



# Heat Unit Requirement for Different Phenophases in Mango Varieties under South Gujarat Conditions

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**Abstract:** The present investigation was conducted at Navsari Agricultural University, Navsari, Gujarat, India during the year 2019-20 and 2020-21. The requirement of heat units viz., growing degree days (GDD), photo thermal units (PTU) and heliothermal units (HTU) for each phenological event was assessed for seven mango varieties viz., Sonpari, Alphonso, Amrapali, Kesar, Dashehari, Totapuri and Rajapuri. Alphonso consumed minimum heat units viz., GDD, PTU and HTU for attaining flower bud differentiation (1436.90, 17682.21 and 6805.82°C, respectively) and grain stage fruits (38.68, 424.52 and 284.10°C, respectively). For panicle initiation, Kesar required minimum GDD (40.73°C) and PTU (452.23°C). However, HTU requirement was minimum in Sonpari (275.61°C). For initiation of flowering, Sonpari required minimum GDD (37.53°C) and PTU (420.67°C). The requirement for HTU was minimum (316.19°C) in cultivar Dashehari. For attaining pea stage fruits, Alphonso required minimum GDD (48.70°C) and PTU (542.44°C). Whereas, HTU requirement was minimum (357.60°C) in Kesar. Dashehari consumed minimum GDD (93.15°C) followed by PTU and HTU for attaining marble stage fruits. However, minimum requirement of GDD (733.58°C), PTU (9201.91°C) and HTU (6717.69°C) for maturity was observed in Sonpari.

**Keywords:** Mango varieties, Heat units, Phenophase

Mango is undoubtedly the most important fruit crops among the tropical and subtropical fruits, grown in more than 110 countries of the world. The climate change has been perceived as a major threats and has maximum impact on mango production in India and particularly in coastal area of South Gujarat (Anon., 2015). This geographic location is continuously becoming increasingly vulnerable to thunder storms during late summer, this results in heavy pre-mature fruit drop which ultimately results in huge economic losses (Parmar et al 2012). In this context, it is necessary to escape crop produce from these losses by manipulating phenological crop cycle through different management practices viz., bahar treatment measures, application of paclobetozol, choice of cultivar etc. In order to predict fruit maturity, requirement of heat units is most accurate among different options. Hence, it is necessary to know the varietal thermal requirements for each phenological event. Computational method using heat unit accumulation during the fruit growth and development has been used as an easy and feasible criterion for determining the fruit maturity (Halepotara 2018). However, information available on this aspect is rare and scanty. Hence, an effort was made to determine the requirement of growing degree days, (GDD) photothermal units (PTU) and heliothermal units (HTU) of different mango cultivars and hybrids for their different phenological events.

## MATERIAL AND METHODS

The present investigation was carried out at Navsari Agricultural University, Navsari during two consecutive seasons 2019-20 and 2020-21. Uniform fifteen year old trees of seven mango varieties viz., V<sub>1</sub>– Sonpari, V<sub>2</sub> – Alphonso, V<sub>3</sub> – Amrapali, V<sub>4</sub>– Kesar, V<sub>5</sub>– Dashehari, V<sub>6</sub>– Totapuri, and V<sub>7</sub> – Rajapuri were selected for this study. The dates of different phenological events were recorded and its respective durations were computed. Accordingly, mean heat units viz., growing degree days (°C), photothermal units (°C) and heliothermal units (°C) were computed as described below.

**Growing degree days (GDD):** The degree days for completion of each phenophase were calculated.

$$\text{Growing degree days (GDD)} = \sum_{i=1}^n \frac{T \text{ max.} + T \text{ min.}}{2} - T_c$$

Maximum and Minimum temperatures of the day

T<sub>c</sub> - Minimum threshold temperature of the crop called as base temperature or minimum threshold temperature. The base temperature of mango crop is 17.9 °C Oppenheimer (1947).

