

Floral Phenology and Maturity Indices in Avocado

Large numbers of Indian farmers are unaware of the flowering behaviour and stage of optimum maturity to harvest. Basically, under favourable conditions, each flower of avocado opens twice over a 24 hour period, firstly as functional female and later as functional male. This favours the cross pollination in avocado crop. In a large number of avocado cultivars, identification of the optimum harvesting stage is very difficult due to its peak climacteric nature and absence of visible phenotypic changes at matured stage. However, in some cultivars, optimum maturity is indicated by changes in fruit surface colour and dropping of few fruits naturally from the trees. However, these are not considered scientific methods to harvest avocado fruits. Hence, knowing the flowering behaviour and stage of optimum maturity is most important for avocado farmers to harvest fruits at the right stage of maturity and to get more profit.

AVOCADO (*Persea americana* Mill.) is an important commodity in the international fruit trade. There are three distinct races of avocado (Mexican, Guatemalan and West Indian), that vary in their shape, size and fat content. These are sometimes categorized as subtropical, semi-tropical and tropical. Earlier in India, avocado was grown mainly as a backyard crop in the states of Kerala, Karnataka, Tamil Nadu and coastal Maharashtra.

From the recent past, Indian farmers have shown more interest in the commercial cultivation of avocado due to its high demand in the market. However, not much information is available to farmers regarding avocado flowering and the stages of fruit growth and development to harvest at proper stage of maturity. Avocado flowers are different from flowers of other fruit crops. They open twice a day which encourages cross pollination between Type A and Type B cultivars. Identification of proper horticultural maturity is difficult in avocado as its maturity is not quantifiable by changes in external appearance. Thus, it is difficult to judge in advance whether fruit has matured satisfactorily or not. However, several studies have been conducted for the identification of maturity indices in avocado fruit. As a result, some attributes like fruit colour,

weight, volume, oil content and dry matter have been recommended as measurable indices to identify maturity. Additional information on its maturity can be obtained from biochemical studies. A mature avocado is one that has attained acceptable stage so that, when picked from plant it will ripen to edible condition with satisfactory taste and flavour specific to the cultivar.

Avocado cultivation in India

Avocado cultivation in India is gaining popularity and is mainly concentrated in the southern and western parts of the country, where the climate is more suitable for avocado trees. The most common avocado variety grown in India is the Hass avocado, known for its creamy texture and rich flavour. Other varieties are also cultivated depending on the specific region and climatic conditions. Recently, ICAR-Indian Institute of Horticultural Research, regional station, IIHR-CHES, Chettalli, has released two avocado varieties viz. Arka Supreme and Arka Coorg Ravi for commercial cultivation in India.

The demand for avocado has been increasing in India, primarily due to changing dietary habits and a growing awareness of the fruit's health benefits. Avocados are consumed both fresh and in





		Day 1		Day 2	
		Morning	Afternoon	Morning	Afternoon
Cultivar type	A	♀			♂
	B		♀	♂	

Flowering behaviour of avocado tree

various processed forms. Along with this, some state governments started initiatives and schemes to promote avocado cultivation. Farmers may receive support in terms of subsidies, technical guidance and access to quality planting material. All this may encourage Indian farmers to cultivate avocado on a commercial scale.

Flowering behaviour of avocado

Avocado flowering is a crucial stage in the life cycle of an avocado tree, as it marks the beginning of fruit development. Avocado trees flower profusely, producing 1-10 lakh flowers. Even with so many flowers, yield is typically low. Indeed, fruit set ranges between 0.001 and 0.23%, depending on cultivar and climatic conditions. Thus, avocado has earned a reputation as a shy and erratic bearer. Flowers are complete and perfect with a rare flowering mechanism called ‘protogynous diurnally synchronized dichogamy’ (PDSD). The flowering season varies depending on the specific avocado variety and the region in which the tree is planted. In India, avocado trees start flowering in the month of December and continue up to February. In some regions, avocado can flower multiple times a year.

Based on flowering morphology, avocado cultivars are

categorized into two types *viz.* Type A and Type B. Type A trees flowers open as functional female in the morning and close in the evening and again in the following day, it opens as a functional male in the afternoon. While, Type B trees open as functional females in the afternoon and functional male in the next day morning. Having both types of trees nearby can improve cross pollination. Understanding the factors influencing avocado flowering can help growers optimize conditions for a successful harvest. Local climate, soil conditions and proper care practices all contribute to the overall health and productivity of avocado trees.

Flowering to fruit maturity

After successful pollination, the fertilized ovaries begin to develop into fruit. Fruit enlargement occurs rapidly as a result of high rate of cell division and expansion, but unlike other fruit, cell division continues throughout fruit development phase. The initial stages of fruit development are critical and the factors like weather conditions and pollination success play key roles. The young fruit starts to grow and proper care and suitable environmental conditions help for healthy development. Adequate water, nutrients and protection from pests and diseases contribute to robust fruit growth. Avocado fruit matures on the tree and the time it takes varies based on the avocado variety and environmental conditions. It usually takes several months to reach maturity. Mexican type matures within 6-8 months after flowering while West Indian and Guatemalan race matures within 9 and 9-12 months, respectively. Many cultivars of commercial significance are hybrids of these three races. The fruit softens and changes colour, indicating that it is ready for harvest. It is essential to note that avocado trees can have a natural variability in fruit development and some fruit drop may occur during the early stages of growth. Adequate care and attention contribute to a successful fruit set and maturation process.

