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Research Article

ANALYSIS OF GROWING DEGREE DAYS FOR COTTON

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ABSTRACT

Growing Degree Days (GDD) or effective heat units or growing degree units are heuristic tool in phenology. It is a simple means of relating plant growth, development and maturity to air temperature. This concept is widely accepted to estimate or predict the lengths of the different phases of development in crop plants. Development refers to the timing or progress of the crop from one stage of maturity to the next. During this progress of the crop through its growth may occur (Gardener *et al*. 1985). Unless stressed by other environmental factors like moisture the development rate from emergence to maturity for many plants depends upon the daily air temperature. Plants require a specific amount of heat to develop from one point in their life-cycle to another. Temperature is the driving force for all biological activity. Consequently, the growth, development and reproduction of many organisms are predictable based on temperature. A growing degree day (GDD) is a measure of heat above a threshold for that day. Growing degree accumulation reflects the number of GDDs or heat units above a base temperature for consecutive 24-hour days. GDD can be used to assess the suitability of a region for production of a particular crop, estimate the growth stages of the crop, predict maturity, cutting dates of forage crops and timing of fertilizer application and to estimate the heat stress on crops. GDD can also be used to more effectively indicate suitable seeding dates as well as to assit in staggering planting dates in order to insure more orderly harvests (Edey 1977). In this study GDD for cotton crop was assessed periodically. The temperature data was collected from Annamalai University meteorological observatory during the period of January-June 2018. Growing Degree Days at different growth stages of cotton were calculated during crop period. Highest GDD was accumulated at the flowering stage (1034.7 days0C) followed by maturity stage (705 days0C)

INTRODUCTION

Different crops require varied optimal climatic condition for better growth and development. It is important to select the crops according to the climatic suitability so that crop yields will be high. Cotton is a heat loving crop during germination it requires 32-34 ^{0}C and 25-27 ^{0}C during the vegetative stage. Average temperature of 21-22 ^{0}C is required for the crop. The relationship between the amount of heat and plant development by summing up mean daily temperature during plant development phase. Gallagher (1979) indicated that a more suitable description would be thermal time, the 'thermal' indicating heat and 'time' referring to the plants view of time. Several other synonymous terms have been used to describe this relationship between temperature and crop development, including degree-days, heat sums or heat units (Nuttonson 1955). Cotton growth milestones are often given in terms of days after planting or between growth stages, but the development rate of cotton is strongly influenced by temperature. A cotton crop grows more slowly on cool days than on warm days, so temperature measurements during the cropping season help to estimate a specific developmental stage it reached.GDD is the number of temperature degrees above a certain threshold base temperature which varies among crop species. It assumes a direct and linear relationship between growth and temperature. The growth of a plant is dependent on the total amount of heat to which it is subjected during its life cycle. Cotton is best adopted to the subtropical climates, At a temperature of about 15 ^{0}C, it sprouts in 12-15 days and a temperature of 20 ^{0}C, it sprouts within 6 days. High temperature encourages the development of the plants and the development rate is the maximum at the temperature range of 25 ^{0}C -30 ^{0}C. High temperatures beyond 40^{0}C have negative effects on the rate of growth. They reduce the percentage of growth and reduce the number of fruits.

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GDDs can be computed using climatic information for any location and the computation, along with data on soil, water, and minimum and maximum temperatures, helps suggest which crops will grow best in a given region.

MATERIALS AND METHODS

The daily growing degree days (GDD) was computed in Annamalai University Experimental Farm, located at $11^0$24'North latitude and $74^0$4'E longitude at an altitude of +5.79 m above mean sea level during 25 January 2018 to 15 June 2018 cotton hybrid RCH 659 . The base temperature is that temperature below which plant growth is zero. The base temperature, sometimes referred to minimum temperature, is an essential parameter for the determination of the beginning and end of the growing season. It has therefore, an influence on the modeling of phenology and consequently of annual biomass increase. Generally base temperature value of 5.0^0C for winter crops and 10^0C for summer season crops have been used. The daily maximum and minimum temperature and threshold of base temperature were collected during the season. The base temperature of 12^0C was adopted for cotton crop (Constable and Shaw., 1988). GDD are calculated by taking the average to a base temperature, T_{Base}. Given an equation:

$$\mathbf{GDD=T_{MAX}+T_{MIN}/2-T_{BASE}}$$

Table 1 Analysis on growing degree days for cotton during germination stage.