### Representation

**Day-1:** A day with a maximum temperature of 35°C and a minimum temperature of 14°C would contribute 6.60 (GDD).  
Narration:  $35 + 14/2 - 17.9 = 6.60$

**Day-2:** A day with a maximum temperature of 22°C and a

minimum temperature of 11°C would contribute – 1.40. So accumulation of GDD will be 0.00, because negative growth is not possible. Narration:  $22 + 11/2 - 17.9 = -1.40 \approx 0.00$

**Photo thermal units (°C):** The photo thermal unit for a given day represents the product of GDD and the maximum possible sunshine hours and PTU was calculated.

$$\text{Photo thermal units (PTU)} = \sum_{i=1}^n \text{GDD} \times \text{N}$$

Where, GDD - Growing degree days and N - Maximum possible sunshine hours. These maximum possible sunshine hours were taken in accounts from the findings obtained by Sahu (2003). In his report at latitude of Navsari (20° latitude) possible sunshine hours for different months viz., Jan. (11.10), Feb. (11.50), March (12.00), April (12.60), May (13.10), June (13.30), July (13.20), Aug. (12.80), Sept. (12.30), Oct. (11.70), Oct. (11.20), Nov. (11.20) and Dec. (10.90) were observed.

**Heliothermal units (°C):** The heliothermal units for a given day represent the product of GDD and the actual bright sunshine hours and HTU was calculated.

$$\text{Heliothermal units (HTU)} = \sum_{i=1}^n \text{GDD} \times \text{N}$$

Where, GDD is the growing degree days and n is the actual bright sunshine hours as recorded by the Campbell-stokes sunshine recorder.

## RESULTS AND DISCUSSIONS

**Flower bud differentiation:** For induction of flower bud differentiation, Alphonso (V<sub>2</sub>) consumed minimum GDD (1436.90°C), PTU (17682.21 °C) and HTU (6805.82°C) in 153.67 days from 1<sup>st</sup> July. However, among all cultivars, Amrapali (V<sub>3</sub>) consumed maximum GDD (1709.03°C), PTU (20696.71°C) and HTU (8759.62°C) in 215.16 days from 1<sup>st</sup> July (Table 1).

Mango varieties viz., Alphonso, Kesar and Rajapuri

detected early FBD and required minimum GDD and HTU, which might be due to varietal character and their interaction with climatic parameters. Kanzariya et al (2015) reported requirements of GDD for FBD of Kesar (1549.42°C in 170.71 days), Alphonso (1559.77°C in 172.63 days) and Rajapuri (1572.81°C in 177.17 days). These findings for thermal indices are in line with Cesaraccio et al (2001) and Halepotara (2018).

**Panicle initiation:** In panicle initiation, Kesar required minimum GDD (40.73°C) and PTU (452.23°C) accumulated during 9.33 days after FBD. Sonpari required minimum HTU (275.61°C) which were accumulated in 10.83 days after FBD. For panicle initiation, Amrapali required maximum GDD (55.83°C), PTU (639.23°C) and HTU (462.69°C) consumed during 10.33 days after FBD (Table 1). Cultivar Amrapali required more heat units than other cultivars under study, this was might be due to its hunger for heat units for the sake of panicle initiation. These results are in close confirmation with results documented by Burondkar et al (2000), Shinde et al (2001), Kanzaria et al (2015) and Souza et al (2015).

**Flowering initiation:** In flowering initiation, cultivar Sonpari required minimum GDD (37.53°C) and PTU (420.67°C) which were harnessed in 11.17 days from panicle initiation. However requirement for HTU was minimum (316.19°C with 10.67 days) in cultivar Dashehari. However, cultivar Alphonso required maximum GDD (75.75°C), PTU (841.63°C) and HTU (557.83°C) which were consumed during 14.16 days from panicle initiation.

The overall performance for thermal indices indicted that, Sonpari consumed minimum GDD, PTU and HTU, whereas, in case of Alphonso and other early cultivars these parameters were higher. These results show the adaptability of Sonpari to climatic conditions of South Gujarat. These results are in close conformity with the findings of Shinde et al (2001), Kanzaria et al (2015) and Souza et al (2015).

