Chapter 19

Phenological Growth Stages of Guava Cultivars under Subtropical Conditions

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Introduction

Guava fruit (***Psidium guajava*** L.) or poor man's apple is an evergreen fruit native to tropical Central America, considered a hardy fruit crop besides being rich in nutrients (Morton, 1987). It has a tendency to produce two to three crops annually offering sustained livelihood options throughout the year. Uttar Pradesh is an important guava growing state in India and best quality guavas are grown here. The best temperature for guava cultivation ranges from 15 to 30 ^{0}C, with an annual average temperature of 18.8 ^{0}C (Somarriba, 1985b). During vegetative growth-guava tree undergoes several physiological changes that are identified because of external signs, such as shoot growth, bud swelling and break, increments in trunk diameter as well as reproductive phases like flower initiation, fruit setting and ripening. Nutritive value of guava is high. Therefore, it is an ideal fruit for nutritional security (Chadha, 2015).

The sequential study of all periodical events involved in a plant life is called 'phenology' (Volpe, 1992; Villalpando and Ruiz, 1993; Schwartz, 1999). Beginning and end of every developmental phase and stage contributes to evaluate plant growth rates (Torres, 1995). Phenological growth is the interval between two different phases (Villalpando and Ruiz, 1993). Different type of phenological indicators are used to moniter and evaluate plant development. Blooming time and fruit ripening is the most significant stage in plants. The interval between blooming and fruit set is one of the most important phenological stages (Villalpando and Ruiz, 1993).

In herbaceous and woody plants a new nomenclature was described by Bleiholder *et al.* (1989). The BBCH general scale applicable was specific to different botanical families into a general scale applicable to all plants. A detailed version of BBCH scale was published by Stauss (1994). First stages refer to its major stage using value from zero to nine and second digit also scaled from zero to nine that relates to its secondary stage of plant growth.

The several authors classify different plant families; like cereals by Zadoks *et al.* (1974), rape, bean and sunflower by Lancashire *et al.* (1991), beet by Meier *et al.* (1993), potato by Hack *et al.* (1993), stone and pip fruits, redcurrant and strawberry by Meier *et al.* (1994), Japanese loquat tree (***Eribotrya japonica*** Lindl.) by Martinez-Calvo *et al.* (1999) , vine, several vegetables and citrus species by Lorenz *et al.* (1994), Feller *et al.* (1995) and Agusti *et al.* (1995), respectively.

The objective of this study was to study the phenological stages of different guava cultivars in sub-tropical condition. The techniques of recording the phenological stages were allowing the exact stage of evolution to be determined at any time during these physiological changes.

Materials and Methods

The experiment was conducted at ICAR- Central Institute for Sub-tropical Horticulture Rehmankhera, Lucknow in randomized block design with three replications in order to analyze phenological stages of guava. The experiment was done with six treatments comprising of six commercial guava cultivars ('Lalit', 'Shweta', 'Allahabad Safeda', 'Chittidar', 'Dharwar' and 'HPSI-46'). Phenological stages were determined for each cultivar. Three branches, which had almost similar morphological conditions, were selected for recording phenological stages regularly. Age of different guava cultivars was from 10 to 12 years. Each tree was planted at 5×5 meter spacing; soil of orchard was sandy loam. Guava plants were irrigated by ridge and furrow method. Highest and lowest mean monthly temperature was recorded 39.8 and 5.3 °C, respectively. Relative humidity ranged from 63.3 to 88.3 per cent and total annual rainfall of 553.2 mm was recorded (Anonymous, 2015). Five plants of each guava cultivars were selected and three branches were marked as replication for data collection; hence thirty guava plants with 90 branches were selected for the study.

Gil-Albert (1989) reported that techniques of recording the phenological stages permitted the study of growth and development of vegetative and reproductive organs of different plant species, allowing the exact stage of evolution to be determined at any time during these physiological changes. Frequency of visit in guava orchard ranged from one week to two weeks, depending upon the change in phenology of guava. Good quality photographs were taken for later analysis. There were rapid growth in guava from bud break to fruit enlargement; hence the orchard was visited one to two days interval. Fruit diameter was measured by vernier calliper. Phenological stages of guava of different cultivars were observed according to BBCH (Biologische Bundesanstalt, Bundessortenamt und Chemische Industrie) scale and different stages data were recorded in days.

