



Performance of some new apple cultivars for yield and physico-chemical characters under mid-hill conditions of Uttarakhand

A. Kishor*, Raj Narayan, Manoj Brijwal, B.L. Attri, Anil Kumar and Sovan Debnath
ICAR-Central Institute of Temperate Horticulture, Regional Station, Mukteshwar 263138, Uttarakhand

ABSTRACT

An experiment was conducted to evaluate the yield and physico-chemical performance of 18 apple cultivars. The highest fruit yield (46.11 kg/tree), fruit weight (217.33 g), fruit volume (231.67 cc), fruit length (6.98 cm) and fruit diameter (8.22 cm) was recorded in 'Spur Type Red Delicious'. The lowest fruit yield (19.12 kg/tree) and fruit length (4.33 cm) was recorded in 'Chaubattia Anupam'; while, lowest average fruit weight (64.67 g), fruit volume (63.33 cc) and fruit diameter (5.32 cm) was observed in 'Gloster'. The maximum TSS was recorded in 'Skyline Supreme' (14.73°B) and minimum was in 'Chaubattia Princess' (11.26°B). However, the highest titratable acidity was recorded in 'Golden Delicious' (0.66%) and lowest in 'Chaubattia Princess' (0.14%). The cultivar 'Skyline Supreme' possessing highest values for ascorbic acid (8.25 mg/100 g), reducing sugars (9.62%), total sugars (12.42%), total carotenoids (235.73 µg/100 g) and total anti-oxidant activity (41.95 mMTE/L) while 'Prima' exhibited lowest values of ascorbic acid (3.92 mg/100 g) and total sugar contents (6.15%). The lowest values for reducing sugars (5.13%), total carotenoids (79.45 µg/100 g) and total anti-oxidant activity (30.66 mM TE/L) were recorded in 'Gloster', 'Vermont Spur' and 'Stark Spur', respectively. The cultivar 'Golden Delicious' is the most luminous (L^* =84.86) and having the highest yellow colour (b^* = 67.10) and hue angle (h° = 87.41), whereas 'Chaubattia Anupam' showed the highest red colour (a^* = 54.15) and Chroma (C^* = 67.53). From this investigation it can be inferred that the cultivar 'Spur Type Red Delicious' and 'Skyline Supreme' performed better in the region under prevailing climatic conditions.

Key words: *Malus domestica*, physico-chemical, mid hills.

INTRODUCTION

Apple (*Malus domestica* Borkh.) is the most important temperate fruit crop and accounting 30 thousand ha area and 77.5 thousand MT production in Uttarakhand (Anonymous, 1). Monoculture of traditional cultivars since long time led to their genetic degeneration and resulted in low productivity as well as poor quality fruits. The existing cultivars have been found shy bearer, poor in colour development, when grown in the mid hills and marginal areas. The new initiatives like diversification of varieties through introduction and evaluation of promising spur type and high colour strains under mid hill condition gave some promise over traditional varieties (Kumar *et al.*, 9). These varieties are spur types, dwarf, prolific bearer and produce fruits of better quality and possess useful traits like less pruning requirements, tolerance to biotic and abiotic stress factors. Apart from spur types, the colour strains develop colour early, with more intensity and have higher yield potential than the existing Delicious groups under relatively warmer conditions, where proper colour development especially in the Delicious group is a major problem (Chadha and Awasthi, 3). Keeping in view, the location specific evaluation of cultivars is essential

to identify the suitable cultivars for commercial exploitation. Therefore, the present investigation was undertaken to evaluate the new apple cultivars under mid hill conditions of Uttarakhand under prevailing climatic conditions.

MATERIALS AND METHODS

The present investigation was carried out at ICAR-CITH, Regional Station, Mukteshwar, Nainital (Uttarakhand) during 2015 to 2016 on 18 apple cultivars belonging to Delicious group, spur type and colour strains. Sixteen years old healthy fruit bearing trees of these cultivars planted at a spacing of 6 m × 6 m and trained on modified leader system were selected for the study. Uniform cultural operations were followed during the course of investigation and the fruits were picked after attaining full maturity. The experiment was laid out in randomized block design (RBD) with three replications comprising four trees per replication.

