

Review Article

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Phenological Stages of Guava-A Review

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ABSTRACT

Phenology is branch of science, which deals with timing of periodic occurrences particularly biological in nature with respect to biotic and abiotic factors and about their interrelationships. As for as guava fruit is concerned, different phenological stages are well defined but they also depend upon climatic conditions but amenable to managements through various cultural intrusions. Various stages are clearly identified but under the influence of environmental conditions. Generally there are sixteen stages are recorded during growing phase, starting from bud dormancy to fruit maturity or ripening. Various scholars concerning bud developments observed substantial differences. In this paper, information regarding various guava species are compiled, viz. in this paper, information regarding various guava species are compiled, viz. *P. guineense*, *P. cattleianum*, *P. chinensis* and cultivar Shweta, Sardar, Arka Kiran, Hisar Surkha, Snow White, Black guava, Lalit, Arka Amulya, Phenological stages from time of leaf flushing to duration of fruiting were considered. Shortest flowering period was recorded in Allahabad Safeda i.e. 33 or 38 days while longest flowering period was observed in Hisar Safeda i.e. 41 or 45 days in both spring and autumn season. The first-to-last-flowering duration is shortest in *P. cattleianum* (30 days) and longest in *P. guineense* (60 days) and this flowering duration lasts upto 65 days in Arka Kiran (65 days). *P. chinensis* (22 days) takes 22 days to achieve 50 percent flowering stage while *P. guineense* takes 28 days and Arka Kiran takes 30 days to achieve this stage. Anther dehiscence time is also varying from species to species it is 7.00 to 8.00 am in *P. guineense*, 8.00 to 10.00 am in *P. chinensis*. Pollen germination percentage is lowest in *P. cattleianum* 40.23% while it is highest in Arka Kiran 80.34%. *P. cattleianum* takes 12 days from flowering to fruit set while *P. guineense* 18 days.

Keywords

Phenological stages, Guava

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Introduction

The guava belongs to the Myrtaceae family, known as 'Apple of Tropics' or "poor man's fruit". It is one of the energetic fruits, grown in the sub-humid, subtropical and tropical regions in India. However unknown, it is accepted that guava began from a territory spreading from Central America or southern

Mexico. Guava is a good source of vitamins A, B, and C (200-250 mg/100 g of pulp), along with other nutrients viz. iron, calcium, and zinc with pleasant smell and flavor (Dhaliwal and Dhillon, 2003). Being a hardy and beneficial fruit, can be grown even in adverse soil and agro-climatic conditions. Guava is India's fifth-largest fruit-growing crop, involving 3.38 % of the all-out region

under fruit cultivation (Anon., 2017). It is currently grown in a large part of Indian subtropical and tropical regions because its optimum temperature and humidity are between 25°C and 30°C and 50%-80% separately for blooming and fruiting. The flowering period of guava may differ from one location to another subject to climatic conditions. The Guava trees bloom and yield fruits throughout the year in the mild tropical climate, provided that moisture and temperature are not limited. However, in northern India, guava flowers twice a year between April to May and from August to September. It is an open-pollinated crop (Agrawal, 2010). To raise new plantations of guava their seedlings are used. It has a high degree of genetic diversity due to the continuous planting of heterogeneous seedlings. Gohil *et al.*, (2006) stated that there might be a difference in genetic composition due to variation in flower initiation. Floral biology in guava helps researchers to recognize elite hybrid/genotypes and helps to modify the cultural operations in relation to flowering and fruiting. Environmental effects and genetic variability information helps to establish crosses, methods for assessment as well as breeding approaches (Thaipong and Boonprakon, 2005). Guava is economically propagated by modified patch budding. For Sardar and Allahabad Safeda varieties, the Portugal rootstock method is used, as it enhances weight and fruit yield. It also provides wilt tolerance to different scion varieties. Guava seeds of cv. Portugal and Sardar are sown on raised beds of 2m X 1m size in March or August. The seedlings can be transplanted after an interval of six months and budding is done when these seedlings achieve a diameter of 1.0 - 1.2 cm at about 15 cm height. The guava seedlings sometimes become drooping means wilted, lifeless because of damping-off and this condition can be improved by soaking the seedbeds with 0.3% (3g in 1-liter water) Captain. The patch

budding when done in May and June gives 75-80 % success. Angular budwood from the current season's growth is involved for budding and it is used as freshly cut wood. A rectangular or semi-circular patch of bark (2.5X1.0 cm) with two buds is removed from the scion stick in this way that the bark may not split. It is then attached to the bare portion of rootstock and covered immediately with a polythene strip in such a way that both the buds are exposed. The bud may take one week or so to show signs of sprouting and the polythene strip is removed. When the shoots emerging from buds reach a length of 15 to 20 cm, keep the quickly grown and healthy shoot and cut the weaker ones. The guava can also be propagated on rootstock seedlings 2.5 to 3.0 cm thick which are earlier from seeds that are directly sown in polythene bags by wedge grafting in February. Eight to ten days before grafting, the scion stick should be defoliated. To conserve humidity, the graft should be instantly covered with a white polythene tube (25 X 6 cm) which should be disposed of after bud sprouting.

