Journal of Agrometeorology 23 (3) : 360-363 (September 2021)

Short communication

Effect of temperature variations on phenology and horticultural traits of guava under North-west Indian conditions

J. S. BRAR[*], N. K. ARORA, KRISHAN KUMAR, R. S. BOORA and GAGANDEEP KAUR

Dept of Fruit Science, PAU, Ludhiana, Punjab, India
[*]Corresponding Author email: *jsbrar74@pau.edu*

Guava (*Psidium guajava* L.) is an evergreen fruit tree, which is grown throughout India. In Punjab, it is the second most important fruit crop after Kinnow and occupies an area of 9,580 hectares area (Anon., 2019). In Punjab, guava produces two distinct crops in a year i.e. rainy and winter season crops. Generally, the flowering for rainy season crop occurs in April-May and for winter season crop, it occurs in July-August (Bal, 2015). The fruits of rainy and winter season crops mature during July-August and November-December, respectively. Rainy season crop has high yields while the winter season fruits are of superior quality by virtue of low incidences of fruit fly and fruit-borer (Boora *et al.*, 2016). Although, guava is a tropical fruit crop, but in Punjab (North-Western India), it is being cultivated under subtropical climate. Under this climate, the physiological growth of the guava starts with the rise of temperature in spring. However, the start of spring is determined by the length of winters in north-west India, which is variable. The information on impact of temperature variability on phenological clock of guava is lacking. Further, for onset of a particular phenological phase, the specific temperature requirement must be met (Islam *et al.*, 2019), which can be reliably measured in terms of heat units (Padilla-Ramirez *et al.*, 2012). The heat unit information for different phenological phases may prove useful in formulating area specific crop management practices to avert sudden climatic risks (Islam *et al.*, 2019). In Punjab (North-Western India), the year 2019 was a relatively cooler than 2018. The study aimed to assess the impact of these inter-annual temperature variations on phenology and horticultural traits of guava; and also to estimate the accumulated heat units for onset of different phenological stages in guava.

The study was carried out on 7 years old trees of guava cv. Shweta growing at Fruit Research Farm, Punjab Agricultural University, Ludhiana, India. The observations were recorded from a total of nine trees with three trees constituting a replication. The experimental trees were managed under uniform cultural practices. The weather data of monthly temperature (maximum, minimum and mean) of the experimental period was collected from PAU Agro-meteorology Observatory, Ludhiana (Table 1). The experimental location received a total rainfall of 919 mm in 2018 and 1147 mm in 2019. To find the impact of yearly temperature variations on phenological cycle, the data was recorded on the onset of phenological stages (bud sprouting, flower initiation, fruit maturity) and days required to reach flower initiation and fruit maturity for rainy and winter season crops. The temperature required for transition of sprouting phase to flowering (SF) and flowering to fruit maturity (FM) was determined in terms of heat units. The heat units were calculated by subtracting the base temperature from the daily average temperature (T_{max}+T_{min}/2). The accumulative heat units were worked out by summing up daily heat units for duration of SF and FM. The temperature of 15°C was taken as base temperature, as shoot growth was arrested below this temperature under Ludhiana conditions. Among the horticultural traits, the data on fruit set, fruit drop and final fruit retention was recorded.

Temperature variability and its impact on guava phenology

The perusal of temperature data of two years revealed that the year 2019 was relatively cooler than 2018 (Table 1). The mean monthly temperature of February and March in 2019 was 1.3 and 3.1°C lower than that of 2018. This relatively lower temperature delayed the onset of vegetative bud sprouting and flower initiation in the year 2019. The vegetative bud sprouting for rainy season crop in 2019 started on 11th of March *i.e.* later by a week compared to 2018 (Table 2). The duration of bud

Table 1: Monthly average maximum, minimum and mean temperature and sunshine hours of experimental location

Months	2018			2019		
	Max. temp.	Min. temp.	Mean	Max. temp.	Min. temp.	Mean
January	18.7	6.2	12.5	18.3	6.1	12.2
February	22.8	9.1	15.9	20.1	9.2	14.7
March	29.3	13.8	21.6	25.3	11.8	18.6
April	35.8	19.9	27.8	35.1	19.5	27.3
May	39.2	24.3	31.7	37.9	22.1	30.0
June	37.7	27.2	32.4	40.4	26.8	33.6
July	34.3	26.7	30.5	33.9	26.7	30.4
August	34.1	27.3	30.7	33.9	26.7	30.3
September	32.1	24.1	28.1	33.1	25.5	29.3
October	31.3	17.2	24.2	30.6	18.4	24.5
November	27.0	11.8	19.4	25.2	13.2	19.2
December	20.7	5.5	13.1	15.9	7.5	11.7

