



## Harvest maturity for low chill cultivars of peach under mid hill conditions of Himachal Pradesh

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### ABSTRACT

The experiment was laid out on 10 years old plants of four commercial low chill cultivars namely; Tropic Sweet, Early Grande, Florida Prince and Pratap. The whole program of study was split into two experiments. First experiment was carried out in Randomized Block Design (RBD) for standardization of optimum harvest maturity for these cultivars. The second experiment was conducted to elucidate the relative storage performance of peach cultivars, harvested at different maturity levels for one week at ambient temperature. Among different maturity indices, days from full bloom (DFFB), fruit colour, TSS and Total sugars were found to be the most reliable indices of maturity for low chill cultivars under study. On the basis of physico-chemical characteristics and storage behaviour of fruits for one week at ambient temperature, 102 DFFB for Tropic Sweet, 93 DFFB for Early Grande, 87 DFFB for Florida Prince and 89 DFFB for Pratap were adjudged as the optimum harvest dates.

**Key words:** *Prunus persica*, maturity, low-chill cultivars, physiological weight Loss.

### INTRODUCTION

Peach is an important fruit crop in the temperate regions of the world. Peaches are considered a good source of nutrients, vitamins and minerals. The peaches are commercially cultivated in areas located at a latitude of 10° to 49° N and 18° to 45° S (Kumar *et al.*, 11). The changing global climatic scenario has extended the cultivation of low-chill cultivars of peaches in mid-hills of north-western Himalayan region. The area under peach cultivation in India is 19,000 ha and the total production is 1,22,000 MT. It is cultivated in Jammu and Kashmir, Himachal Pradesh, Punjab, Uttarakhand, Nilgiri hills, Jharkhand and north-eastern states. In Himachal Pradesh, the area under peach cultivation is 5,042 ha with an annual production of 7,292 MT (NHB, 1).

Peach is the most preferred and legendary fruit among stone fruits and is grown under low temperatures in hilly areas of the temperate world. Due to their exciting colours and high texture, peaches are generally valued for their fresh and canned fruits. Now the peach has become a pride to poor and marginal hilly farmers of sub-mountainous and plains areas of northern India and southern hills. It is also cultivated in irrigated arid and plateau ecosystems (Gupta and Jawandha, 6). The performance of peach is quite good under mid-hill conditions of the Himalayas. With the advent of crop improvement programs, affords have been made to develop peach cultivars with a relatively less chilling

requirements which are suitable for mid and foot-hill elevations. Recently, some traditional cultivars of peach have shown a decline in production in the mid-hills of Himachal Pradesh, mainly due to the changing climate. The introduction of low-chill peach cultivars in the subtropical plain areas of Northern India have extended their scope for cultivation in the mid-hills under changing climatic scenario (Kuden *et al.*, 10).

Peaches harvested at immature stage may fail to ripen properly or may ripen abnormally. The immature fruits soften slowly and never reach the desired melting texture of fully mature fruit. Green ground colour of immature fruit may also persists. The immature fruits lack fully developed surface cuticle, characteristic aroma and are more susceptible to water loss than the properly matured fruits. Normal shelf-life of commercially available peach is 3-5 days under ordinary environmental conditions (Tonini and Tura, 16). The major bottlenecks in commercial cultivation of peach are lack of information on low chill cultivars as an alternative to existing cultivars in the mid hills of Himachal Pradesh with respect to their maturity indices and postharvest life.

### MATERIALS AND METHODS

The present investigation was carried out in the experimental block of the Department of Fruit Science, Dr. YSP University of Horticulture and Forestry, Solan (HP) during the period from 2019 to 2020. The region falls under the sub-temperate, mid-hills agro-climatic zone of Himachal Pradesh

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with an average annual precipitation of 100-130cm. The experiment was laid out on 10 years old plants of four commercial low chill cultivars namely; Tropic Sweet, Early Grande, Florida Prince and Pratap. The selected experimental trees were uniform in size and planted at a spacing of 4.5m × 4.5m. The experiment was laid out in a Randomized Block Design with seven treatments and each treatment was replicated thrice. The fruits of all four cultivars were harvested on seven different dates and fruits from each harvest were subject to one-week storage at ambient temperature.