Normally vegetative growth period begins during mid-spring and ends in autumn, undergoes several physiological changes. These changes are recognized as bud swelling and break, spring growth, increase in trunk diameter, including reproductive phase alterations such as the initiation of flowers, fruit formations, and ripening, etc. Joshi *et al.*, (2017) also considered fruit ripening as a genetically programme process which alters fruit flavor, texture, color, and other traits of the fruit. Ripening is an irreversible type of activity that involves a series of biochemical, physiological, along organoleptic changes.

These variations include changes in various constituents like color, flavor, texture, carbohydrate, sugar content, phenolic compounds, and along with organic acids. Brecht (2002) has also supported this fact that

during fruit ripening, a series of changes occur that lead to changes in texture, breakdown of starch, color, pigment formation, etc. and development of flavor, aroma, etc. The fruit softening occurs simultaneously because of various activities like depolymerization and solubilization of cell wall constituents (Korban *et al.*, 2010). There is a breakdown of complex molecules to simpler molecules during the process of respiration that supplies energy. Tripathi *et al.*, (2016) submitted that cellular metabolic activity showed that the ripening process might include various phases of life of fruit like development, maturity, and senescence. Respiration rate in case of climacteric fruits is very high because of the production of a high amount of ethylene gas, which lead to improvement in the ripening. On the other hand, this rate is almost constant or decreases regularly towards senescence, indicating that the production of ethylene gas is very low (Bouzayen *et al.*, 2010).

The nature of guava fruit is climacteric. Harvesting is done at full maturity so that to obtain good flavor and taste of the fruit. At maturity, the fruits change their color from dark green to greenish-yellow. If the fruits are over-ripened on trees, they are more likely to be damaged by birds and also lower in shelf life and quality. Some farmers keep few leaves or small branches with the fruit to draw the attention of customers but this practice leads to high moisture loss from the fruit and may also damage the adjoining fruits and aggravate spoilage.

Guava fruit should be marketed immediately after harvest due to their short shelf life. The harvested fruits are packed in bamboo baskets of different sizes or CFB cartons of size 4 to 10 kg, after cleaning sorting and grading. The guava fruits can be stored at room temperature for one week in perforated polythene bags. In commercial cold storage, it

can be kept for three weeks in CFB cartons at 0-3.3°C and RH of 85-90%. Shelf life greatly depends on cultivar of fruit for instance cv. Shweta can be kept for one week at ambient temperature (15-20°C) and for two weeks in cold storage at 6-8°C and 85-90% RH. Guava cv. Sardar harvested at the physiological mature stage can be ripened at 20°C in 72 hours and can be preserved for 48-72 hours at ambient conditions in winter. This paper is written with view to compile the scattered knowledge concerning physiological developmental studies particularly at bud stage. Salazar *et al.*, (2006) stated that guava tree (*Psidium guajava* L.) demonstrates various phenological stages throughout vegetative period in response to climatic conditions. They have identified sixteen unlike stages, starting at bud dormancy and ending at ripening of the fruit.

Time of leaf flushing

Day from budding burst to leaf emerging ranges between 6-9 days in different guava species. However, shortest leaf flushing period was recorded in *Psidium chinensis* and subsequently followed in *P. guineense* and *P. cattleianum* while period was the longest in *Arka Kiran* (Alfia *et al.*, 2017).

Duration of flower bud initiation to full bloom

This is considered that during this period, flower bud becomes completely visible and on an average, this period varies from 19 to 23 days in different varieties. The least number of days takes by cv. *P.cattleianum* to reach full flower stage followed by *Arka Kiran*, *P.chinensis* and while *P. guineense* takes the highest number of days to full bloom (Alfia *et al.*, 2017).

