

Harvest maturity standards and fruit quality of some apple cultivars under high altitudal conditions

Biswajit Das*, Hare Krishna**, B.L. Attri, Nazeer Ahmad*** and J.K. Ranjan****

Central Institute of Temperate Horticulture, Regional Station, Mukteshwar 263 138, Nainital, Uttarakhand

ABSTRACT

The maturity standards and fruit quality of apple cultivars, viz., Vance Delicious, Starkinson, Red Chief, Oregon Spur, Gala Must, Royal Delicious, Red Delicious and Golden Delicious were assessed during 2007-2008 at Mukteshwar (Uttarakhand) situated at 2,250 m amsl. The studies revealed that full bloom duration of different cultivars varied during both the years but the varietal sequence of flowering was the same. Among the cultivars Vance Delicious came into bloom early in both the years. The estimated harvesting date for sampling of each cultivar was determined on the basis of fruit size, weight, TSS, acidity, back ground skin colour and ease of fruit separation from spur. The various cultivars were found to mature when the average starch iodine score reached 4.83 to 5.67. Furthermore, red coloured cultivars attained maturity when the skin colour developed between 50 to >75%. Similarly the skin colour of Golden Delicious cultivar turned into yellowish-green on maturity. All the fruit physical parameters and TSS increased significantly from first to fifth sampling in all the cultivars. Accordingly fruit acidity showed a declining trend from 2.53% in Gala Must to 0.38% in Royal Delicious. The mean days after full bloom to harvest at IV sampling stage varied from 110.0 (Vance Delicious) to 145.5 (Golden Delicious). In the range of 68.0% (Red Delicious) to 74% (Vance Delicious) fruits were harvested with ease of separation at IV sampling stage and this stage was found to be suitable for harvesting of fruits on optimum maturity.

Key words: Apple cultivars, maturity standard, harvesting, fruit quality.

INTRODUCTION

Apple, being a climacteric fruit, quality depends mainly on its maturity at harvest. Gustatory and appealing quality of fruits is the main criteria for consumer preference. Under "Good horticultural practices" fruit harvesting as per the maturity indices is one of the main criteria. Moreover, several countries and European Union have imposed regulations and norms for quality standards for fruits and vegetables in terms of marketing and import-export policies (Grechi *et al.*, 10). Crop maturity and harvesting as per specific standards has been one of the important control points and compliance criteria under Draft Indian Standard, Requirements for Good Agricultural Practices (Anon, 3). There is a relationship amongst fruit physico-chemical properties and a gradual conversion takes place during the process of maturation.

As the days progress from full bloom to harvest fruit growth follows a sigmoid curve. Determining the critical stage of fruit maturity for harvesting at the right time on the basis of external and internal fruit characteristics is very important for maintaining quality standards. These fruit characteristics depend on local environment, cultivar and tree management factors. Moreover, orchard elevation influences maturity and apple fruit quality (Dhanaraj *et al.*, 6). Predicting average or optimum harvest dates

depend on annual deviations in terms of chilling hour accumulations, bloom period, degree days, temperature and rainfall during fruit growth. Cultivar and location specific maturity indices have become essential as per international fruit quality standards. Over the years many new apple spur types as well as superior color strains have been evaluated and found very much promising in different apple growing areas in India. In Uttarakhand, cultivars like Red Chief, Starkinson, Gala Must, Vance Delicious and Oregon Spur have been found promising for cultivation along with Red Delicious, Royal Delicious and Golden Delicious. As the quality planting materials of these cultivars have been also distributed for planting and started bearing. It becomes essential to determine their harvest maturity time under hill altitude climatic conditions of the state. Majority of the orchards in the state are dominated by old cultivars like Fenny, Early Shanburry, Rhymer, Buckingham etc. and harvesting has always been a debating factor for the growers to catch the market early to escape competition from apple of Himachal Pradesh and Kashmir in term of quality. Apple matures and ripens over an extended period on the tree and even after harvest, so many harvesting at phages are required depending upon different maturity parameters. This ensures picking of fruits near to optimum maturity (Kingston, 11).