Stages	Date	Maximum Temperature (^{0}C)	Minimum Temperature (^{0}C)	GDD
Germination stage	25, Jan, 2018	28.6	20.6	12.6
	26, Jan, 2018	28.6	19.0	11.8
	27, Jan, 2018	29.0	19.5	12.25
	28, Jan, 2018	28.8	20.4	12.6
	29, Jan, 2018	28.0	19.8	11.9
	30, Jan, 2018	29.0	20.6	12.8
	31, Jan, 2018	28.2	18.6	11.4
	1, Feb, 2018	28.5	17.8	11.15
	2, Feb , 2018	28.2	16.2	10.2
	3, Feb, 2018	29.0	17.8	11.4
	4, Feb, 2018	28.0	18.8	11.4
	5, Feb, 2018	28.6	19.4	12.0
	6, Feb, 2018	28.0	21.2	12.9
	7, Feb 2018	29.2	21.0	13.1
	8, Feb, 2018	30.2	22.4	14.3
	9, Feb 2018	30.0	22.0	14.0
	10,Feb, 2018	30.6	20.8	13.7
	11,Feb, 2018	29.8	21.5	13.65
	12,Feb, 2018	30.2	21.8	13.85
	13,Feb, 2018	30.0	21.5	13.7
Vegetative stage	14,Feb, 2018	29.5	22.0	13.75
	15,Feb, 2018	30.2	22.5	14.35
	16,Feb, 2018	30.0	22.2	14.1
	17,Feb, 2018	30.2	20.2	13.2
	18,Feb, 2018	30.8	20.0	13.4
	19,Feb, 2018	30.0	19.5	12.75
	20,Feb, 2018	29.0	20.2	12.6
	21,Feb, 2018	29.2	19.6	12.4
	22,Feb, 2018	29.8	18.6	12.2
	23,Feb, 2018	29.0	20.6	12.9
	24,Feb, 2018	30.0	21.4	13.7
	25,Feb, 2018	29.8	21.8	13.8
	26,Feb, 2018	30.0	21.8	13.9
	27,Feb, 2018	31.0	21.6	14.3
	28,Feb, 2018	30.0	22.0	14.0
	1, Mar, 2018	31.0	22.4	14.7
	2, Mar, 2018	31.5	22.0	14.75
	3, Mar, 2018	30.6	19.5	13.05
	4, Mar, 2018	31.8	18.2	13.0
	5, Mar, 2018	31.0	18.6	12.8
	6, Mar, 2018	31.5	18.0	12.75
	7, Mar, 2018	30.2	20.6	13.4
	8, Mar, 2018	32.0	21.2	14.6
	9, Mar, 2018	31.0	20.4	13.7
	10, Mar, 2018	30.8	22.8	14.8
	11, Mar, 2018	30.0	22.0	14.0
	12, Mar, 2018	31.5	23.8	15.65
	13, Mar, 2018	31.4	25.0	16.2
	14, Mar, 2018	32.0	24.2	16.1
	15, Mar, 2018	33.0	24.4	16.7
	16, Mar, 2018	33.2	24.2	16.7
	17, Mar, 2018	33.6	25.5	17.55
	18, Mar, 2018	28.5	23.2	13.85
	19, Mar, 2018	32.0	22.4	15.2
	20, Mar, 2018	32.0	21.0	14.5
	21, Mar, 2018	32.2	21.2	14.7
	22, Mar, 2018	34.8	22.0	16.4
	23, Mar, 2018	36.2	22.5	17.35
	24, Mar, 2018	36.0	24.8	18.4
	25, Mar, 2018	33.6	22.4	16.0
	26, Mar, 2018	32.8	21.0	14.9
	27, Mar, 2018	31.6	22.6	15.1
	28, Mar, 2018	33.6	24.6	17.1
	29, Mar, 2018	35.0	24.5	17.75
	30, Mar, 2018	36.0	24.4	18.2
	31, Mar, 2018	35.2	25.4	18.3
	1, Apr, 2018	36.0	26.0	19.0
	2, Apr, 2018	34.5	25.4	17.95
	3, Apr, 2018	34.8	25.8	18.3
	4, Apr, 2018	34.4	25.2	17.8
	5, Apr, 2018	33.8	23.6	16.7
	6, Apr, 2018	33.6	23.0	16.3
	7, Apr, 2018	34.2	23.2	16.7
	8, Apr, 2018	35.0	24.6	17.8
	9, Apr, 2018	34.0	26.2	18.1
	10, Apr, 2018	33.2	24.5	16.85
Flowering stage	11, Apr, 2018	34.0	24.8	17.4
	12, Apr, 2018	33.8	25.6	17.7
	13, Apr, 2018	34.2	25.8	18.0
	14, Apr, 2018	34.4	25.6	18.0
	15, Apr, 2018	33.0	25.4	17.2
	16, Apr, 2018	34.0	25.5	17.75
	17, Apr, 2018	34.6	25.8	18.2
	18, Apr, 2018	34.8	24.5	17.65
	19, Apr, 2018	34.9	24.8	17.85
	20, Apr, 2018	36.0	25.6	18.8
	21, Apr, 2018	37.2	25.5	19.35
	22, Apr, 2018	35.5	25.4	18.45
	23, Apr, 2018	36.8	25.6	19.2
	24, Apr, 2018	37.0	24.6	18.8
	25, Apr, 2018	36.2	25.5	18.85
	26, Apr, 2018	36.4	26.0	19.2
	27, Apr, 2018	36.0	26.2	19.1
	28, Apr, 2018	35.0	25.5	18.25
	29, Apr, 2018	35.2	25.6	18.4
	30, Apr, 2018	36.0	26.0	19.0
	1, May, 2018	38.4	26.8	20.6
	2, May, 2018	37.2	27.0	20.1
	3, May, 2018	38.0	27.4	20.7
	4, May, 2018	38.2	27.0	20.6
	5, May, 2018	35.8	26.5	19.15
	6, May, 2018	36.2	26.0	19.1
	7, May, 2018	36.0	26.8	19.4
	8, May, 2018	35.2	27.4	19.3
	9, May, 2018	38.0	26.2	20.1
	10, May, 2018	35.2	25.2	18.2
	11, May, 2018	36.0	26.0	19.0
	12, May, 2018	36.5	26.8	19.65
	13, May, 2018	37.4	26.6	20.0
Maturity stage	14, May, 2018	36.4	26.4	19.4
	15, May, 2018	36.2	26.0	19.1
	16, May, 2018	36.0	26.0	19.0
	17, May, 2018	35.8	26.6	19.2
	18, May, 2018	36.2	26.8	19.5