The full bloom period in each cultivar was noted when more than 75-80 per cent of the flowers had opened. Time of fruit harvest was recorded on the basis of total days after full bloom stage to harvest maturity for each replication of each cultivar. At the time of harvest, all the fruits from each replication were

*Corresponding author's E-mail: aruniar@gmail.com

weighed on pan balance and yield was expressed in kg/tree. The fruit's physical properties in terms of weight (g), volume (cc), size (cm), specific gravity (g/cc) and fruit firmness (lb/in²) were recorded by calculating the mean of ten fruits at final harvesting stage. The chemical characteristics of the fruits viz. TSS, titratable acidity, ascorbic acid, reducing sugars, total sugars, non-reducing sugars and total carotenoids were recorded by using the methods described by Ranganna (13). For estimation of total carotenoids, the samples were extracted in 3% acetone in petroleum ether. Total carotenoids were read colorimetrically using 3% acetone in petroleum ether for baseline correction and the absorbance at 452 nm was recorded against a reagent blank. The total carotenoids were expressed as µg/100 g. Total anti-oxidant activity was recorded by using the method described by Apak *et al.* (2). The antioxidant activity was expressed as m mol Trolox[®] per litre, or mMTE.

The colour values of different apples cultivars were obtained in terms of L*, a*, b*, C* and h° values using a Lovibond RT series reflectance tintometer. The 'L' measures luminosity or lightness and varies from zero (black) to one hundred (perfect white). The chromaticity dimension 'a' measures redness

when positive, grey when zero, and greenness when negative. The 'b' value measures yellowness when positive, grey when zero, and blueness when negative. The 'C' describes the chroma (saturation) of the colour, a measure of how far from the grey tone the colour is. Hue angle (h°), describes the hue of the colour, *i.e.*, colour tonalities (red, green, yellow etc.) as per the method described by Jha *et al.* (6). The statistical analysis was done as per procedure described by Panse and Sukhatme (12).

RESULTS AND DISCUSSION

Data presented in table 1 shows the full bloom in different apple cultivars under study varied from 9th April to 19th April in 2015 and 7th April to 17th April in 2016. The date of full bloom was first noticed in cultivars 'Vermont Spur' and 'Gala Must' (9th April) in 2015 and 'Chaubattia Anupam' and 'Mollies Delicious' (7th April) in 2016, while the cultivars 'Rich-A-Red' (19th April) in 2015 and 'Golden Delicious' (17th April) in 2016 were late to reach the full bloom. The marked differences in full bloom in different cultivars may be attributed to inherent genetic characteristics of the cultivars (Das *et al.*, 4 and Sharma *et al.*, 14). However, winter precipitation, temperature and ultimate accumulation of chilling

Table 1. Performance of different apple cultivars with respect to flowering traits

Cultivar	Date of full bloom		Days from full bloom to harvest			Date of fruit harvest	
	2015	2016	2015	2016	Pooled mean	2015	2016
Gloster	14/04/2015	11/04/2016	107	106	106.50	30/07/2015	26/07/2016
Vance Delicious	14/04/2015	16/04/2016	116	117	116.50	08/08/2015	11/08/2016
Vermont Spur	09/04/2015	12/04/2016	121	121	121.00	08/08/2015	11/08/2016
Rich-A-Red	19/04/2015	15/04/2016	121	123	122.00	18/08/2015	16/08/2016
Bright-N-Early	15/04/2015	13/04/2016	125	123	124.00	18/08/2015	14/08/2016
Stark Spur	17/04/2015	15/04/2016	130	130	130.00	25/08/2015	23/08/2016
Red Chief	16/04/2015	14/04/2016	121	121	121.00	15/08/2015	13/08/2016
Golden Delicious	11/04/2015	17/04/2016	140	137	138.50	29/08/2015	01/09/2016
Spur Type Red Delicious	17/04/2015	16/04/2016	120	120	120.00	15/08/2015	14/08/2016
Top Red	15/04/2015	13/04/2016	120	121	120.50	13/08/2015	12/08/2016
Skyline Supreme	16/04/2015	15/04/2016	128	125	126.50	22/08/2015	18/08/2016
Chaubattia Anupam	13/04/2015	07/04/2016	103	104	103.50	25/07/2015	20/07/2016
Chaubattia Princess	16/04/2015	08/04/2016	105	112	108.50	30/07/2015	29/07/2016
Mollies Delicious	11/04/2015	07/04/2016	108	107	107.50	28/07/2015	23/07/2016
Starkrimson	14/04/2015	13/04/2016	122	124	123.00	14/08/2015	15/08/2016
Oregon Spur	12/04/2015	16/04/2016	134	131	132.50	24/08/2015	25/08/2016
Gala Mast	09/04/2015	13/04/2016	114	113	113.50	01/08/2015	04/08/2016
Prima	11/04/2015	09/04/2016	111	111	111.00	31/07/2015	29/07/2016
CD at 5%	-	-	4.79	5.76	3.54	-	-