*Corresponding author's E-mail: biswajitsom_dr@yahoo.co.in

MATERIALS AND METHODS

The experiment was conducted during 2007 and 2008 on 13-15-year-old bearing apple trees in the apple Germplasm Collection Block, at Central Institute of Temperate Horticulture, Regional Station, Mukteshwar, Nainital. The orchard is situated at 2,250 m amsl. Cultivars included in the study are Vance Delicious, Starkrimson, Oregon Spur, Red Chief, Gala Must, Royal Delicious, Red Delicious and Golden Delicious. Days after full bloom to harvest (DAFH) was determined on the basis of total days after peak bloom day (75-80% bloom) to estimated fruit harvesting for sampling. Accordingly, fruits were collected from the marked trees for physico-chemical analysis at five intervals (Table 1). Physical parameters like fruit length, diameter and weight were estimated as per standard methods of AOAC (1). Total soluble solids (TSS) ($^{\circ}$ B) was recorded with hand refractometer (0-32 $^{\circ}$ B). Acidity (%) was estimated following standard

methods of AOAC (1). Starch iodine test was done by dissolving apple slices for 1 min. in 75 ml solution comprising iodine crystals (2.5 g) and potassium iodide (10 g). Scoring (linear scale 1-9) was done on the basis of blue black colour pattern on the flesh (Table 1). Fruit colour was scored on the basis of linear scale of 1 to 4 (Table 1). Ease of separation of fruits from the spur was determined by lifting or turning the fruit upward to separate from the spur easily without breaking the stem and was scored (linear scale 1 to 5) on the basis of ease of separation after lifting the fruit. Percentage of fruit became ready for harvest at different stages of sampling was also determined. Two years data was pooled and analyzed as per method designed by Panse and Sukhatme (14).

RESULTS AND DISCUSSION

Full bloom of different apple cultivars as depicted in the Table 2 show that Vance Delicious was early

Table 1. Scoring for starch iodine test, fruit colour and ease of separation of fruits from the spur.

	Staining rate	Maturity indication
A. Starch Iodine Test score		
1	100% full starch	Very immature
2	clear of stain in seed cavity	Immature
3	clear of stain in seed cavity and half way to vascular area	Immature to mature stage
4	Clear through the area including vascular bundle	Mature
5	Vascular bundle and half of the flesh clear of stain	Mature
6	More than half of flesh is clear of stain	Mature
7	Staining just around the periphery of the flesh	Over mature
8	Stain only under the skin	Over mature
9	Free of starch (no staining)	Over mature
B. Colour score		
	Colour development on skin (%)	Maturity indication
Red coloured apples		
1	>25 Red colour	Immature
2	25-50	Immature
3	50-75	Mature
4	>75	Mature
Golden Delicious		
1	Dark green	Immature
2	Light green	Immature
3	Yellowish green	Mature
4	Golden yellow	Mature
C. Ease of separation		
	Fruit separation at the joint of fruit stalk and spur when fruit is turned upward	Maturity indication
1	Fruits remains intact with spur	Immature
2	Fruit is separated with light force	Immature
3	Fruit is separated with ease	Mature
4	Fruit is separated at half turn upward	Mature
5	Fruit is separated just with touch	Mature to over mature

Table 2. Full bloom duration and pick bloom day of different apple cultivars.

Cultivar	Full bloom duration (70 to 85% bloom)		Pick full bloom day (80 to 85% bloom)	
	2007	2008	2007	2008
Vance Delicious	10/4-13/4	01/04-04/04	11/04	02/04
Gala Must	14/04-19/04	02/04-06/04	16/04	04/04
Starkrimson	13/04-19/04	03/04-07/04	16/04	05/04
Red Chief	16/04-19/04	04/04-08/04	17/04	05/05
Oregon Spur	16/04-20/04	05/04-10/04	17/04	06/04
Golden Delicious	17/04-21/04	08/04-12/04	19/04	09/04
Royal Delicious	18/04-23/04	06/05-10/04	20/04	09/04
Red Delicious	20/04-23/04	08/04-12/04	22/04	11/04