Results and Discussion

Phenological studies are very useful to know the periodicity of life-cycle of fruit trees for better agronomical management. The extended BBCH (Biologische Bundesanstalt, Bundessortenamt und Chemische Industrie) scale can provide more accurate and detailed description of the most important phenological events than any of the other coding systems for guava (Table 1). Phenological stages (in days) with their respective codes are given in Table 1 and Fig. 1. The development stage in different guava cultivars stats from swelling of bud to ripening of fruit. Collected data was subjected to analyze in excel sheet. Details of phonological stage and its description are given in Table 2.

Table 2: Details of phonological stage

BBCH scale	Phonological stage	Description
00	Winter bud	The bud is greenish brown and completely closed. It is closely linked to the twig
01	Bud swelling	The bud swells and becomes greenish
02	Bud growth begins	The bud gets longer, and scales start opening
11	First leaves sprouting	The first leaf appears and becomes visible
15	More leaves unfolded	Not yet at full size
19	Leaves completely developed	Leaf growth completed
51	Appearance of flower buds	Calyx becomes visible. Internodes lengthening stops
55	Flower buds visible	Sepals still closed
57	Flower petals elongating	Sepals slightly open petals just visible
59	Sepals totally open	Sepals fully extended so that petals can open
65	Full flowering	At least 50% of flowers open. First petal falling
67	Petal fall	Flowers fading and most petals collapse
71	Fruit setting	Fruit size upto 10 mm
78	Fruit growth	Fruit increase upto 80% of final size
81	Fruits colour changing	Beginning of ripening; fruit reaching its final volume. Colour changing from green to yellowish pale green
89	Fruit ripening	Fruit reached final volume and become completely yellow. Releasing pleasant aroma, and fruit right for consumption

In guava, vegetative growth normally includes bud, leaf and shoots development. Results from Table 2 revealed that from bud to first leaf development it takes about (10-12 days). It takes 9-12 days to complete leaf development. Appearance of flower buds takes 1-3 days and flowers bud became visible from 2-3 days. Elongation of flower

petals takes 15-19 days in different cultivars. It was observed that sepals totally opened 8-10 days. Flowers 50% opened ranged from 2-3 days. Fruit set started from 2-3 days. Fruit growth was completed in 95-112 days in different cultivars (Table 1). Fruit colour changes from 5-7 days and fruit ripens in 6-10 days. Growth of guava fruit shows the double sigmoid pattern described by Araujo *et al.* (1997), Mercado-Silva *et al.* (1998) and Selvaraj *et al.* (1999). It is shown in Fig. 2, which have similar growth trend. The stages from fruit set to guava physiological maturity takes 119 to 130 days reported by Laguado *et al.* (1999) and Mercado-Silva *et al.* (1998). Somarriba (1985a) found in his study that guava reaches in maturity 90-150 days after anthesis.

Fruit growth of guava was monitorised from fruit set to fruit maturity. It is clear from the Fig. 2 that guava fruit follows the double sigmoid growth curve. During the entire study, total 130 days cycle and three stages were identified. First stage went to 55 days and it is characterized by an exponential growth due to cell division and enlargement of guava fruit (Garces, 1987) at the end of this stage guava reached 30 mm average fruit diameter. Second stage took from 56 to 80 days after fruit set. Guava growth clearly slowed down (up to 36 mm) because of cell division and enlargement reductions caused by endocarp hardening (Barcelo *et al.*, 1992). Physiological maturity of guava came 130 days after fruit set. Maximum growth of fruit diameter was recorded in this stage due to water and solute accumulations within cell vacuoles (Coombe 1976; Garces 1987). At this stage guava reached 57.5 mm diameter.

After identification of the phenological stages of guava, the different activities like pruning time, pesticide application, application of growth regulators, irrigation and maturity dates can be performed at appropriate time. Hence, knowledge of phenological stages of six guava cultivar can be useful for farmers.

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