hours are main factors for such drift in flowering (Jindal and Mankotia, 7). The days from the full bloom to harvest were observed minimum (103.50 days) in 'Chaubattia Anupam' resulting into early fruit maturity, whereas the maximum period (138.50 days) from full bloom to harvesting were taken by 'Golden Delicious' ensuing to the late crop maturity. On the basis of date of fruit harvesting all the cultivars can be grouped into early maturing ('Chaubattia Anupam', 'Mollies Delicious', 'Gloster', 'Chaubattia Princess', 'Prima', 'Gala Mast' and 'Vance Delicious'), mid season maturing ('Vermont Spur', 'Top Red', 'Red Chief', 'Bright-N-Early', 'Spur Type Red Delicious', 'Starkrimson' and 'Rich-A-Red') and late maturing cultivars ('Skyline Supreme', 'Stark Spur', 'Oregon Spur' and 'Golden Delicious'). Time and duration of flowering are important traits in classification of apple with respect to their span of flowering under different regions and have been assessed by other workers (Das *et al.*, 4 and Sharma *et al.*, 14).

A close perusal of data presented in table 2 exhibited significant variation in yield and fruit physical characteristics of different apple cultivars. The highest fruit yield was recorded in 'Spur Type Red Delicious' (46.11 kg/tree) which was statistically *at par* with 'Starkrimson' (45.57 kg/tree) and 'Skyline

Supreme' (44.13 kg/tree) but significantly differed with rest of the cultivars. The lowest fruit yield was recorded in 'Chaubattia Anupam' (19.12 kg/tree) followed by 'Gloster' (22.69 kg/tree) and 'Chaubattia Princess' (23.92 kg/tree). The higher fruit yield in 'Spur Type Red Delicious' was primarily due to their bigger size. These results are in conformity with the earlier findings of Dwivedi and Dwivedi (5) and Thakur *et al.* (16). Similarly, fruit weight and fruit volume was also recorded maximum in 'Spur Type Red Delicious' *i.e.*, 217.33 g and 231.67 cc, respectively; while, the minimum fruit weight (64.67 g) and fruit volume (63.33 cc) was observed in 'Gloster'. The highest fruit length was recorded in 'Spur Type Red Delicious' (6.98 cm) followed by 'Vance Delicious' (6.64 cm) and 'Vermont Spur' (6.60 cm) while lowest in 'Chaubattia Anupam' (4.33 cm) which was statistically *at par* with 'Gala Mast' (4.81 cm) and 'Gloster' (4.89 cm). The highest fruit diameter was recorded under 'Spur Type Red Delicious' (8.22 cm) followed by 'Mollies Delicious' (7.73 cm), while lowest in 'Gloster' (5.32 cm). The results obtained in the present investigation are found to be in close conformity with the studies of Kumar *et al.* (9) who also recorded the fruit length and diameter in different apple cultivars varying from 3.62 cm (Top Red) to 6.38 cm (Spur Type Red

Table 2. Comparative data on yield and fruit physical characteristics among different apple cultivars (pooled mean).