to come into full bloom stage which ranged from 10th to 13th and 1st to 4th of April during 2007 and 2008, respectively. This was followed by Gala Must, Starkrimson, Red Chief and Oregon Spur with the respective full bloom period of 14th to 19th, 13th to 19th, 16th to 19th, 16th to 20th April in 2007 and 2nd to 6th, 3rd to 7th, 4th to 8th, 5th to 10th April in 2008. Golden Delicious, Royal Delicious and Red Delicious were comparatively late in flowering with respective full bloom period. Observations on full bloom durations of different cultivars show that flowering took place early in the year 2008; however, varietal sequence of flowering was almost the same. Such trend in pome and stone fruit flowering was also reported by Grauslund (8). Therefore, winter precipitation, temperature and ultimate accumulation of chilling hours are main factors for such drift in flowering (Jindal and Mankotia, 10). Calendar dates for harvesting of fruits for determining optimum harvest maturity (OHM), *i.e.* days after full bloom to harvest (DAFH) were calculated on the basis of peak bloom day (Table 3). First estimated harvesting date for sampling of each cultivar was mainly determined on the basis of field assessment of fruit size, weight and skin colour development after frequent pre-sampling starting from 50 days after full bloom. Thus, first sampling of cv. Vance Delicious for chemical analysis was done on 87 and 91 days after full bloom, *i.e.* on 6th July and 1st July respectively in 2007 and 2008. Successive four samplings were done at 7 days intervals on 94 (13th July), 101 (20th July), 108 (27th July) and 115 (3rd August) days from full bloom in 2007, and 98 (8th July), 105 (15th July), 112 (22nd July) and 119 (29th July) days after full bloom in 2008. Similarly, for other cultivars, *viz.*, Starkrimson, Oregon Spur, Red Chief, Gala Must, Royal Delicious, Red Delicious and Golden Delicious the first sampling dates were 91, 95, 97, 98, 98, 110 and 123 days in 2007 and 98, 98, 101, 107, 100, 112 and 126 days in 2008, respectively.

Such type of fruit sampling by harvesting at intervals considering fruit size and skin colour for prediction of predicted harvest time for different cultivars, *viz.*, McIntosh, Gala, Cortland, Jonamac, Empire and Spartan has been found very effective, where year to year deviation was also observed by 3 to 10 days from normal peak harvest date (Beaudry and Danilovich, 3). Kvikliene *et al.* (12) used similar five sampling by picking fruits of cv. Auskis at weekly intervals starting from 100 days after full bloom.

Physico-chemical analysis of fruits harvested at different intervals (Table 4) reveal that characters like fruit length, weight, diameter, and TSS increased significantly from first sampling date to fifth sampling date in all the cultivars. Average fruit length significantly increased from 5.40 to 7.10 cm in Vance Delicious, 5.20 to 7.17 cm in Starkrimson, 5.12 to 7.47 cm in Oregon Spur, 5.50 to 7.13 cm in Red Chief, 5.13 to 7.17 cm in Gala Must, 5.10 to 7.30 cm in Royal Delicious, 5.20 to 7.17 cm in Red Delicious and 5.49 to 7.47 cm in Golden Delicious. Similarly, the respective fruit diameter also increased. In relation to fruit size, fruit weight also increased gradually from 150.0 to 192.0, 152.0 to 189.67, 148.0 to 186.67, 154.33 to 195.33, 152.33 to 194.33, 158 to 185.33, 152.0 to 189.67, and 169.0 to 200.67, respectively. However, variation between sampling stages III and IV, and IV and V was very less which signifies that rate of incremental change in these physical characteristics slowed down as fruits reached average harvest maturity. Quality parameters namely TSS and acidity showed a drastic change from stage I to V where TSS increased from 8.43 to 14.53^oB and acidity decreased from as high as 2.53 to 0.38% in different cultivars. At sampling stage IV TSS level in different cultivars was recorded to be 12.90, 12.67, 12.97, 13.23, 12.37, 13.43, 12.67 and 13.37^oB in Vance Delicious, Starkrimson, Oregon Spur, Red Chief, Gala Must, Royal Delicious, Red Delicious

Table 3. Harvesting dates and days from full bloom to harvest at five intervals.