Under rainy and winter season conditions cv. *Hisar Surkha* took the shortest period i.e. 27

days and 32 days, respectively, this period was the longest in while Banaras Round i.e. 36 days in the rainy season and it was interesting to note that HRS Pride took 40 days under winter conditions. Sahoo *et al.*, (2017) reported that the time of flower bud appearance also depends upon the variety of guava along with the season i.e. rainy or winter season. They also concluded that this difference might be due to environmental influence on the fruit tree.

It was noted that in different genotypes, flowering occurred during the 3rd and 4th week of April. Among different cultivars, Allahabad Safeda was first to bloom (24th April) followed by Snow White, Black guava, Lalit, Arka Amulya, and Hissar Surkha (25th April), although L-49 (Sardar) was last to flower (10th May) (Banoth, 2017).

Time of flowering

Under Hisar agro-climatic conditions, the flowering begins twice a year, particularly during spring (April-May) and then again in autumn (August-September). Lucknow-49 and Hisar Surkha bloom first in the spring and autumn. The shortened flowering periods were recorded i.e. 33 or 38 and 30 days and 37 and 40 days, respectively for Allahabad Safeda and Lucknow-49, but the longest flowering period was observed in Hisar Surkha and Hisar Safeda for the 38 or 43 and 41 or 45 days in the flowering season, both in spring and autumn. The data obtained from four cultivars showed that the autumn flowering season (38-45 days) takes a longer duration of flowering in contrast to the spring flowering season (33-44 days) because of the climate in autumn-flowering was placid which stretched the duration of flowering (Sharma *et al.*, 2017).

In *P. cattleianum* the time of flowering is June while it varied from February-April and

August-September in *P. guineense*, *P. chinensis*, and Arka Kiran. Alfia *et al.*, 2017 concluded that wild species i.e. *P. chinensis* and *P. guineense* coexist with the commercially cultivated species *P. guajava* cv Arka Kiran. Therefore, it was a suitable trait for utilization of the specific character of wild species in which hybridization can be achieved with fresh pollen to increase the chances of seed recovery and good fruit set. For example, higher fruit set and seed recovery have been achieved in mango by the use of fresh pollen.

Early pruning took less time to initiate a flower in both seasons, while the severity of pruning took time to initiate a flower. During the rainy season, the control trees on which experiment was done, no longer took time to start the flowering, as the flowers used to be present in the tree in the middle of May when counting began (mid-April, early-May, mid-May). The interaction effect was important in both seasons. For the initiation of flowering, it takes a longer period in both seasons, when plants are exposed to 30 cm in the middle of May. The early start of the new vegetative growth lead to an early initiation of flowering in early prune trees. A delaying flower initiation is the indication of late beginning of the new vegetative growth in lately pruned trees. After pruning, pruned trees immediately began new vegetative growth so that whole quantities of carbohydrates are to be used in the vegetative growth of trees, resulting in the late start of pruned trees flowering (Adhikari *et al.*, 2015).

Duration of flowering

The first-to-last-flowering duration ranged from 30 to 65 days. *P. cattleianum* (30 days) was took the lowest duration and followed by *P. chinensis* (58 days), *P. guineense* (60 days), and Arka Kiran (65 days) was taken longest duration. These effects might be due to

intrinsic species behavior. Alfia *et al.*, 2017 spotted that the reason for the least duration of flowering in *P.cattleianum* was the rapid maturation of floral buds and fruits. To avoid excess supply of fruits in the market, the knowledge about the duration of flowering in cultivars is very helpful.

Flowering occurs thrice in a year under Dharwar conditions e.g. March-April, June-July, and September-October. In India, the time of flowering in guava differs from the climatic states of a specific district. In various cultivars, the duration of the flowering period varies from 38 to 45 days in autumn and 33 to 44 days in the spring flowering season. The longer flowering time in autumn (38-45 days) than in spring, (33-44 days) may be due to the calm autumn atmosphere (Dolkar *et al.*, 2014).

Sahoo *et al.*, 2017 reported that duration of flowering across the rainy season (Ambe Bahar) crop was shortest in Hisar Safeda and L-49 (44 days) followed by Banaras Round, Allahabad Safeda and Sweta (48 days) and the longest in HRS Pride (51 days). In the winter season (Mrig Bahar) shortest flowering duration was reported in Pant Prabhat (48 days) followed by Hissar Surkha (51 days) although, the longest duration was reported in HRS Pride (52 days). In the rainy season (Ambe Bahar) crop, Hisar Surkha was the earliest to flower (3rd week of February) whereas HRS Pride and Banaras Round were last to flower (2nd week of March). In the winter season (Mrig Bahar) crop, Pant Prabhat flowered during the 2nd week of July whereas Allahabad Safeda, Shweta, HRS Pride, and Banaras Round flowered during the 4th week of July. In the Ambe Bahar crop, the course of the end of flowering varied from the 2nd week of April (L-49, Pant Prabhat) to the 1st week of May (HRS Pride, Hisar Surkha and Banaras Round). Although, in the winter season, the course of the end of flowering