Cultivar	Yield (kg/ tree)	Fruit wt. (g)	Fruit vol. (cc)	Fruit length (cm)	Fruit dia. (cm)	Sp. gr. (g/cc)	Fruit firmness (lb/in ²)
Gloster	22.69	64.67	63.33	4.89	5.32	0.92	7.73
Vance Delicious	37.82	159.33	150.00	6.64	7.29	1.06	8.07
Vermont Spur	34.71	167.33	160.00	6.60	7.59	1.05	8.67
Rich-A-Red	38.98	158.67	163.33	6.53	7.45	0.97	6.87
Bright-N-Early	24.03	146.00	160.00	5.97	7.20	0.91	7.23
Stark Spur	32.93	132.00	140.00	6.13	6.85	0.94	7.20
Red Chief	38.56	140.00	141.67	6.41	6.98	0.99	8.17
Golden Delicious	38.13	119.78	133.33	6.03	6.64	0.90	7.41
Spur Type Red Delicious	46.11	217.33	231.67	6.98	8.22	0.94	6.47
Top Red	34.12	144.67	160.00	6.15	7.22	0.90	7.37
Skyline Supreme	44.13	117.33	121.67	5.66	6.78	0.96	7.20
Chaubattia Anupam	19.12	70.90	81.67	4.33	5.88	0.87	5.30
Chaubattia Princess	23.92	100.75	110.00	5.25	6.46	0.91	9.28
Mollies Delicious	28.92	172.52	186.67	6.51	7.73	0.93	7.71
Starkrimson	45.57	168.00	176.67	6.38	7.61	0.95	8.12
Oregon Spur	40.26	151.11	163.33	6.37	7.11	0.93	7.70
Gala Mast	27.16	82.67	83.33	4.81	5.96	0.99	7.60
Prima	37.79	86.00	93.33	5.03	6.02	0.92	4.90
CD at 5%	2.92	22.38	23.55	0.65	0.47	0.04	1.73

Delicious) and 4.20 cm (Tydeman's Early Worcester) to 7.69 cm (Spur Type Red Delicious), respectively. In another study, Dwivedi and Dwivedi (5) measured the variation in different apple cultivars in a range of 6.27 cm (Stark Spur) to 8.36 cm (Silver Spur) in fruit length and 6.84 cm (Stark Spur) to 8.93 cm (Spur Type Red Delicious) in fruit diameter. The variation in fruit size (length and diameter), weight and volume with respect to different apple cultivars are mainly attributed to the inter-varietal differences associated with genetic make-up of the cultivars and governed mainly by the cell size and intercellular spaces of the fruit tissues.

The specific gravity of fruits was recorded highest in 'Vance Delicious' (1.06 g/cc) which was statistically *at par* with 'Vermont Spur' (1.05 g/cc), while lowest was recorded in 'Chaubattia Anupam' (0.87 g/cc). The findings are in agreement with the prior records of Singh (15). The variation in specific gravity may probably be due to corresponding changes in fruit weight and volume. The increase in intercellular spaces in the fruit flesh with the advancement of maturity affects the specific gravity of the fruits. The fruit firmness was found highest in 'Chaubattia

Princess' (9.28 lb/in²) followed by 'Vermont Spur' (8.67 lb/in²) while the lowest in 'Prima' (4.90 lb/in²). These findings are in agreement with the prior records of Kumar *et al.* (9) and Dwivedi and Dwivedi (5). A change in fruit firmness is primarily attributed to break down of insoluble protopectins to soluble pectin compounds, which ultimately affect the cell wall consistency and thus varied at different stages of fruit growth and ripeness. The preliminary study indicated that the variability in fruit yield and various physical characteristics of apple cultivars may be due to environmental factors and genetic makeup of the cultivars.

The data pertaining to the chemical characteristics of fruits showed considerable variations among different cultivars of apple (Table 3). From perusal of the data presented in table 3, the highest TSS was found in 'Skyline Supreme' (14.73°B) followed by 'Stark Spur' (14.60°B) and 'Chaubattia Anupam' (14.20°B) while lowest in 'Chaubattia Princess' (11.26°B). The appreciable differences with respect to TSS among different apple cultivars may be explained on the basis of genetic differences with respect to various cultivars, which subsequently affect the synthesis

Table 3. Comparative data on fruit chemical characteristics among different apple cultivars (pooled mean).

