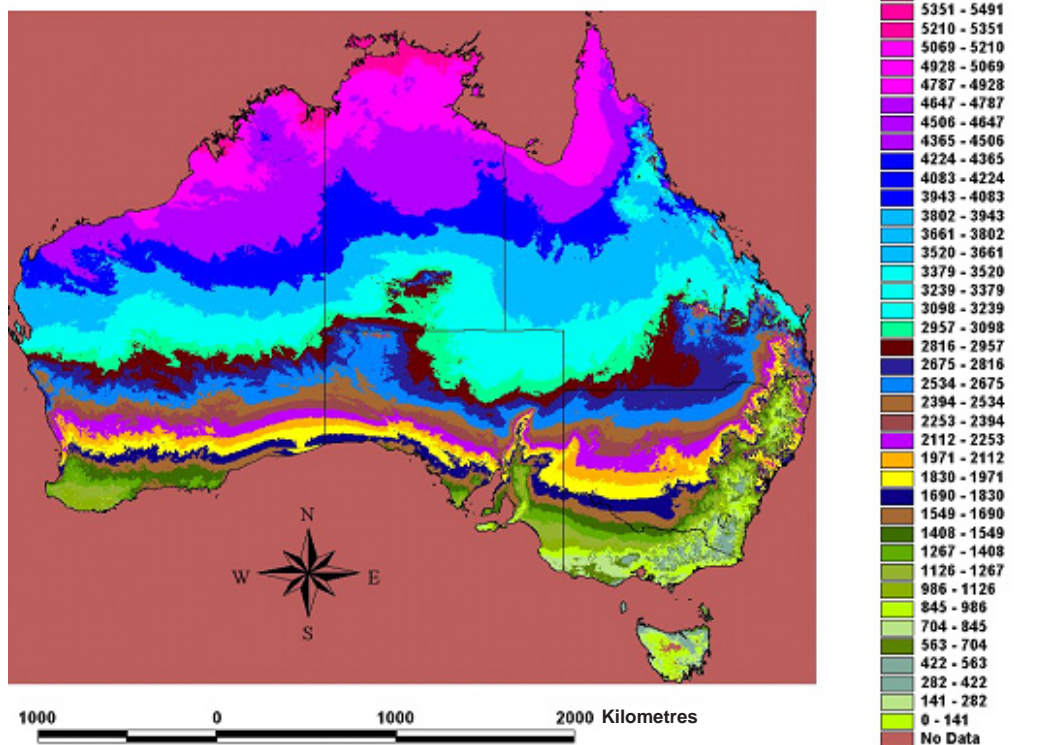
Results are then added to determine the accumulated weekly, monthly or yearly heat units. When calculating daily heat units all results below zero (negative results) are not used. Additionally all maximum temperatures above 35°C (≥ 35.1) are changed to 35. An example of how to calculate heat units using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

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. Tables 2 and 3 summarise the main phenological stages for citrus.

Table 3. Diagrammatic representation of the citrus phenological cycle



Map depicting various heat unit categories in Australia



## References

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