



Impact of GDD on phenology of mango (*Mangifera indica*)

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Received: 22 May 2015; Accepted: 22 June 2015

ABSTRACT

The present investigation was undertaken to see the influence of Heat Units on the phenological changes in mango (*Mangifera indica* L.) cultivars under South Saurashtra agro-climatic conditions at Department of Horticulture, Junagadh Agricultural University, Junagadh during year 2012-13 and 2013-14. The treatments were comprised of three locations, viz. Junagadh (L₁), Talala (L₂) and Dhari (L₃) and three commercial important mango varieties, viz. Kesar (V₁), Alphonso (V₂) and Rajapuri (V₃). The experiment was laid out in Randomized Block Design with Factorial concept (FRBD) and replicated four times. Significantly the minimum days for bud differentiation (166.46 days with 1402.94 GDD), early flower initiation (73.04 days with 420.36 GDD) and short flowering span (60.42 days with 444.69 GDD) was observed at Talala location. Among the varieties, early flower initiation (75.83 days and 381.04 GDD) and compact flowering span (60.63 days with 382.84 GDD) was observed in Kesar. The minimum days for fruit set (24.33 with 131.61 GDD), pea stage (20.63 with 173.10 GDD), marble stage (42.96 days and 446.48 GDD), egg stage (69.17 days and 809.13 GDD) and maturity (93.75 days with 1272.06 GDD) were rerecorded at Talala location, whereas early fruit set (24.00 days with 100.63 GDD), pea stage (20.83 days with 144.47 GDD), marble stage (43.67 days and 361.66 GDD), egg stage (70.54 days and 694.79 GDD) and maturity (95.88 days and 1062.71 GDD) was also noted in Kesar. The highest fruit set at pea (13.84%), marble (1.57%), egg stage (0.31%) and fruit retention (1.39%) were recorded at Talala. Among the varieties, the maximum fruit set at pea stage (13.84%) was recorded in Alphonso, while it was the maximum at marble (1.60%), egg stage (0.32%) and fruit retention (1.32%) in Kesar. However, the maximum numbers of fruits/tree were recorded at Talala location (335.21) in Alphonso variety (344.33).

Key words: Flowering, Fruit set, GDD, Location, Mango, Variety

Mango (*Mangifera indica* L., Family Anacardiaceae) unarguably is one of the oldest and choicest tropical fruits of the world (Singh *et al.* 2011). Mango is renowned for its excellent flavour, attractive fragrance, and high nutritional value; and gradually gaining global market (Sikhmany 2005). Growing degree days (GDD) are the number of temperature degrees above a certain threshold base temperature within consecutive 24 hr period. The GDD varies among the crops or even within cultivars of the same crop. So, GDD is computed by subtracting base temperature from mean daily temperature. The base temperature for mango is 17.9°C (Oppenheimer 1947). GDD unit concept is based on the assumptions that growth or development occurs only when the average daily temperature exceeds the certain temperature and the number of accumulated GDD between various growth stages are constant for species across the years, locations and climates. GDD are a measure of heat accumulation used to predict the growth stages including the date when a flower will bloom or a crop will reach to the maturity. Plants grow in a cumulative stepwise manner,

which is strongly influenced by temperature. Growing degree days take aspects of local weather into account and allow predicting the plants tendency towards maturity. Climate change is already having an effect on farming, thereby increasing the need for research and programs to assist adaptive decision making. Patterns of temperature, moisture and weather conditions greatly influence the plant and animal performance, inputs, management practices, yields, and economic returns. This could be beneficial if it results in production opportunities from an extended growing season and an increase in available heat unit. Tracking temperature trends leading to and occurring throughout mango season assists growers. This could be very important as regards consumers, marking new expectations of emerging markets. Looking to the changing climatic conditions, this experiment was undertaken to estimate the effect of temperature on different varieties of mango under South Saurashtra agro-climatic conditions.

MATERIALS AND METHODS

The research work was carried out under South Gujarat climatic conditions. The treatments of the experiment were comprised of three locations, viz. Junagadh (L₁), Talala (L₂) and Dhari (L₃) with three commercial mango varieties,

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viz. Kesar (V_1), Alphonso (V_2) and Rajapuri (V_3). The experiment was laid out in Randomized Block Design with Factorial (FRBD) and replicated four times. Daily meteorological data were recorded by automatic weather data logger instrument installed at all experimental locations in the field. Each data logger was programmed to record the maximum as well as minimum temperature and humidity at every 30 minutes interval. The 1st July and 1st November of consecutive year was set as cutoff date for BDS and rest of stages, respectively. GDD was computed by mean daily temperature degree above base temperature. The formula applied for calculation of GDD was $(T_{\max} + T_{\min})/2 - T_{\text{base}}$. The various observations related to phenological changes in mango varieties were recorded as per schedule. Uniform cultural practices were practiced at all the locations and varieties.