Cultivar	Harvesting date (days) from full bloom to harvest										Mean days from full bloom to harvest				
	2007					2008					I	II	III	IV	V
	I	II	III	IV	V	I	II	III	IV	V					
Vance Delicious	06/07 (87)	13/07 (94)	20/07 (101)	27/07 (108)	03/08 (115)	01/07 (91)	08/07 (98)	15/07 (105)	22/07 (112)	29/07 (119)	89.0	96.0	103.0	110.0	117.0
Starkrimson	18/07 (91)	25/07 (98)	01/08 (105)	08/08 (115)	15/08 (119)	12/07 (98)	19/07 (105)	26/07 (112)	02/08 (119)	09/08 (126)	94.5	101.5	108.5	117.0	122.5
Oregon Spur	24/07 (95)	31/07 (102)	07/08 (109)	10/08 (116)	17/08 (123)	13/07 (98)	20/07 (105)	27/07 (112)	03/08 (119)	10/08 (126)	96.5	103.5	110.5	117.5	124.5
Red Chief	22/07 (97)	29/07 (104)	05/08 (111)	12/08 (118)	19/08 (125)	15/07 (101)	22/07 (108)	29/07 (115)	05/08 (122)	12/08 (129)	99.0	106.0	113.0	120.0	127.0
Gala Must	25/07 (98)	01/08 (101)	08/08 (115)	15/08 (122)	22/08 (129)	19/07 (107)	26/07 (114)	02/08 (121)	09/08 (128)	16/08 (135)	102.5	107.5	118.0	125.0	132.0
Royal Delicious	26/08 (98)	02/08 (105)	09/08 (112)	16/08 (119)	23/08 (126)	17/07 (100)	24/07 (107)	31/07 (114)	07/08 (121)	14/08 (128)	99.0	106.0	113.0	120.0	127.0
Red Delicious	09/08 (110)	16/07 (117)	23/08 (124)	30/08 (131)	06/09 (138)	30/07 (112)	07/07 (119)	14/08 (126)	21/08 (133)	28/08 (140)	111.0	118.0	125.0	132.0	139.0
Golden Delicious	19/08 (123)	26/08 (130)	02/09 (137)	09/09 (144)	16/09 (151)	12/07 (126)	19/07 (133)	26/08 (140)	02/09 (147)	09/07 (154)	124.5	131.5	138.5	145.5	152.5

Table 4. Physico-chemical properties of some apple cultivars harvested at five intervals.

A. Vance Delicious												
Harvesting stage	Fruit length(cm)	Fruit dia. (cm)	Fruit wt. (g)	TSS (°B)	Acidity (%)	Starch iodine score	Fruit colour	Ease of fruit separation from spur	Fruit harvested (%) with ease of separation from the spur			
I	5.40	5.23	150.00	9.60	1.77	1.47	2.33	1.67	0.00 (0.71)			
II	6.30	6.00	161.33	10.70	1.23	2.03	3.00	2.33	4.00 (1.91)			
III	6.93	6.93	171.33	12.23	0.87	2.93	3.33	3.00	16.00 (4.04)			
IV	7.10	7.73	191.33	12.90	0.50	4.93	4.00	3.33	74.67 (8.67)			
V	7.10	7.87	192.00	14.43	0.45	5.63	4.00	4.33	93.33 (9.69)			
CD _{0.05}	0.26	0.22	2.15	0.86	0.20	0.35	0.60	0.64	0.98			
CV (%)	2.14	1.70	0.66	3.80	11.23	5.40	9.49	11.64	10.39			
B. Starkrimson												
Harvesting stage	Fruit length (cm)	Fruit dia. (cm)	Fruit wt. (g)	TSS (°B)	Acidity (%)	Starch iodine score	Fruit colour	Ease of fruit separation from spur	Fruit harvested (%) with ease of separation from the spur			
I	5.20	5.43	152.00	9.30	1.87	1.60	2.67	1.33	0.00 (0.71)			
II	5.80	6.37	161.33	10.37	1.47	2.27	3.00	2.00	2.67 (1.65)			
III	6.37	7.13	173.67	11.63	0.77	3.23	4.00	3.00	17.33 (4.18)			
IV	7.10	7.43	188.33	12.67	0.53	5.17	4.00	3.33	72.00 (8.51)			
V	7.17	7.57	189.67	14.10	0.50	5.53	4.00	3.67	93.33 (9.69)			
CD _{0.05}	0.18	0.27	2.85	0.41	0.25	0.21	0.49	0.91	0.95			
CV (%)	1.54	2.11	0.87	1.89	13.07	3.18	7.31	18.11	10.21			