The days from full bloom to harvest (DFFB) were counted from the number of days taken from full bloom to harvest. The average fruit weight was estimated on the electronic top pan balance. The surface colour of the fruit was observed by comparing it with the colour chart of the Royal Horticultural Society, London. The total soluble solids (%) and fruit firmness (lb/inch<sup>2</sup>) was determined with an Erma hand refractometer (0-32° Brix) and Magness-Taylor Pressure Tester, respectively. The pulp-to-stone ratio was worked out by dividing the weight of flesh by the weight of the stone. The Titratable acidity and total sugars content was estimated according to the standard procedure (A.O.A.C, 2). The percent physiological loss in weight was determined by loss of fruit weight during one-week storage at ambient storage which was expressed as a percent of the initial weight. The data obtained from these observations were appropriately computed, tabulated, and analysed according to Randomized Block Design (RBD) (Gomez and Gomez, 5).

## RESULTS AND DISCUSSIONS

The data presented in Table 1 revealed the number of days taken from full bloom (DFFB) to harvest for different peach cultivars under study. The fruits were picked at 84-102, 81-99, 78-96, and 80-98 DFFB in Tropic Sweet, Early Grande, Florida Prince, and Pratap, respectively, for standardization of harvest maturity. Based on physico-chemical characteristics of the fruits and storage behaviour for one week at ambient temperature, the cultivars Tropic Sweet, Early Grande, Florida Prince and Pratap attained optimum harvest maturities at 102 DFFB, 93 DFFB, 87 DFFB and 89 DFFB, respectively. The fruit development in peach starts in the first week of March and is rapid for next 22 days, after that it shows slow development upto for 56 days, followed by a rapid growth for 21 days. A large number of maturity indices, such as days after full bloom (DAFB), fruit size, firmness, sugar, acidity, starch, and sugar/acid ratio have been used to judge optimum harvest maturity. These results are supported by the findings of Khajuria *et al.*, (8) and Babu and Yadav (3)

The observations on the fruit colour revealed that in Tropic Sweet, Yellow Green Group to Orange Red Group 34A was obtained on the 7<sup>th</sup> sampling date and in Early Grande, Yellow Green Group (142C) changed to Orange Red Group from 34A on the 5<sup>th</sup> sampling date. However, Florida Prince exhibited the fruit colour change from Yellow Green Group 145B to Orange Red Group 34A on the 4<sup>th</sup> sampling date, and Pratap fruit also changed from Yellow Green Group 142B to Orange Red Group 34B on the 4<sup>th</sup>

**Table 1.** Effect of picking maturity on DFFB and fruit colour of low chill peaches.

Code	Harvest Date	Days from full bloom				Fruit colour			
		Tropic Sweet	Early Grande	Florida Prince	Pratap	Tropic Sweet	Early Grande	Florida Prince	Pratap
D <sub>1</sub>	May,06	84	81	78	80	Yellow Green Group 145B	Yellow Green Group 142C	Yellow Green Group 145B	Yellow Green Group 142B
D <sub>2</sub>	May,09	87	84	81	83	Yellow Green Group 145C	Yellow Orange Group 20B	Yellow Green Group 145C	Yellow Green Group 150C
D <sub>3</sub>	May,12	90	87	84	86	Yellow Green Group 150B	Yellow Orange Group 23C	Orange Red Group 34B	Orange Red Group 33C
D <sub>4</sub>	May,15	93	90	87	89	Yellow Green Group 151B	Orange Red Group 33C	Orange Red Group 34A	Orange Red Group 34B
D <sub>5</sub>	May,18	96	93	90	92	Orange Red Group 33C	Orange Red Group 34A	Orange Red Group 34A	Orange Red Group 34B
D <sub>6</sub>	May,21	99	96	93	95	Orange Red Group 31B	Orange Red Group 34A	Orange Red Group 34A	Orange Red Group 34B
D <sub>7</sub>	May, 24	102	99	96	98	Orange Red Group 34A	Orange Red Group 34A	Orange Red Group 34A	Orange Red Group 34B