Cultivar	TSS (°B)	Titrateable acidity (%)	Ascorbic acid (mg/100 g)	Reducing sugars (%)	Total sugars (%)	Non-reducing sugars (%)	Total carotenoids (µg/100 g)	Total anti-oxidant activity (mM TE/L)
Gloster	13.23	0.44	5.42	5.13	6.47	1.28	108.00	36.11
Vance Delicious	12.93	0.40	4.17	7.81	9.14	1.26	155.05	33.36
Vermont Spur	12.20	0.43	4.58	7.99	10.01	1.92	79.45	34.44
Rich-A-Red	13.17	0.27	4.17	5.90	6.72	0.77	116.48	32.77
Bright-N-Early	13.33	0.24	4.00	6.65	7.97	1.26	105.68	30.67
Stark Spur	14.60	0.26	4.42	6.82	7.30	0.46	94.88	30.66
Red Chief	11.93	0.29	4.00	7.09	8.38	1.22	93.73	32.54
Golden Delicious	13.77	0.66	6.25	6.90	9.69	2.65	102.60	33.60
Spur Type Red Delicious	13.83	0.28	4.17	8.07	11.93	3.67	132.68	34.90
Top Red	13.83	0.26	5.42	7.86	10.87	2.86	104.14	36.36
Skyline Supreme	14.73	0.32	8.25	9.62	12.42	2.66	235.73	41.95
Chaubattia Anupam	14.20	0.42	7.45	7.58	9.19	1.30	125.68	36.93
Chaubattia Princess	11.26	0.14	5.96	7.18	9.07	1.80	123.13	34.91
Mollies Delicious	12.73	0.30	6.83	7.83	9.49	1.57	181.00	33.57
Starkrimson	12.00	0.31	6.67	6.26	7.56	1.24	109.16	32.12
Oregon Spur	12.00	0.31	7.08	7.55	8.85	1.23	168.42	36.62
Gala Mast	13.33	0.28	6.67	6.29	7.94	1.57	151.97	31.21
Prima	13.03	0.42	3.92	5.47	6.15	0.65	222.63	34.63
CD at 5%	1.32	0.10	1.20	0.69	1.0	0.72	12.37	3.54

of photosynthates and their further breakdown into simple metabolites. The highest titratable acidity (0.66%) was recorded in 'Golden Delicious' followed by 'Gloster' (0.44%) and 'Vermont Spur' (0.43%) and lowest in 'Chaubattia Princess' (0.14%). The inter-varietal differences in the titratable acidity level of fruits are attributed to the presence of varying amount of organic acids in them. These results obtained in the present investigation are found to be close conformity with the studies of Wu *et al.* (18) and Dwivedi and Dwivedi (5).

The highest ascorbic acid was recorded in 'Skyline Supreme' (8.25 mg/100 g) which was statistically *at par* with 'Chaubattia Anupam' (7.45 mg/100 g) and 'Oregon Spur' (7.08 mg/100 g) while lowest in 'Prima' (3.92 mg/100 g). The synthesis of ascorbic acid in the fruits depends on adequate supply of hexose sugar, which decline at ripening stage might be due to decrease in titratable acidity, which could be attributed to oxidation of ascorbic acid (Mapson, 11). The findings are in agreement with the prior records of Thakur *et al.* (16). The highest reducing (9.62%) and total sugars (12.42%) were recorded in 'Skyline Supreme' which were statistically *at par* with 'Spur Type Red Delicious' *i.e.*, 8.07% and 11.93% respectively, while lowest reducing sugars were recorded in 'Gloster' (5.13%) and total sugars were recorded in 'Prima' (6.15%). The highest non-reducing sugars were recorded in 'Spur Type Red Delicious' (3.67%), while lowest in 'Stark Spur' (0.46%). These results obtained in the present investigation are found to be in close conformity with the studies of Kumar *et al.* (9). Sugar is a vital constituent of fruits which is directly related with sweetness and is fundamental feature of fruit quality (aroma, flavour and texture). The extent of variation in sugars in different apple cultivars may be explained on the basis of leaf: fruit ratio and subsequently on the synthesis of more photosynthates and variable amount of starch in young fruits, which in turn converted into sugars at fruit maturity.