**Table 1.** Requirement of days and heat units for attaining FBD, panicle initiation and flowering in mango varieties (Two years mean)

Treatments	Flower bud differentiation				Panicle initiation				Flowering initiation			
	Days	GDD (°C)	PTU (°C)	HTUs (°C)	Days	GDD (°C)	PTU (°C)	HTUs (°C)	Days	GDD (°C)	PTU (°C)	HTUs (°C)
Sonpari	193.17	1620.90	19715.23	8153.24	10.83	49.33	547.01	275.61	11.17	37.53	420.67	320.76
Alphonso	153.67	1436.90	17682.21	6805.82	9.67	47.73	530.94	369.64	14.16	75.75	841.63	557.83
Amrapali	215.16	1709.03	20696.71	8759.62	10.33	55.83	639.23	462.69	9.33	51.53	592.54	436.84
Kesar	161.17	1488.00	18253.46	7192.20	9.33	40.73	452.23	289.26	14.00	65.78	721.05	471.23
Dashehari	193.00	1626.95	19781.89	8120.18	12.50	50.23	557.50	378.01	10.67	37.98	425.00	316.19
Totapuri	199.83	1652.90	20069.93	8292.84	11.17	45.68	506.99	374.62	10.50	67.25	770.62	561.23
Rajapuri	158.16	1472.65	18081.54	7098.88	12.00	50.63	564.16	331.06	13.67	63.38	695.67	482.95
C.D. at 5%	30.50				NS				1.26			
C.V. (%)	3.52				14.32				8.97			

**Grain stage:** Alphonso consumed minimum GDD (38.68°C), PTU (424.52°C) and HTU (284.10°C) during 9.67 days from initiation of flowering. However, Amrapali consumed maximum GDD (76.78°C), PTU (890.32°C) and HTU (712.03°C) accumulated during 10.83 days from initiation of flowering. These variations in requirement of heat indices might be due to respective varietal characters. These results are in agreement with Burondkar et al (2000), Shinde et al (2001), Kanzaria et al (2015) and Souza et al (2015) (Table 2).

**Pea stage:** Alphonso required minimum GDD (48.70°C) and PTU (542.44 °C) which were harnessed in 13.66 days after grain stage (Table 2). However, HTU requirement was minimum (357.60°C with 12.00 days) in Kesar. The requirements of GDD, PTU and HTU was maximum (69.30, 798.63 and 622.06°C, respectively) in cultivar Totapuri which were accumulated in 9.83 days after grain stage. The overall performance for thermal indices shows that Alphonso consumed minimum GDD, PTU and HTU, whereas, in Totapuri these parameters were maximum. Totapuri consumed more heat units, hence highlighted its hunger for heat units for attaining pea stage fruits. These results are in agreement with findings obtained by *Kanzaria* et al (2015) and Souza et al (2015).

**Marble stage:** Dashehari required minimum GDD (93.15 °C), PTU (1094.20°C) and HTU (848.17 °C) which were consumed in 14.00 days after attaining pea stage fruits (Table 2). For attaining marble stage fruits, maximum GDD (132.35°C) and PTU (1495.19°C) were required by cultivar Alphonso ( $V_2$ ) with 23.17 days after attaining pea stage fruits. However, consumption of HTU (1058.00°C) was highest in Sonpari with 19.50 days after pea stage. The cultivar Alphonso required maximum GDD and Dashehari and Totapuri required minimum GDD. This highlighting requirement of specific variety for particular heat units. Similar results were reported by Shinde et al (2001), Kanzaria et al (2015) and Souza et al (2015).

**Maturity:** The thermal requirement for attaining fruit maturity predominately indicated that Sonpari required minimum GDD (733.58°C), PTU (9201.91°C) and HTU (6717.69°C) which were absorbed in 65.67 days after attaining marble stage (Table 2). However, cultivar Totapuri consumed maximum GDD (961.73°C) and PTU (12246.22°C) which was harnessed in 82.83 days after marble stage. Requirement for HTU was highest (8658.33°C) in cultivar Rajapuri with 95.00 days after attaining marble stage. The cultivar Sonpari consumed comparatively much less heat units than other cultivars under study. This was might be due to attaining maturity in relatively short time. This underlines the early maturing nature of this cultivar. On the contrary,

**Table 2.** Requirement of days and heat units for attaining grain, pea, marble and maturity in mango varieties (Two years mean)