varied from 1st week of September (Pant Prabhat, L-49, Hisar Safeda, Hisar Surkha) to 3rd week of September (HRS Pride). In the rainy season, Hisar Safeda and L-49 took the shortest duration for flowering (44 days) whereas HRS Pride took the longest duration for flowering (51 days). In the winter season (Mrig Bahar), the shortest duration for flowering was observed in Pant Prabhat (48 days) and longest in HRS Pride (52 days). The winter season has longer duration of flowering as compared to the rainy season.

In guava, the time and duration of flowering depends upon varietal differences and upon environmental conditions (Reddy and Kurian, 2008).

Sometimes the mixed type of flowering occurs but both lateral and terminal flowering have also been noted. The time needed for opening the first flower to the opening of the last flower was on a particular panicle. Among different cultivars, the duration of flowering varied between 39 to 52 days as showed in table 1 (Banoth, 2017).

Peak flowering

The guava cultivars nearly take 15 to 30 days to reach up to 50% flowering from the initial flowering stage. *P.chinensis* (22 days) took the shortest time to achieve 50 percent flowering stage followed by *P.guineense* (28 days) and Arka Kiran (30 days). Among the various varieties of guava, *P.cattleianum* (15 days) took the lowest number of days to reach peak flowering (Alfia *et al.*, 2017). The phenological developments in flowering as well as fruiting instances of *P.galapageium* and *P.guajava* were similar. In the two species, during comparable times, there was a complex combination of botanical buds, fruitlets, open flowers, and fruits of different sizes found. In October, flowering begins in *P.galapageium* with the completion of bloom

in February, while four months later *P.guajava* began blooming with open peak flowering in February. From August to October, *P. guajava* yielded fruit but did not

yield fruits during November and December because the fruit was spoiled due to heavy rain in November (Valdebenito, 2018).

Table.1 Flowering duration in guava genotypes

S. No	Genotype	Flowering duration (Days)
1	Allahabad Safeda	48
2	Arka Amulya	50
3	Arka Mridula	41
4	Behat Coconut	44
5	Black Guava	47
6	Hafsi Red	39
7	Hissar Safeda	47
8	Hissar Surkha	51
9	Lalit	52
10	Lucknow -49	47
11	<i>P.friedrichsthalianum</i>	48
12	<i>P.pumilum</i>	43
13	Pant Prabhath	49
14	Punjab Pink	46
15	Red peel	45
16	Red type	46
17	Sasni collections	51
18	Sasri selection	45
19	Shweta	52
20	Snow White	41
21	Sour Type	42
22	T.N selection	48
23	Thai guava	41
24	Yellow type	42

Source – (Banoth, 2017)

Anther dehiscence

Alfia *et al.*, 2017 reported that in different species of Guava, the anther dehiscence was noted and expressed in hours which was generally in the range of 7.00 to 10.00 a.m. The anther dehiscence time of various varieties of guava is as follows: *P.guineense* (7.00 to 8.00 a.m.), *P.cattleianum* (7.30 to 8.30 a.m.), Arka Kiran (7.00 to 9.00 a.m.), and *P.chinensis* (8.00 to 10.00 a.m.). Due to the similarity of anther dehiscence of wild

species with economically cultivated crops, it helps in the transfer of fresh viable pollen grains, which results in good seed and fruit set.

The first opening of flowers and another dehiscence occurred in the two seasons i.e. in spring and autumn in all cultivars during morning hours. The anthesis was related to minimum temperature while a corresponding climatic stickiness was correlated with the anther dehiscence. The peak anthesis (5.30

a.m. to 6.30 a.m.) or another dehiscence (6.00 to 8.00 a.m.) varies because of changes in flowering times and the nature of cultivars. During the opening of the flowers in different cultivars of guava and during 48 hours, the stigma became receptive, such that the stigma was not receptive before 24 hrs or one day before anthesis (Adhikari *et al.*, 2015).