sampling date. The development of the red colour in peaches also depends on exposure to light. Kurnaz and Kaska (12) observed that the green ground and flesh colour of the fruit were gradually replaced by yellow as stage III began in peach. The intensity of red skin colouration increased until maturation but decreased towards fruit ripening.

Fruit weight recorded on different sampling dates exhibited an increase with the advancing maturity in all the cultivars, but the rate of increase was non-significant on a particular date of sampling depending upon the cultivars (Table 2). A rapid increase in fruit weight was observed upto the 7<sup>th</sup> sampling date in Tropic Sweet and the 5<sup>th</sup> sampling date in Early Grande, whereas, Florida Prince and Pratap cultivars noticed a significant increase in fruit weight upto the 4<sup>th</sup> sampling date. Thereafter, the fruit weight followed a marginal increase. Khajuria *et al.*, (8) and Babu and Yadav (3) reported that average fruit weight increased by 2-4 g/day during the final stage of ripening and the rate of increase is steadied near harvest maturity.

Fruit firmness declined gradually till the 5<sup>th</sup> harvesting date in tropic sweet and significantly thereafter, recording the lowest fruit firmness (8.45 lb/inch<sup>2</sup>) on the 7<sup>th</sup> harvesting date. Similarly, the fruit firmness declined marginally upto the 5<sup>th</sup> sampling date (9.75 lb/inch<sup>2</sup>) in Early Grande and declined thereafter at a faster pace. The cultivars, namely; Florida Prince and Pratap recorded a significant decline in fruit firmness upto the 4<sup>th</sup> sampling date, recording 10.03 and 10.15 lb/inch<sup>2</sup> fruit firmness values, respectively. The modifications in cell wall ultrastructure, cell wall polysaccharides, and the activities of some enzymes involved in cell wall degradation during the development and ripening of peach fruit from immature to over-ripe hence, both the firmness of the fruit and the production of ethylene went down (Kan *et al.*, 7). The fruit pulp stone ratio increased rapidly in the initial harvesting dates in all the cultivars, but the rate of increase was slower down with the advancing maturity (Table 2). However, the pulp stone ratio increased rapidly upto the 7<sup>th</sup> date of sampling in Tropic Sweet, Early Grande and Florida prices, recording 13.07, 22.94 and 18.18, respectively. The cultivar Pratap recorded significant increase in pulp stone ratio upto the 6<sup>th</sup> sampling date (21.46).

The data recorded on the periodic changes in total soluble solids (TSS) and total sugars during fruit maturity are presented in Table 3. It is revealed that TSS content and total sugars increased significantly throughout the sampling period. The highest (15.81%) TSS values were recorded on the 7<sup>th</sup> harvesting date in Tropic Sweet, Early Grande (13.85%), Florida