C. Oregon Spur

Harvesting stage	Fruit length (cm)	Fruit dia. (cm)	Fruit wt. (g)	TSS (°B)	Acidity (%)	Starch iodine score	Fruit colour	Ease of fruit separation from spur	Fruit harvested (%) with ease of separation from the spur
I	5.12	5.70	148.00	9.23	1.77	1.23	2.67	1.33	0.0 (0.71)
II	5.70	6.53	161.00	9.90	1.27	1.77	2.67	1.67	2.67 (1.65)
III	6.50	7.17	174.00	11.13	0.85	3.30	3.00	2.67	24.00 (4.94)
IV	7.40	7.77	185.67	12.97	0.48	5.03	3.67	3.00	68.00 (8.27)
V	7.47	7.87	186.67	14.23	0.42	5.37	4.00	3.33	92.00 (9.62)
CD _{0.05}	0.166	0.185	5.208	0.525	0.170	0.306	0.84	1.00	0.80
CV (%)	1.367	1.403	1.617	2.425	9.446	4.859	13.98	22.18	8.45

D. Red Chief

Harvesting stage	Fruit length (cm)	Fruit dia. (cm)	Fruit wt. (g)	TSS (°B)	Acidity (%)	Starch iodine score	Fruit colour	Ease of fruit separation from spur	Fruit harvested (%) with ease of separation from the spur
I	5.50	5.60	154.33	8.43	1.97	1.13	1.67	1.33	0(0.71)
II	6.17	6.50	167.33	9.77	1.47	1.70	2.67	2.00	1.33(1.18)
III	6.83	7.17	178.00	11.17	0.80	3.30	3.33	2.33	20.00(4.51)
IV	7.07	7.60	193.67	13.23	0.53	5.00	4.00	3.33	73.33(8.59)
V	7.13	7.67	195.33	14.50	0.47	5.77	4.00	3.33	92.00(9.62)
CD _{0.05}	0.27	0.18	2.39	0.60	0.09	0.18	0.91	1.06	0.91
CV (%)	2.22	1.41	0.72	2.80	4.69	2.75	15.42	22.81	9.84

E. Gala Must

Harvesting stage	Fruit length (cm)	Fruit dia. (cm)	Fruit wt. (g)	TSS (°B)	Acidity (%)	Starch iodine score	Fruit colour	Ease of fruit separation from spur	Fruit harvested (%) with ease of separation from the spur
I	5.13	5.37	152.33	8.43	2.53	1.07	2.00	1.00	0.00 (0.71)
II	5.97	6.17	167.00	9.30	1.97	1.93	2.67	1.67	2.67 (1.65)
III	6.67	6.97	177.33	10.10	0.78	3.20	2.67	3.00	17.33 (4.18)
IV	7.13	7.80	192.33	12.37	0.57	4.83	3.33	3.00	73.33 (8.59)
V	7.17	7.87	194.33	13.80	0.48	5.50	3.67	3.33	93.33 (9.68)
CD _{0.05}	0.37	0.21	3.43	0.64	0.18	0.19	0.88	0.64	0.84
CV (%)	3.08	1.65	1.03	3.16	7.39	3.07	16.24	14.23	9.00