RESULTS AND DISCUSSION

Results of study revealed that the number of days required for flower bud differentiation was significantly affected at locations only. Early bud differentiation (166.46 days with 1402.94 GDD) was observed at Talala location which was found non-significant among the varieties (Table 1). Number of days and GDD required for flower initiation and progressive phenological stages affected significantly. The minimum days for flower initiation (73.04 days with 420.36 GDD) and short flowering span (60.42 days with 444.69 GDD) was observed at Talala location. As far as variety is concern, early flower initiation (75.83 days and 381.04 GDD) and shorter flowering span (60.63 days with 382.84 GDD) was observed in Kesar variety of mango. The minimum days for fruit set (24.33 with 131.61 GDD), pea

stage (20.63 with 173.10 GDD), marble stage (42.96 days and 446.48 GDD), egg stage (69.17 days and 809.13 GDD) and maturity (93.75 days with 1272.06 GDD) were recorded at Talala and fruits completed all the stages earlier when compared to Junagadh and Dhari locations. Among the varieties, early fruit set (24.00 with 100.63 GDD), pea stage (20.83 with 144.47 GDD), marble stage (43.67 days and 361.66 GDD), egg stage (70.54 days and 694.79 GDD) and maturity (95.88 days and 1062.71 GDD) was noted in Kesar variety followed by Alphonso and Rajapuri. Significant effect of days and GDD was noted for fruit set (%) to retention (%). The maximum fruit set at pea (13.84%), marble stage (1.57%), egg stage (0.31%) and fruit retention (1.39%) were recorded at Talala which was higher as compared to Junagadh and Dhari locations. For varieties, the maximum fruit set at pea stage (13.84%) was recorded in Alphonso, on the contrary, it was found the maximum at marble (1.60%), egg stage (0.32%) and fruit retention (1.32%) in Kesar which was considerably higher as compared to Alphonso and Rajapuri varieties of mango (Table 3). The effect of days and GDD were also found significant for number of fruits. The maximum numbers of fruits per tree were recorded at Talala location (335.21) and in Alphonso variety (344.33).

The delayed flowering at Dhari might be due to its location at higher altitude (229m) as compared to Talala (148m) and Junagadh (81m). Altitude is one of the factors responsible for flowering. At higher altitude, temperature regime remains lower as compared to lower altitudes. Lower temperature accumulated less which might have resulted into delayed flowering (Table 2). Polito (2009) and Mathieu (2006) reported similar results which are closely in agreement with the findings of present research work. Rajan (2008) investigated that the altitude also affects the time of flowering. These lesser GDD accumulations lead the bud to break the dormancy earlier than warmer ones. Byrne and Bacon (1992) clearly stated that if winter temperatures do not satisfy a variety's chilling requirement, trees will show signs of delayed bloom and foliation with reduced fruit set. Along with local climatic conditions, it may be possible that flowering span might be of more genetic concern. Owing to climatic conditions, flowering span might be differed, but flowering span of particular variety is over when required GDD are accumulated. The findings reported

Table 1 Days and GDD requirements at bud differentiation, flower initiation and flowering span of different mango varieties at various locations

Treatment	Calendar days and GDD requirements for different stages					
	Bud differentiation		Flower initiation		Flowering span	
	Days	GDD	Days	GDD	Days	GDD
<i>Location</i>						
L ₁ -Junagadh	175.21	1621.88	79.79	399.20	63.88	452.08
L ₂ -Talala	166.46	1402.94	73.04	420.36	60.42	444.69
L ₃ -Dhari	178.83	1657.18	85.25	358.40	64.75	410.78
SEm±	2.446		1.93		0.80	
CD (P=0.05)	6.96		5.49		2.29	
<i>Variety</i>						
V ₁ -Kesar	170.71	1549.42	75.83	381.04	60.63	382.84
V ₂ -Alphonso	172.63	1559.77	79.46	393.78	63.08	424.70
V ₃ -Rajapuri	177.17	1572.81	82.79	403.15	65.33	500.00
SEm±	2.446		1.93		0.80	
CD (P=0.05)	NS		5.49		2.29	
CV (%)	6.91	10.24	6.24			

Table 2 Daily GDD accumulations for various growth stages at different locations for mango varieties

Treatment	Bud different-iation	Flower initia-tion	Fruit set	Pea stage	Marble stage	Egg stage	Matu- rity
L ₁ -Junagadh	9.26	5.00	5.11	7.61	8.93	10.21	11.25
L ₂ -Talala	8.43	5.76	5.41	8.39	10.39	11.70	13.57
L ₃ -Dhari	9.27	4.20	3.82	7.33	8.69	9.94	10.85
V ₁ -Kesar	9.08	5.02	4.19	6.94	8.28	9.85	11.08
V ₂ -Alphonso	9.04	4.96	4.77	7.61	9.32	10.42	11.83
V ₃ -Rajapuri	8.88	4.87	5.21	8.56	10.15	11.39	12.54

Table 3 Effect of days and GDD on fruit set, fruits at pea, marble and egg stage, fruit retention and number of fruits/ tree of mango varieties at various locations