Pollen viability assessment

In freshly opened flowers the, percentage of pollen germination varied between 40.23 to 80.34. The percentage of pollen germination was lowest in *P.cattleianum* (40.23) followed by *P.guineense* (62.30), *P.chinensis* (65.46), and highest in Arka Kiran (80.34). The promising results attained by wild species show their potential for crossing success. Because of the different behavior of species, *P.cattleianum* (40.23) displayed the lowest percentage of pollen germination. In *P.cattleianum* pollen, which was compatible with this analysis, Seth¹⁸ found the lowest viability. Hirano and Nakasone¹⁹⁶⁹ noted that 32% germination was showed by pollen of *P.cattleianum* while there was no germination in pollen of *P.cattleianum* var. *lucidum*, which was auxiliary with this analysis. They also pointed to high germination rates of *P.guajava* pollen (cultivars have been used n = 22 and 33), compared to high-chromosome species (Alfia *et al.*, 2017).

Pollen viability is an important condition for sexual reproduction in plants. This characteristic can be changed by plant age, environmental and genetic factors. In guava (*Psidium guajava* L.), a cross-pollination species was investigated for viability. Genetic parameters were determined by analyzing various plant ages, 22 plant genotypes, and two environments for this characteristic feature. The viability of the pollen in plant genotypes was therefore examined in two

experimental orchards (established in an arbitrary block design with two plants and three blocks per plot) over three years (2013, 2014, and 2015) and two separate regions of Espirito Santo in Brazil. The plants were analyzed at the age of 19, 24, and 38 months in 2013 and in Mimoso do Sul (ES) in 2014 and in 2015 in Linhares (ES). The flower buds were gathered, settled in ethanol: acetic acid (3:1), and held at -20°C during the stage pre-anthesis. The genetic parameters were predicted by modes of mixed models and colorimetric methods (Acetic Orcein's, Lugol dyes, and Alexander) were used to get Pollen viability. The pollen viability of these genotypes was high in all three harvests, with a cumulative average of 93.46%. The three harvests showed a small probability of predicting genetic gains based upon that characteristic, and in 2015 the mean heritability was greater, 0.583, and lower in 2013 (0.479) and 2014 (0.126). These outcomes collectively provide information concerning pollen viability of superior and commercial guava genotypes, as pollen donor genotypes are recorded to influence the fruit quality and weight characteristics of this species. Besides, these genotypes have good cross-pollination potential and can be used as crosses within breeding programs and pollinators in orchards (da Silva *et al.*, 2017).

Duration of flowering to fruit set

The varieties/species of guava typically took between 12 and 18 days from the anthesis to peanut stage. *P.cattleianum* took the lowest number of days (12 days) to obtain fruit set followed by *P.chinensis* (15 days), Arka Kiran (15 days), and *P.guineense* (18 days) (Alfia *et al.*, 2017).

Pant Prabhat has the longest flowering duration concerning fruit ripening (134 days in the rainy season and 138 days in winter) whereas Hisar Surkh and L-49 (124 days in

the rainy season and 123 days in winter) has a shorter flowering and fruit ripening period. The analytical findings of Deshpande (2006) were the same in conditions under Arabhavi, who described that the time from flowering to fruit set was 121.33 (cv. GR-1) to 125.93 (cv. CIW-5). Milan, however, recorded that the flowering to fruit ripening periods ranged from 105 to 124 days (Sahoo *et al.*, 2017).

Duration of fruit set to harvesting

The days between the fruit set (pea size) and the horticultural maturity varied from 103 to 120 days between different varieties and species of Arka Kiran. The shortest period (100 days) was noted in *P.cattleianum* followed by *P.guineense* (103 days), *P.chinensis* (120 days), and Arka Kiran (120 days). This shortest duration was important to the early production of fruit, in which time is reduced from the fruit growth to early harvest (Alfia *et al.*, 2017). For all genotypes of guava, the fruit diameter showed an increasing trend from commencing phase of fruit growth up to maturity and ripening (127 days). The increase in fruit diameter was slow down between 60 to 90 DAFS whereas it was comparatively more between 30 to 60 DAFS and 90 to 127 DAFS. This fruit growth of guava showed a double sigmoid pattern. Depending on the genotypes of the fruit set, the first and second rapid growth phases were recorded between 30 to 60 days and 90 to 127 days (Patel *et al.*, 2015).

Duration of fruiting

Alfia *et al.*, (2017) reported that the guava approximately took 60 to 120 days from first fruiting to last fruiting. They concluded that *P.cattleianum* exhibits the shortest duration (65 days) of fruiting followed by *P.chinensis* (70 days) and *P.guineense* (80). Arka Kiran took the longest duration (120 days) of fruiting. To avoid excess supply of fruits in

the market and to get a good market price, the longest duration of fruiting is very essential to get extended crop availability in the market.

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