Physico-chemical changes during avocado fruit growth and development

Avocado fruit growth and development involve a series of physico-chemical changes that contribute to the maturation of the fruit. The process can be divided into several stages, each characterized by specific event. Following are some key physico-chemical changes that occur during avocado fruit growth and development.

Cell division and elongation: During the early stages of fruit development *i.e.* 30 to 90 days after fruit set (DAFS), there is rapid cell division and elongation. The fruit and seed weight increases with simultaneous increase in fruit length, width and volume as cells divide and expand. Fruit shape changes majorly during the rapid growth and development stages (*i.e.* 30 to 120 DAFS).

Specific gravity: Specific gravity of avocado fruit decreases as the fruit advances in growth and development. At full maturity (150 DAFS), it will be around 1.00 (Table 1).

Water Content: Water content in the fruit is initially high but decreases as the fruit matures. Water loss can contribute to changes in fruit texture and firmness.

Accumulation of dry matter: As the fruit matures, there

Table 1. Changes in physical parameters of avocado fruit (Acc. CHES–HA–II/I) during different stages of growth and development

DAFS	Physical parameters						
	Fruit weight (g)	Fruit length (cm)	Fruit width (cm)	Shape index	Fruit volume (cc)	Specific gravity	Seed weight (g)
Day 30	0.55	1.16	0.46	3.18	0.43	1.27	0.02
Day 60	19.83	5.08	2.79	1.81	16.33	1.23	1.92
Day 90	219.22	12.38	5.73	2.16	189.67	1.16	16.32
Day 120	259.32	13.28	6.68	2.00	233.33	1.11	21.84
Day 130	311.78	13.60	7.08	1.92	295.17	1.06	23.29
Day 140	391.76	14.02	7.92	1.77	381.53	1.03	35.10
Day 150	485.29	15.17	8.43	1.80	480.40	1.00	40.25

Table 2. Changes in chemical composition of avocado fruit (Acc. CHES–HA–II/I) during different stages of growth and development

DAFS	Chemical parameters					
	Total soluble solids (°Brix)	Titratable acidity (%)	TSS: acid ratio	Insoluble carbohydrates (%)	Fat (%)	Proteins (%)
Day 30	10.03	1.25	8.17	1.30	1.00	0.60
Day 60	12.10	1.16	10.44	1.83	3.67	1.18
Day 90	10.53	1.03	10.30	2.57	9.33	2.51
Day 120	10.40	0.94	11.11	3.91	15.07	3.83
Day 130	9.57	0.76	12.75	5.63	16.53	4.14
Day 140	9.50	0.65	13.86	5.75	17.07	4.15
Day 150	9.23	0.60	15.39	5.83	18.33	4.17

is an accumulation of dry matter, including carbohydrates, fat and proteins. The increase in dry matter contributes to the overall growth and development of avocado fruits.

Sugar accumulation: Avocado fruit undergoes a period of sugar accumulation during rapid developmental stage. Glucose and fructose are the primary sugars that deposit in the fruits.

Fat biosynthesis: Avocado fruit is rich in monounsaturated fatty acids and majority of its synthesis takes place during rapid fruit growth and development stages. The predominant fatty acids present in avocado fruit are oleic acid, linoleic acid, linolenic acid and palmitic acid. The concentration of fat increases as the fruit matures.

Chlorophyll degradation: Avocado fruits undergo a transition from a green to a darker colour as chlorophyll degrades. This colour change is associated with the maturation process.

Ethylene production: Ethylene is a plant hormone that plays a crucial role in avocado fruits. Ethylene production increases during the later stages of fruit development.

Other biochemical changes: Fruit acidity, insoluble carbohydrates and protein content also play an important role in judging fruit maturity. As the fruit matures, acidity decreases and insoluble carbohydrate and protein content increases.