F. Royal Delicious

Harvesting stage	Fruit length (cm)	Fruit dia. (cm)	Fruit wt. (g)	TSS (°B)	Acidity (%)	Starch iodine score	Fruit colour	Ease of fruit separation from spur	Fruit harvested (%) with ease of separation from the spur
I	5.10	5.77	158.00	8.67	1.70	1.10	2.33	1.33	0.0 (0.71)
II	5.50	6.37	170.00	9.70	1.33	2.10	2.67	1.67	1.33 (1.18)
III	6.43	7.00	178.33	11.77	0.82	3.17	3.33	3.00	25.33 (5.08)
IV	7.20	7.83	184.33	13.43	0.45	5.07	3.67	2.33	73.33 (8.59)
V	7.30	7.93	185.33	14.53	0.38	5.90	3.67	3.33	90.67 (9.55)
CD _{0.05}	0.18	0.11	3.07	0.35	0.14	0.26	0.73	1.06	0.66
CV (%)	1.48	0.83	0.93	1.62	8.07	3.98	12.36	24.12	7.01

G. Red Delicious

Harvesting stage	Fruit length (cm)	Fruit dia. (cm)	Fruit wt. (g)	TSS (°B)	Acidity (%)	Starch iodine score	Fruit colour	Ease of fruit separation from spur	Fruit harvested (%) with ease of separation from the spur
I	5.20	5.43	152.00	9.30	1.87	1.60	2.33	1.33	0.0 (0.71)
II	5.80	6.37	161.33	10.37	1.47	2.27	2.67	1.67	0.0 (0.71)
III	6.37	7.13	173.67	11.63	0.77	3.23	3.00	2.67	25.33 (5.07)
IV	7.10	7.43	188.33	12.67	0.53	5.17	3.33	3.33	72.0 (8.51)
V	7.17	7.57	189.67	14.10	0.50	5.53	3.67	3.67	88.0 (9.41)
CD _{0.05}	0.18	0.27	2.85	0.41	0.25	0.21	0.81	0.60	0.50
CV (%)	1.54	2.11	0.87	1.89	13.07	3.18	14.27	12.48	5.41

177

H. Golden Delicious

Harvesting stage	Fruit length (cm)	Fruit dia. (cm)	Fruit wt. (g)	TSS (°B)	Acidity (%)	Starch iodine score	Fruit colour	Ease of fruit separation from spur	Fruit harvested (%) with ease of separation from the spur
I	5.49	5.97	169.00	9.03	2.30	1.37	2.33	1.33	0 (0.71)
II	5.96	6.57	179.00	10.47	1.50	1.77	2.67	1.67	0 (0.71)
III	6.38	7.23	192.00	11.70	0.77	3.63	3.00	2.67	16.0 (4.04)
IV	7.40	8.03	200.00	13.37	0.47	5.67	3.33	3.00	69.33 (8.36)
V	7.47	8.10	200.67	14.00	0.44	5.93	3.67	3.33	89.33 (9.48)
CD _{0.05}	0.31	0.12	4.24	0.56	0.15	0.38	0.81	0.81	0.42
CV (%)	2.50	0.86	1.20	2.54	7.43	5.55	14.27	17.84	4.84

Digits in parenthesis are transformed values.