Total carotenoids of fruits were found highest in 'Skyline Supreme' (235.73 µg/100 g) followed by 'Prima' (222.63 µg/100 g) and 'Mollies Delicious' (181 µg/100 g) while lowest in 'Vermont Spur' (79.45 µg/100 g). The results obtained in the present investigation are found to be in close conformity with the studies of Kishor *et al.* (8). The highest total anti-oxidant activity was found in 'Skyline Supreme' (41.95 mMTE/L), while lowest in 'Stark Spur' (30.66 mMTE/L) and 'Bright-N-Early' (30.67 mMTE/L). The results obtained in the present investigation are found to be close conformity with the studies of Lejaa *et al.* (10). The antioxidants are mainly scavengers that reduce the various free radicals

serving in the avoidance of cellular injury and other disease. Likewise, fruit antioxidants have ability to produce resistance in tissues against disease and stress conditions. However, plant genotypes may differ in their antioxidant capacity (Lejaa *et al.*, 10). In the present study, antioxidant activity was due to presence of high ascorbic acid and total carotenoids contents in fruits of the apple cultivars.

There were significant differences in colour parameters (L^* , a^* , b^* , C^* and h°) among the different apple cultivars (Table 4). The cultivar 'Golden Delicious' was the most luminous ($L^*=84.86$) followed by 'Stark Spur' ($L^*=75.18$), while 'Bright-N-Early' was the least luminous ($L^*=31.36$) followed by 'Skyline Supreme' ($L^*=31.69$). The ground colour as well as blush depends on sunlight during ripening. Low value of L^* indicates a dark fruit skin. This is in agreement with the lower luminosity value observed in Bright-N-Early which is distinguished by a dark red colour. The cultivar 'Golden Delicious' showed a significant difference in L^* value from all other cultivars. This cultivar is characterized by a greenish yellow colour therefore inducing higher luminosity than the other cultivars. The a^* or red-green values showed a significant differences among the different cultivars studied. The cultivar 'Chaubattia Anupam' showed the highest red colour ($a^*=54.15$), followed by 'Gala Mast' ($a^*=34.76$), while the lowest values were shown by 'Golden Delicious' ($a^*=3.77$) followed by 'Stark Spur' ($a^*=4.15$). Better red colour in 'Chaubattia Anupam' may be due to its early maturity during which there is more sunshine and less effect of clouds and fog in the region. The b^* or yellow-blue component values were found highest in 'Golden Delicious' ($b^*=67.10$) followed by 'Stark Spur' ($b^*=65.21$), whereas the lowest values were shown by 'Red Chief' ($b^*=5.82$) followed by 'Bright-N-Early' ($b^*=5.89$). These results agree with the colour of the cultivars, 'Golden Delicious' and 'Stark Spur', characterized by intense yellowish green shades. The Chroma (C^*) values measures colour saturation or intensity. A higher C^* value is indicative of brighter red colour. The cultivars 'Chaubattia Anupam' ($C^*=67.53$) and 'Golden Delicious' ($C^*=67.23$) showed the highest C^* value among the different cultivars, whereas the cultivars 'Red Chief' ($C^*=14.86$) and 'Bright-N-Early' ($C^*=18.31$) showed the lowest C^* values. The hue angle (h°) that correlates with a^* and b^* values, was a good factor to access changes of the characteristic colour in these cultivars. Lower h° values indicate a redder colour, as exemplified by the cultivars 'Bright-N-Early' ($h^\circ=16.84$) and 'Skyline Supreme' ($h^\circ=19.95$), whereas the cultivars 'Golden Delicious' ($h^\circ=87.41$) and 'Stark Spur' ($h^\circ=86.36$) showed the highest h° values. Colour is the most important

Table 4. Comparative data on fruit colour characteristics among different apple cultivars (pooled mean).

Cultivar	Skin ground colour				
	L*	a*	b*	Chroma (C*)	Hue angle (h°)
Gloster	64.11	24.14	38.19	52.51	51.43
Vance Delicious	37.13	31.33	13.98	34.31	24.05
Vermont Spur	39.89	26.09	13.10	29.19	26.67
Rich-A-Red	46.31	20.18	20.64	29.46	45.05
Bright-N-Early	31.36	17.28	5.89	18.31	16.84
Stark Spur	75.18	4.15	65.21	65.34	86.36
Red Chief	33.39	13.90	5.82	14.86	20.41
Golden Delicious	84.86	3.77	67.10	67.23	87.41
Spur Type Red Delicious	38.66	23.20	11.31	26.07	25.05
Top Red	45.63	22.28	20.68	32.38	43.26
Skyline Supreme	31.69	26.59	9.00	26.20	19.95
Chaubattia Anupam	55.98	54.15	40.23	67.53	36.54
Chaubattia Princess	50.55	33.83	28.43	44.75	40.72
Mollies Delicious	59.35	30.68	37.10	48.73	50.14
Starkrimson	39.26	26.23	11.29	28.55	23.14
Oregon Spur	48.16	21.11	41.73	31.85	45.91
Gala Mast	70.63	34.76	44.22	57.03	52.05
Prima	44.82	24.27	27.35	36.56	48.42
CD at 5%	9.50	10.01	18.34	7.78	16.06