**Table 2.** Effect of picking maturity on the fruit weight, firmness and pulp stone ratio of low chill peaches.

Code	Harvest Date	Fruit Weight (g)			Fruit firmness (lb/inch <sup>2</sup> )			Fruit Pulp Stone Ratio									
		Tropic Sweet	Early Grande	Florida Prince	Pratap	Mean	Tropic Sweet	Early Grande	Florida Prince	Pratap	Mean						
D <sub>1</sub>	May,06	42.53	54.59	58.89	68.47	56.12	10.18	10.31	10.28	10.43	10.30	4.18	9.46	5.88	11.03	7.64	
D <sub>2</sub>	May,09	49.05	61.05	64.83	74.05	62.25	10.16	10.27	10.26	10.41	10.28	6.53	13.09	8.70	11.04	9.84	
D <sub>3</sub>	May,12	54.52	67.83	69.47	81.15	68.24	10.09	10.19	10.21	10.31	10.20	7.35	13.21	10.34	12.26	10.79	
D <sub>4</sub>	May,15	59.83	79.46	74.37	85.24	74.73	9.93	9.98	10.03	10.15	10.02	8.81	14.05	10.72	12.56	11.54	
D <sub>5</sub>	May,18	65.05	85.27	74.39	85.37	77.52	9.68	9.75	9.76	9.97	9.79	10.47	19.12	12.70	17.96	15.06	
D <sub>6</sub>	May,21	70.60	85.37	74.48	85.49	78.99	8.56	8.25	8.23	8.56	8.40	12.64	20.25	15.50	21.46	17.46	
D <sub>7</sub>	May,24	72.10	85.74	74.94	85.92	79.68	8.45	7.89	7.25	7.78	7.84	13.07	22.94	18.18	21.50	18.92	
Mean		59.10	74.19	70.20	80.81		9.58	9.52	9.43	9.66		41.37	9.01	16.02	11.72		
LSD <sub>0.05</sub>																	
Cultivars(C)				1.16					0.15								0.21
Dates(D)				1.54					0.20								0.28
C×D				3.08					0.40								0.56

**Table 3.** Effect of picking maturity on chemical characteristics of low chill Peaches at harvest.

Code	Harvest Date	TSS (%)			Total sugars (%)			Titratable acidity (%)			Sugar acid ratio								
		Tropic Sweet	Early Grande	Florida Prince	Mean	Tropic Sweet	Early Grande	Florida Prince	Mean	Tropic Sweet	Early Grande	Florida Prince	Mean						
		10.55	11.53	10.32	11.51	10.98	7.39	8.07	7.22	8.06	0.97	0.94	0.91	0.93					
D <sub>1</sub>	May,06	10.55	11.53	10.32	11.51	10.98	7.39	8.07	7.22	8.06	0.97	0.94	0.91	0.93	7.62	8.59	7.93	8.67	8.20
D <sub>2</sub>	May,09	12.14	12.35	11.15	12.61	12.06	8.62	8.77	7.92	8.95	0.89	0.91	0.86	0.84	9.69	9.64	9.21	10.65	9.80
D <sub>3</sub>	May,12	13.78	12.68	12.69	13.32	13.12	9.92	9.13	9.14	9.59	0.85	0.87	0.81	0.8	11.67	10.49	11.28	11.99	11.36
D <sub>4</sub>	May,15	14.64	13.05	13.25	14.27	13.80	10.69	9.53	9.67	10.42	0.83	0.77	0.72	0.74	12.88	12.38	13.43	14.08	13.19
D <sub>5</sub>	May,18	15.17	13.43	13.49	14.46	14.04	11.23	9.94	9.69	10.70	0.78	0.73	0.69	0.69	14.4	13.62	14.04	15.51	14.39
D <sub>6</sub>	May,21	15.49	13.75	13.84	14.66	14.44	11.62	10.31	10.38	11.00	0.72	0.72	0.68	0.68	16.14	14.32	15.26	16.18	15.48
D <sub>7</sub>	May,24	15.81	13.85	13.97	14.71	14.59	11.86	10.39	10.48	11.03	0.65	0.71	0.67	0.68	18.25	14.63	15.64	16.22	16.19
Mean		13.94	12.95	12.62	13.65		10.19	9.45	9.21	9.96	0.81	0.81	0.76	0.77	12.95	11.95	12.4	13.33	
LSD <sub>0.05</sub>				0.26				0.18				0.01					0.19		
Cultivars(C)				0.35				0.23				0.02					0.25		
Dates(D)				0.69				0.47				0.03					0.49		
CxD																			