19, May, 2018	37.0	27.0	20.0
20, May, 2018	36.0	26.5	19.25
21, May, 2018	38.0	27.2	20.6
22, May, 2018	37.2	25.6	29.4
23, May, 2018	36.0	27.0	19.5
24, May, 2018	35.0	26.0	18.5
25, May, 2018	34.8	25.4	18.1
26, May, 2018	35.2	25.5	18.35
27, May, 2018	34.4	26.0	18.2
28, May, 2018	33.2	27.2	19.0
29, May, 2018	37.5	27.5	20.5
30, May, 2018	39.8	27.0	21.4
31, May, 2018	38.2	27.5	20.85
1, Jun, 2018	39.2	28.0	21.6
2, Jun, 2018	37.0	27.0	20.0
3, Jun, 2018	35.2	27.4	19.3
4, Jun, 2018	37.0	25.4	19.2
5, Jun, 2018	38.0	27.0	20.5
6, Jun, 2018	38.2	22.5	18.35
7, Jun, 2018	37.4	25.2	19.30
8, Jun, 2018	36.0	26.6	19.30
9, Jun, 2018	37.2	27.8	20.50
10, Jun, 2018	35.5	27.5	19.50
11, Jun, 2018	37.5	27.2	20.35
12, Jun, 2018	37.6	27.6	20.60
13, Jun, 2018	38.0	27.0	20.50
14, Jun, 2018	36.0	26.5	19.25
15, Jun, 2018	36.4	26.6	19.50

RESULT

From this study, it was revealed that for each phase in the growth of cultivar, there is a temperature range within which growth and development is optimum. Temperature influences the most plant processes including photosynthesis, respiration, germination, flowering, adaptation and distribution of crops. The range of maximum growth is between 15-40^0 C, the optimal temperatures for different growth stages functions involved in photosynthetic and biochemical processes of any crop. In general high temperature associates growth processes, and reduction of growth and difficulties in fertilization even in heat loving crop, cotton or sorghum occur at temperatures below the lethal limit. The daily alteration of high or low temperature decide the prediction of any crop. It gave an idea about the suitability of a region for production of cotton and for the selection of the particular RCH 659. Also, the micro climate could be modified in such way to produce optimum condition at the each point in the developmental cycle. Also, but GDD the critical period was not considered and the other parameters like rainfall, wind, humidity which are responsible for crop growth and development are not taken for consideration of GDD. The temperature for cotton crop during germination phase is 209 days ^{0}C, vegetative stage is 572.5 days ^{0}C, flowering stage is 1034 days ^{0}C and maturity stage is 705.45 days ^{0}C.

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