Table 2: Dates of onset of different phenological phase, their duration in terms of days and heat units for rainy and winter season crops

Year and season of crop	Initiation of vegetative bud sprouting	Initiation of flowering	Commen-cement of fruit maturity	Duration of bud sprouting to flower initiation (SF-days)	Duration of flower initiation to fruit maturity (FM-days)	∑ Thermal units (day^{0}C)	
						SF	FM
2018 (R)	4th March	15th April	19th July	42	95	351.5	1545.3
2018 (W)	3rd July	17th July	18th Nov	14	124	217.2	1476.0
2019 (R)	11th March	29th April	5th Aug	49	98	439.2	1574.2
2019 (W)	16th July	1st Aug	5th Jan	16	157	238.9	1228.4

Table 3: Fruit set, fruit drop and final fruit retention of rainy and winter season crops

Parameters	2018		2019	
	Rainy season	Winter season	Rainy season	Winter season
Number of set fruits	488	395	688	395
Number of dropped fruits	76	39	96	182
Per cent fruit drop	15.6	9.9	14.0	46.1
Number of retained fruits	412	356	592	213

sprouting to flower initiation for rainy season crop was 49 days in 2019 as against 42 days in 2018. Unlike flower initiation, the transition period of flower initiation to fruit maturity for rainy season crop was almost similar in the two years (Table 2).

Due to delay of cycle of rainy season crop in 2019, the phenology of winter season crop was also altered. The sprouting of vegetative bud and initiation of flowering was delayed by 13 and 15 days, respectively. The most apparent effect was noticed for fruit maturity, which took 33 more days in 2019 compared to 2018 (Table 2). Leaf sprouting and flower development in spring season starts early with an increase of temperature during late winters and early spring (Chmielewski and Rotzer, 2001). In contrast, the extreme cold and frosty conditions for longer period may delay the flower initiation. Similarly, the duration of flowering is also influenced by temperature (Lomas and Burd, 1983: Singh and Bhatia, 2011).

Heat units required for onset of different phenophases

The accumulated heat units for flower initiation from sprouting (SF) was highly different for rainy season crop (351.5 and 439.2 day^{0}C), but almost similar for winter season crop (217.2 versus 238.9 day^{0}C) in both the years i.e. 2018 and 2019 (Table 2). The lower temperature retards shoot growth in guava as the reserved carbohydrates are diverted to protect against for low temperature stress (Hao *et al*., 2009). In geophytes, the exposure of plants to a temperature higher than the optimal (25-30°C) during the period of flower initiation also delays the onset of flowering (Khodorova and Boitel-Conti, 2013). Hence, the delay of flowering of rainy season crop in 2019 could be a consequence of bi-faceted effect of prevailing temperature. The lower temperature first retarded the vegetative growth and prolonged the duration to attain optimum growth stage for flower induction. The later concurrence of flower induction period with higher temperature in SMW 17 further extended it.

For transition of flowering to fruit maturity (FM), the accumulated heat units for rainy season crop were almost similar (1545 day^{0}C in 2018 versus 1574 day^{0}C in 2019) and highly variable for winter season crop in both the years (Table 2). The actual relationship of fruit maturity with temperature is not known under fluctuating temperature conditions in guava, though, in tomato, when plants were grown under different temperature regimes of 14, 18, 22 and 26°C, the fruit maturity was advanced at higher temperature compared to lower temperatures (Adams *et al.,* 2001). There was a significant difference of 33 days in fruit maturity (FM) duration of winter season crop among both the years (Table 2). Thus, the early onset of flowering (by two weeks) and initiation of fruit development under the optimum temperature regimes might have helped in inducing timely fruit maturity of winter season crop in 2018 compared to 2019.