Treatment	Days, GDD and fruit set (%) at various stages												Fruit retention	No. of fruits/tree	Yield/ha (t/ha)		
	Fruit set			Pea stage			Marble stage			Egg stage						Maturity	
	Days	GDD	%	Days	GDD	%	Days	GDD	%	Days	GDD	%				Days	GDD
<i>Location</i>																	
L ₁	25.50	130.38	23.25	176.95	13.34	46.71	416.99	1.45	71.50	729.79	0.27	96.54	1086.41	0.15	1.13	286.29	8.02
L ₂	24.33	131.61	20.63	173.10	13.84	42.96	446.48	1.57	69.17	809.13	0.31	93.75	1272.06	0.19	1.39	335.21	9.04
L ₃	27.42	104.66	24.50	179.61	12.37	50.25	436.56	1.30	79.04	785.51	0.24	107.13	1162.68	0.11	0.88	241.42	7.49
SEM±	0.538		0.631		0.241	1.064		0.045	1.075		0.008	1.561		0.01	0.06	8.418	0.294
CD (P=0.05)	1.53		1.80		0.69	3.03		0.13	3.06		0.02	4.44		0.02	0.17	23.96	0.84
<i>Variety</i>																	
V ₁	24.00	100.63	20.83	144.47	13.39	43.67	361.66	1.60	70.54	694.79	0.32	95.88	1062.71	0.17	1.32	303.63	6.77
V ₂	25.83	123.21	22.92	174.39	13.84	46.46	432.78	1.39	72.04	751.01	0.27	97.13	1149.03	0.14	1.04	344.33	6.58
V ₃	27.42	142.81	24.63	210.81	12.32	49.79	505.59	1.33	77.13	878.63	0.22	104.42	1309.41	0.13	1.03	214.96	11.20
SEM±	0.538		0.631		.241	1.064		0.045	1.075		0.008	1.561		0.01	0.06	8.418	0.294
CD (P=0.05)	1.53		1.80		0.69	3.03		0.13	3.06		0.02	4.44		0.02	0.17	23.96	0.84
CV (%)	11.18		7.72		8.96		15.45		14.05		14.05		13.31		25.78	14.34	17.62

Location: L₁- Junagadh, L₂- Talala, L₃- Dhari; Variety: V₁- Kesar, V₂- Alphonso, V₃ - Rajapuri

by Thomas *et al.* (2000) also support current research and stated that the period of flowering in mango is governed by local climatic conditions, the variety and cultural practices. The accumulation of extra GDD might have accelerated the physiological processes in the plant and awarded early flowering and progressive stages. But for varieties, it might be varietal characteristics and performed individually. The earliness in the fruit set, pea stage, marble stage, egg stage and maturity was noted at Talala location, because of accumulation of daily extra GDD and earliness in previous growth stages. Earliness in Kesar might be due to the distinct varietal requirement of GDD. Moreover, fruit size was smaller than Rajapuri and a distinct genetically makeup. The same might be the case for Alphonso, even though it received lesser numbers of GDD during the growth span. Malte (2011) also reported similar results in mango and supports the present findings. Ravi *et al.* (2002) evaluated different mango cultivars and reported that these cultivars differed in flowering, setting fruit and ripening period.

Per cent fruit set at pea stage were higher in Alphonso variety, but it was less at marble stage. This might be a varietal character that might have caused more fruit drop in Alphonso variety at pea stage and less fruit drop in Kesar variety. Hence, fruit set at marble stage was found to be the maximum in Kesar variety. An investigation carried out by Uddin *et al.* (1995) in mango also supported the present investigation. Rodrigo and Herrero (2002) made generalized statement that “pre-blossom temperatures affect fruit set and subsequent yields.” Talala received daily extra GDD compared to other locations, the physiological processes accelerated; cell division and cell expansion might be positively affected by extra GDD. Moreover, bud differentiation was earliest at the Talala location. Though the bud differentiation is a qualitative event but it might took place in more numbers of buds. Hence, more numbers of fruits were received which contribute to the yield at various locations. Number of hermaphrodite flowers, pollination and fruit retention at various locations and for different variety might played a vital role for the yield and yield attributing characters. Majumder and Sharma (1990) and Rajan (2008) worked for mango and supported this research work.

On the basis of results obtained in the present experiment, it may be concluded that early bud differentiation, flower initiation, fruit set and maturity in mango were observed at Talala location, while Kesar variety required minimum calendar days and GDD to reach maturity. All the varieties at Talala location exhibited maximum fruit set and retention. Among the varieties, the Kesar variety had the highest fruit set and retention. Alphonso variety was found sensitive to changing climatic conditions and showed less fruit retention, hence yielded poorly. The maximum number of fruits/plant were recorded at Talala location with Alphonso variety. Fruit yield/ha was recorded maximum at Talala location in Rajapuri variety. GDD have direct influence on the phenological changes during fruit

development in different varieties, but it did not reveal any direct influence on qualitative attributes of fruits. The GDD requirements of different varieties were found distinct and a variety with low GDD requirement was found to be Kesar and a location devising the highest GDD was Talala.

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