The Growth Degree Day Calculation (GDD)

GDD = ((Max Air Temperature + Min Air Temperature) / 2) – (Base Temperature °C)

I use a base temperature of 6°C for my calculations of GDD simply because that is the temperature when we start to see visible shoot growth from grass. This is different from the U.S GDD calculations which use 0°C. In the U.S instance, the GDD calculation will always return a positive number which to me doesn't make sense if this is meant to be a growth model as there are plainly days (like in example day 3) when no measurable growth occurs.

Example Day 1

Maximum Air Temperature = 20°C
Minimum Air Temperature = 18°C
Base Temperature = 6°C

GDD = (20 + 18) / 2 = 19
19 – 6 (Base Temperature = 6°C)
= 13 D°C (13 GDD)

Example Day 2

Maximum Air Temperature = 30°C
Minimum Air Temperature = 18°C
Base Temperature = 6°C

GDD = (30 + 18) / 2 = 24
24 – 6 (Base Temperature = 6°C)
= 18 D°C (18 GDD)

Example Day 3

Maximum Air Temperature = 12°C
Minimum Air Temperature = 0°C
Base Temperature = 6°C

GDD = (12 + 0) / 2 = 6
6 – 6 (Base Temperature = 6°C)
= 0 D°C (0 GDD)

Example Day 4

Maximum Air Temperature = 12°C
Minimum Air Temperature = 8°C
Base Temperature = 6°C

GDD = (12 + 8) / 2 = 10
10 – 6 (Base Temperature = 6°C)
= 4 D°C (4.0 GDD)

Examples 1 and 2 illustrate the fact that the GDD model has no 'top out', if the air temperature keeps increasing then so does the resultant GDD calculation. So GDD doesn't allow for a scenario when the air temperature is above optimum for grass growth.

To give an idea of scale and essentially that is what a GDD calculation is, a GDD figure of 4.0 would mean visible growth in the box when cutting greens (assuming moisture and nutrition are present), a GDD figure of 13 would mean flush growth, lots of clippings and likely soft leaf tissue.

Example days 3 and 4 illustrate a typical spring scenario. Day 3 reflects a warm spring day with a frost at night vs. Day 4 where we have the same maximum air temperature but a mild night as well. Despite the same day temperature, Day 3 would suggest no growth would take place (0 GDD), whereas with a milder night, Day 4 would suggest a reasonable growth rate for the spring would occur (4GDD). In the spring night temperatures are everything.

The Growth Potential Calculation (GP)

$$GP = e^{-0.5\left(\frac{t - t_o}{var}\right)^2}$$

Where GP = Growth Potential (Scale from 0-1)
e = 2.71828
t = average temperature
t_o=optimum temperature for grass growth (I think 18°C is closer than 20°C)
Var = 5.5

The formula above returns a value between 0 and 1.0, where 0 = No Growth Potential and 1.0 = Maximum Growth Potential.

Growth Potential is an improvement on the GDD calculation in a number of ways. The most important is that it has an optimum temperature within the equation. This is 20°C for cool season grasses (C3) and 31°C for warm season grasses. So if the maximum and minimum air temperatures exceed the optimum for cool season grass species growth the calculation will return a lower figure. In practice this feature is a good indicator for potential periods of high temperature stress. In my G.P calculations I utilise 18°C as the optimum temperature for grass growth as I think it more accurately reflects high temperature stress events on Poa annua.

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Example Day 1

Maximum Air Temperature = 20°*C*

Minimum Air Temperature = 18°*C*

GP = 0.98

Example Day 2

Maximum Air Temperature = 30°*C*

Minimum Air Temperature = 18°*C*

GP = 0.55

Example Day 3

Maximum Air Temperature = 12°*C*

Minimum Air Temperature = 0°*C*

GP = 0.09

Example Day 4

Maximum Air Temperature = 12°*C*

Minimum Air Temperature = 8°*C*

GP = 0.35

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The examples above illustrate the reduction in growth as indicated by a lower G.P figure comparing day 2 to day 1 because in practice a maximum day temperature of 30°*C* would cause some grass species (like Poa annua) to have a slower growth rate as they shut down to conserve water.

Examples 3 and 4 indicate that on a spring day with 12°C maximum air temperature and a ground frost at night (0°C), the grass plant would only be growing at 9% (0.09 / 1.0) of optimum. With a milder night in example 4, the growth rate increases to 35% of optimum (0.35 / 1.0) according to the Growth Potential calculation.

A great reference paper by Micah Woods is available on this link ;

https://www.files.asianturfgrass.com/201306_growth_potential.pdf