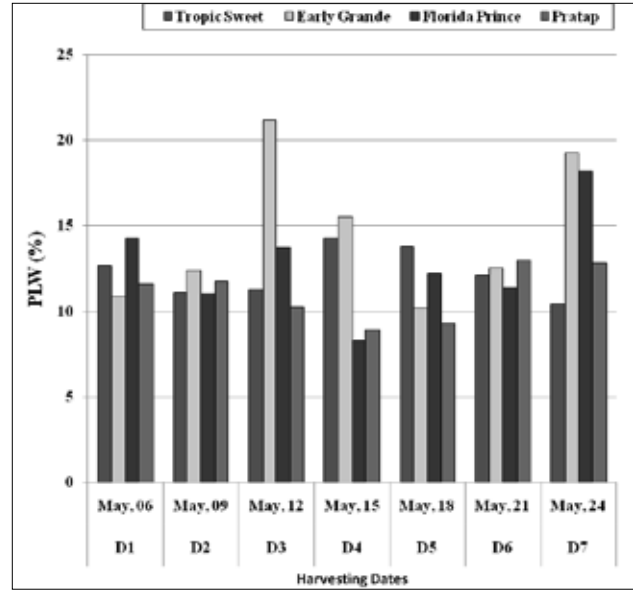
Prince (13.97%) and Pratap (14.71%). The total sugars increased significantly upto the 7<sup>th</sup> sampling date in Tropic Sweet, upto the 5<sup>th</sup> sampling date in Early Grande and the 6<sup>th</sup> sampling date in Florida Prince and Pratap cultivar recordings, 11.86, 9.94, 10.38 and 11.00 percent in Tropic Sweet, Early Grande, Florida Prince and Pratap, respectively. The significant rise in sugars and soluble solids content and a decrease in citric and malic acids after harvesting (Ozelkok *et al.*, 13). Prerak and Kaul (15) reported that the total soluble solids content varied from 13.4° in Shan-i-Punjab to 13.80°B in Florida Sun.

It is evident from the data illustrated in Figure 1 that per cent physiological loss in weight (PLW) after one-week storage at ambient temperature was recorded to be the highest in fruits from earlier sampling dates in all the cultivars. The lowest PLW was found on the seventh sampling date for Tropic Sweet, the 5<sup>th</sup> sampling date for Early Grande, and the 4<sup>th</sup> sampling date for both Florida Prince and Pratap. Table 4 showed the data on the TSS of peach fruits after one week of storage at room temperature as influenced by different harvesting dates. It is revealed that TSS increased significantly till the 3<sup>rd</sup> harvesting date in Tropic Sweet and thereafter a gradual increase was observed upto the 7<sup>th</sup> harvesting date. The highest (17.39%) total soluble solids as recorded on 7<sup>th</sup> harvesting date. Similarly, the TSS contents of other cultivars increased gradually with the advancement of picking maturity. However, the rate of increase was slower down after 5<sup>th</sup> picking date in Early Grande and the 4<sup>th</sup> sampling date in Florida Prince and Pratap. The highest TSS contents were recorded for the aforesaid cultivars on the 7<sup>th</sup> picking date, recording 15.24%, 15.37% and 16.18% in Early Grande, Florida Prince and Pratap, respectively. The data presented on the titratable acidity after one-week storage of fruits revealed a significant declining trend upto the 7<sup>th</sup> harvesting date in all the cultivars understudy. The lowest titratable acidity was recorded on 7<sup>th</sup> harvesting dates in Tropic Sweet (0.48%), Early Grande (0.53%), Florida Prince (0.50%) and Pratap (0.50%). The observations on the TSS acid ratio revealed that the TSS acid ratio increased significantly upto 7<sup>th</sup> picking date in Tropic Sweet, 6<sup>th</sup> picking date in Early Grande, 4<sup>th</sup> picking date for the cultivar Florida Prince and 5<sup>th</sup> picking date for Pratap (Table 4), recording 36.23, 28.02, 26.51 and 30.60 for Tropic Sweet, Early Grande, Florida Prince and Pratap, respectively.