Treatments	Grain Stage			Pea Stage			Marble Stage			Maturity						
	Days	GDD (°C)	PTU (°C)	HTUs (°C)	Days	GDD (°C)	PTU (°C)	HTUs (°C)	Days	GDD (°C)	PTU (°C)	HTUs (°C)	Days	GDD (°C)	PTU (°C)	HTUs (°C)
Sonpari	8.33	40.55	462.71	329.76	9.00	60.88	700.06	543.13	19.50	121.33	1421.31	1058.00	65.67	733.58	9201.91	6717.69
Alphonso	9.67	38.68	424.52	284.10	13.66	48.70	542.44	359.28	23.17	132.35	1495.19	1000.52	85.50	792.30	9760.23	7217.25
Amrapali	10.83	76.78	890.32	712.03	9.67	60.25	723.00	525.83	12.67	116.53	1398.30	932.42	77.50	924.13	11872.63	8144.26
Kesar	13.33	49.25	542.10	381.79	12.00	55.78	632.02	357.60	18.33	101.03	1145.18	862.21	92.16	927.13	11546.12	8496.70
Dashehari	11.17	54.83	630.49	479.39	9.50	61.18	703.51	492.83	14.00	93.15	1094.20	848.17	67.67	752.88	9447.92	6904.89
Totapuri	11.17	67.70	778.55	555.74	9.83	69.30	798.63	622.06	14.33	101.68	1214.73	909.54	82.83	961.73	12246.22	8576.02
Rajapuri	12.33	45.60	502.12	321.41	10.83	49.43	560.17	381.04	20.00	114.95	1306.15	904.83	95.00	941.98	11735.37	8658.33
C.D. at 5%	1.33				3.36				NS				15.55			

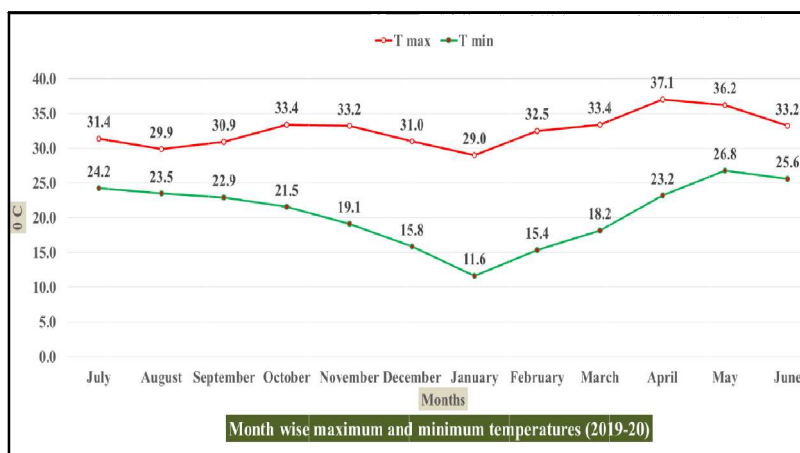


Fig. 1. Month wise maximum and minimum temperatures (2019-20)

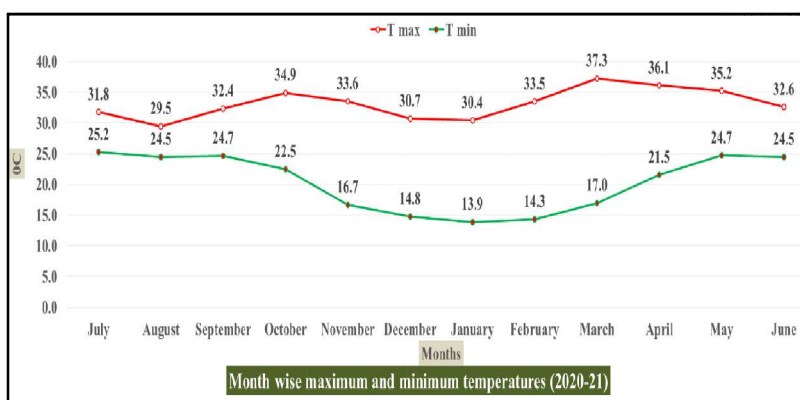


Fig. 2. Month wise maximum and minimum temperatures (2020-21)

Totapuri, Kesar and Rajapuri consumed higher heat units, because these cultivars required more days for maturity. These results are in close confirmation with findings of Kanzaria et al (2015) and Souza et al (2015).

### CONCLUSIONS

The requirement of heat units for attaining different phenophase shown great varietal variations, which underlines the varietal specific heat requirement for each phenophases. Sonpari required minimum heat units for attaining maturity and thus ultimately required minimum days to attain the fruit maturity.

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