Fruit set and fruit drop pattern

For rainy season crop, the number of fruits set was higher (46.1%) in 2019 than 2018 (Table 3). However, for winter season crop, the number of fruits set in both the years was almost similar. The higher fruit set for rainy season crop of 2019 may be due to longer exposure to lower temperature regimes. The higher accumulation of low temperature hours preceding bloom is known to increase intensity of flowering in citrus (Valiente and Albrigo, 2004). The fruit drop in winter season crop of 2019 was substantially higher when compared to 2018. Comparatively low temperature and associated weather conditions during fruiting in second season may be the cause of more fruit drops when compared with first season's fewer fruit drops in guava. It might have coincidence of fruit maturity with the low temperature and foggy weather/low radiation availability. Similarly, the off season winter fruits of longan had developmental problems which led to heavy fruit drop under field conditions (Yang *et al*., 2010).

In conclusion, the prevalence of low temperature during pre-sprouting period (February and March) substantially delayed the onset of phenological clock both of rainy as well as winter season crops in 2019. This delay caused the fruit maturity of winter season guava to coincide with peak winters of 2019-20, which led to excessive fruit drop. The future thrust should be to manage such fruit drop by advancing fruit maturity with some chemicals interventions. The heat unit concept based information will serve as a valuable guide for such innovative interventions.

Conflict of Interest Statement : The author(s) declare(s) that there is no conflict of interest.

Disclaimer : The contents, opinions, and views expressed in the research article published in the Journal of Agrometeorology are the views of the authors and do not necessarily reflect the views of the organizations they belong to.

Publisher's Note : The periodical remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

REFERENCES

Adams, S.R., Cockshull, K.E. and Cave, C.R.J. (2001). Effect of temperature on the growth and development of tomato fruits. *Ann. Bot.,* 88:869-877.

Anonymous. (2019). Fruit production database. Ministry of Agriculture and Farmer Welfare, Government of India (ON 2224). http://indiastat.com.

Bal, J.S. (2015). Fruit growing, 3rd Ed. Kalyani publishers, New Delhi p.257.

Boora, R.S., Dhaliwal, H.S. and Arora, N.K. (2016). Crop regulation in guava-A review. *Agric. Reviews*, 37 (1):1-9.

Chmielewski, F.M. and Rotzer, T. (2001). Response of tree phenology to climate change across Europe. *Agric. For. Meteorol.,* 108:101-112.

Hao, W., Arora, R., Yadav, A. K. and Joshee, N. (2009). Freezing tolerance and cold acclimation in guava (*Psidium guajava* L.). *Hort. Science,* 44(5): 1258-1266.

Islam, M.R., Barutcular, C., Çig, F., El Sabagh, A., Alam, M.A., Kamal, M.M., Zaman, R., Hossain, A., Alharby, H., Bamagoos, A. and Farooq, M. (2019). Assessing impact of thermal units on growth and development of mustard varieties grown under optimum sown conditions. *J. Agrometeorol.*, 21(3):270-281.

Khodorova, N.V. and Boitel-Conti, M. (2013). The role of temperature in the growth and flowering of geophytes. *Plants*, 2:699-711.

Lomas, J. and Burd, P. (1983). Prediction of the commencement and duration of the flowering period of citrus. *Agric. Meteorol.*, 28:387-396.

Padilla-Ramirez, J.S., Gonzalez-Gaona, E., Perez-Barraza, M.H., Osuna-Garcia, J.A., Espindola-Barquera, M. and Reyes-Aleman, J.C. (2012). Phenological behavior of guava trees under different climatic conditions of Mexico. *Acta Hortic.*, 959:97-102.

Singh, M. and Bhatia, H. S. (2011). Thermal time requirement for phenophases of apple genotypes in Kullu valley. *J. Agrometeorol*, 13(1):46-49

Valiente, J.I. and Albrigo, L.G. (2004). Flower bud induction of sweet orange trees [*Citrus sinensis* (L.) Osbeck]: effect of low temperatures, crop load, and bud age. *J. Am. Soc. Hort. Sci.*, 129:158-164.

Yang, Y.H., Zhu, X.C., Wang, S.C., Hu, G.B., Hee, H. and Huang, X.M. (2010). Developmental problems in over-winter off-season longan fruit. I: effect of temperature. *Sci. Hortic*., 126:351-358.

Received : June 2020 : Accepted : May 2021