The fruit quality parameters changed according to the stage of harvest. With the advancement of maturity and storage period, there was an increase in

**Table 4.** Effect of picking maturity on biochemical changes of low chill peaches after one-week storage at ambient room temperature.

Code	Harvest Date	TSS (%)				Titratable acidity (%)				TSS: Acid ratio						
		Tropic Sweet	Early Grande	Florida Prince	Pratap	Mean	Tropic Sweet	Early Grande	Florida Prince	Pratap	Mean	Tropic Sweet	Early Grande	Florida Prince	Pratap	Mean
D <sub>1</sub>	May,06	11.61	12.68	11.35	12.66	12.08	0.78	0.75	0.73	0.74	0.75	14.88	16.91	15.55	17.11	16.11
D <sub>2</sub>	May,09	13.35	13.59	12.27	13.87	13.27	0.70	0.72	0.69	0.66	0.69	19.07	18.88	17.78	21.02	19.19
D <sub>3</sub>	May,12	15.16	13.95	13.96	14.65	14.43	0.66	0.68	0.63	0.62	0.65	22.97	20.51	22.16	23.63	22.32
D <sub>4</sub>	May,15	16.10	14.36	14.58	15.70	15.18	0.64	0.59	0.55	0.57	0.59	25.16	24.34	26.51	27.54	25.89
D <sub>5</sub>	May,18	16.69	14.77	14.40	15.91	15.44	0.59	0.55	0.53	0.52	0.55	28.29	26.85	27.17	30.6	28.23
D <sub>6</sub>	May,21	17.04	15.13	15.22	16.13	15.88	0.54	0.54	0.51	0.51	0.53	31.56	28.02	29.84	31.63	30.26
D <sub>7</sub>	May,24	17.39	15.24	15.37	16.18	16.04	0.48	0.53	0.50	0.50	0.50	36.23	28.75	30.74	32.36	32.02
Mean		12.23	15.33	14.24	13.88	15.01	0.63	0.62	0.59	0.59	0.59	25.45	23.47	24.25	26.27	
LSD <sub>0.05</sub>																
Cultivars(C)																0.42
Dates(D)																0.55
CxD																1.10



**Fig. 1.** Effect of picking maturity on the per cent Physiological loss in weight (PLW) of low chill Peaches after one-week storage at ambient room temperature.

physiological loss in weight and TSS:acid ratio. There was a gradual decrease in the reducing sugars of the fruits picked at optimum maturity with an increase in storage period. After 3 days at room temperature, fruits that were picked at the best time still had the highest TSS, acid ratio, and palatability rating. The results also revealed that the peach fruits harvested at the optimum stage can be stored with a post-storage shelf life of 3 days at ambient temperature (Gupta and Jawandha, 6). Fruit quality, sugars and organic acid profiles as well as bioactive compounds and antioxidant activities were investigated in exocarp and mesocarp during three ripening stages. During ripening, there was a significant decrease in citric and malic acids, in addition to titratable acidity. The results are similar to the findings of Park and Ko (14) and Khan *et al.* (9).

The present study revealed that DFFB, fruit colour, TSS and total sugars were found to be the dependable indices of maturity for low-chill cultivars under study. Based on physico-chemical characteristics of the fruits, 24<sup>th</sup> May for Tropic Sweet (102 DFFB), 18<sup>th</sup> May for Early Grande (93 DFFB) and 15<sup>th</sup> May (87 DFFB and 89 DFFB, respectively) for both cultivars, namely; Florida Prince and Pratap, were adjudged as the optimum harvest dates. After one week of storage at room temperature, the fruits harvested on these dates had the best storage performance.

## AUTHORS' CONTRIBUTION

Conceptualization of research (VSR, LNM, DST); Designing of the experiments (VSR, LNM); Contribution of experimental materials (LNM, VSR); Execution of field/lab experiments and data collection (LNM); Analysis of data and interpretation (VK); Preparation of the manuscript (SS, RP)

## DECLARATION

The authors declare no conflict of interest.

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