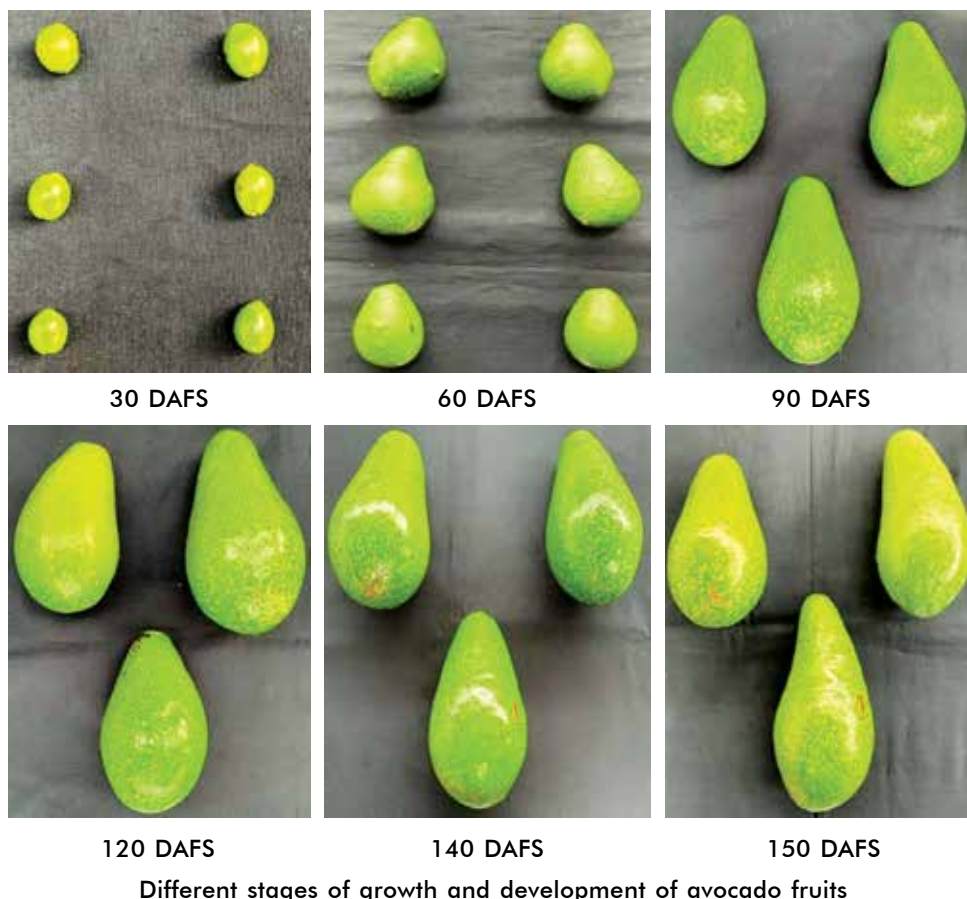
Understanding these physico-chemical changes

during avocado fruit growth and development is essential for growers, researchers and the avocado industry to optimize harvesting times and postharvest handling practices to ensure the delivery of good quality fruits to consumers.

Identification of optimum stage of maturity in avocado

Avocado fruits are harvested based on various maturity standards in different parts of the world. However, fat content is the most widely used maturity index by majority of the avocado growers. In general, total soluble solids and acidity decrease while carbohydrates, protein and fat content increase with advancement in fruit growth and development. The specific gravity will be higher at immature stage and gradually decrease during the growth phase (Table 1). Among all the parameters,





size and shape of the particular cultivar, farmers can harvest the matured fruits in the current season.

Mature fruit drop: Some avocados will naturally fall from the tree when they are mature. However, it is not advisable where avocados are affected by high wind speed during fruit development and maturation stage.

However, standards for maturity index vary from cultivar to cultivar. Therefore proper information and understanding of these physico-chemical changes in the fruit is crucial to identify and harvest fruit at the right stage of maturity.

Optimum maturity and its effect on fruit quality

Optimum maturity has a great impact on the physiological weight loss, changes in fruit colour, total soluble solids, acidity, ascorbic acid and total antioxidant capacity of fruits. It has direct effect on fruit quality and shelf life during post-harvest management. Several studies have confirmed that over-mature or immature fruits have lesser shelf life than optimum matured fruits. These fruits are more prone to moisture loss, mechanical injuries, post-harvest decay and inferior quality along with poor marketability. Parameters such as

specific gravity of 1.00 could be used as a non-destructive maturity index while fat content can be taken as destructive maturity index. The ideal harvesting period for commercial purposes is between 140-150 DAFS, when avocado is grown under Bengaluru/Tumakuru, Karnataka conditions.

General tips for identifying the optimum stage of maturity in avocado

Skin colour: The most common variety, Hass changes colour as they mature. It is usually green when unripe and turn purplish-black as they mature. However, the colour alone is not always a reliable indicator, as some fruits may still be firm and unripe even when they have turned dark.

Stem method: Easy detachment of the small stem or cap at the top of the avocado fruit with green surface underneath the stem indicates that the fruits are matured. While if it is difficult to remove or if you see brown underneath, the avocado may not have attained optimum maturity.

Fruit size and shape: Avocado should have a consistent and regular shape. Based on previous observations on fruit

DAFS, fruit weight, total soluble solids, specific gravity and fat content, etc., are considered as critical determinants for deciding the optimum maturity in avocado.

SUMMARY

Harvesting avocado at the optimum stage of maturity is crucial to ensure good flavour, texture and overall quality of the fruit. Harvesting time is influenced by factors such as the avocado variety, climate and local growing conditions. The specific conditions for harvesting may vary based on the avocado variety and local growing conditions. It is essential to observe the individual characteristics of the avocado trees in the orchard and adjust harvesting practices accordingly. By this, farmers can get more profit and consumers will also be satisfied with good quality fruits.

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