and Golden Delicious, respectively. Acidity at this stage was found to be 0.50, 0.53, 0.48, 0.53, 0.57, 0.45, 0.53 and 0.47%. Starch iodine test showed very low score at I sampling stage with a range from 1.07 (Gala Must) to 1.60 (Starkrimson and Red Delicious) indicating full of starch. However, as the maturity progressed at successive sampling stages conversion of starch into sugars took place and the score also increased to 5.93 in Golden Delicious at V sampling stage. At IV sampling stage starch iodine score recorded as 4.93, 5.17, 5.03, 5.00, 4.83, 5.07, 5.17 and 5.67 in Vance Delicious, Starkrimson, Oregon Spur, Red Chief, Gala Must, Royal Delicious, Red Delicious and Golden Delicious, respectively. Regarding fruit skin colour development, all the red colour cultivars, viz., Vance Delicious, Starkrimson, Oregon Spur, Red Chief, Gala Must, Royal Delicious, and Red Delicious developed more than 75% colour at IV sampling stage with respective scores of 4.00, 4.00, 3.67, 4.00, 3.33, 3.67 and 3.33. Golden Delicious fruits attained yellowish-green colour (score 3.0) at IV stage, which turned to golden yellow (3.33) towards stage V. Ease of separation of fruit at the joint (abscission layer) of stalk and spur when assessed, it was observed that 68.00 (Oregon Spur) to 74.67% (Vance Delicious) fruits were picked easily when turned full upward with score of 3.00 to 3.33 in different cultivars. However, percentage fruits picked with ease of separation increased significantly with in one week interval ranging from 88.00 (Red Delicious) to 93.33% (Vance Delicious, Gala Must and Starkrimson). Under Indian conditions apple fruit diameter at harvest is around 7.50 (\pm 2.5) cm and >80.00 (\pm 2.5) cm, which have been designated as large and extra large, respectively (Anon, 2) and this range of fruit diameter has been considered very preferable for market grading. Proportionate fruit diameter and length determines ultimate fruit shape which is though cultivar specific but depends on maturity stage apart from growing conditions. Both fruit length and diameter are relative to fruit weight and they do not change in any way when cell division in fruit system stops (Skene, 16). The fruit longitudinal (lengthwise) growth rate has been observed to be rapid at eye end than the stalk end, however, lengthwise growth was found to be slower than the growth in diameter. On an average it has been noted that cell division in apple fruits continues till 65 to 70 days after full bloom, however there is an increase of expansion of air space and fruit enlargement. The significance of early prediction fruit size and fruit weight at harvest as a maturity index was also reported by Stanley *et al.* (18), and Costa *et al.* (5) in relation to DAFH, growing degree days (GDD) and fruit growth. Another important factor in apple maturity is the relationship of fruit background colour and starch content with TSS

and acidity apart from other quality attributes. Fruits without characteristic back ground colour at harvest is immature and starchy. Background colour has been also considered to be an important maturity index by Watkins *et al.* (19). Starchy fruits are low in sugars and flavour. In general, apples with starch iodine scores 4 to 6 have been considered to be mature (Chu, 4; Sharma and Sharma, 15). During summer, sugar from the leaves is transferred to the fruits and is stored as starch. At maturity fruit starch is gradually hydrolyzed to sugars starting from the core area and progresses towards periphery (Sharma and Sharma, 15; Kingston, 11). At maturity TSS in different cultivars has been recorded in the ranges of 11 to 15^oB (Anon, 2). However, in generally it has been reported to be 12 to 14^oB TSS in Delicious or spur type cultivars at harvest maturity. During advance maturity period there is steady decline in acidity and increase in soluble solids in apple (Recasens *et al.*, 13).

On the basis of these findings and data generated from the present study indicated that sampling stage IV may be designated as optimum harvest date for the cultivars under study. Thus, average days from full bloom to harvest have been found to be 110.0, 117.0, 117.5, 120.0, 125.0, 120, 132.0 and 145.5 days for cvs. Vance Delicious, Starkimson, Oregon Spur, Red Chief, Gala Must, Royal Delicious, Red Delicious and Golden Delicious, respectively (Table 3). Harvesting time in the year 2008 was predicted early by 2 (Royal Delicious) to 6 (Gala Must) days in different cultivars. Annual variation in the normal harvest days by approximately one week may be attributed to the shift in full bloom dates, prevailing temperature, sun shine durations, over cast days and rainfall conditions during fruit growth period. Cooler temperature during summer delays apple maturity (Domoto, 7). Therefore, it may be advisable to adjust predicted harvest days by ± 7 days and an average harvest date may also be extended by ± 3 to ± 4 days in a given year. Over all best quality of harvested apples can be retained when picked at optimum harvest date, however late harvested apples have a better colour and TSS though are more prone to senescence related symptoms and some other disorders (Skrzynski, 17). Similarly in another study, starch iodine test on cv. Golden Delicious apple predicted harvesting time 137 and 141 DAFB (Sayyari, 14).

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