indicator of maturity and quality in many fruit species. It is mainly influenced by the concentration and distribution of various anthocyanins in the skin, as well as by other factors, such as light, temperature, ethylene and cultural practices (Usenik *et al.*, 17). The results obtained in the present investigation are found to be in close conformity with the studies of Jha *et al.* (6).

The variability in various chemical characteristics of fruits may be due to environmental conditions, harvesting of fruits at different time of maturity/ripening and genetic variability in genotypes. Thus, it can be inferred that the yield and physico-chemical performance of cultivar 'Spur Type Red Delicious' and 'Skyline Supreme' are better under changing climatic conditions of this region, hence would be popularized in the region.

REFERENCES

1. Anonymous. 2014. *Indian Horticulture Database* 2013-14, pp. 26-33.
2. Apak, R., Guclu, K., Ozyurek, M. and Karademir, S.E. 2004. Novel total anti-oxidant capacity index for dietary polyphenol and vitamin C and E, using their cupric ion reducing capability in presence of neocuproine; CUPRAC method. *J. Agric. Food Chem.* **52**: 7970-81.
3. Chadha, K.L. and Awasthi, R.P. 2005. *The Apple: Improvement, Production and Post-harvest Management*, Malhotra Publishing House, New Delhi, 511 p.
4. Das, B. Krishna, H., Attri, B.L., Ahmad, N. and Ranjan, J.K. 2011. Harvest maturity standards and fruit quality of some apple cultivars under high altitude conditions. *Indian J. Hort.* **68**: 170-79.
5. Dwivedi, S.K. and Dwivedi, D.H. 2009. Performance of some newly introduced apple cultivars under high altitude cold arid conditions of Ladakh. *Prog. Hort.* **41**: 220-22.
6. Jha, S.N., Rai, D.R. and Gunasekaran, S. 2010. Visual spectroscopy and colour modelling for non-destructive quality evaluation of apple. *J. Agr. Eng.* **47**: 9-13.
7. Jindal, K.K. and Mankotia, M.S. 2004. Impact of changing climatic conditions on chilling

- units, physiological attributes and productivity of apple in Western Himalayas. *Acta Hort.* **662**: 111-17.
8. Kishor, A., Attri, B.L., Brijwal, M., Kumar, A., Narayan, R., Singh, D.B., Debnath, S., Mer, M.S. and Tiwari, V.K. 2016. Physico-chemical characterization of wild apple (*Malus baccata*) in Kumaon hills of Uttarakhand. *Eco. Env. Cons.* **22**: 285-89.
 9. Kumar, P., Dimri, D.C. and Singh, S.C. 2006. Physico-chemical evaluation of spur and standard cultivars of apple (*Malus × domestica* borkh.) under mid hill conditions of Uttaranchal. *Prog. Agric.* **6**: 123-26.
 10. Lejaa, M., Mareczeka, A. and Benb, J. 2002. Antioxidant properties of two apple cultivars during long-term storage. *Food Chem.* **80**: 303-07.
 11. Mapson, L.W. 1970. Vitamins in fruits. In: The biochemistry of fruit and their products. Academic Press, London and New York, pp. 369-84.
 12. Panse, V.G. and Sukhatme, P.V. 1989. *Statistical Methods for Agricultural Workers*, ICAR Publication. New Delhi, 109 p.
 13. Ranganna, S. 2010. *Handbook of Analysis and Quality Control for Fruit and Vegetable Products*. 2nd edn. Tata McGraw Hill Publishing Company Ltd., New Delhi, p. 1103.
 14. Sharma, D.P., Sharma, H.R. and Sharma, N. 2017. Evaluation of apple cultivars under sub-temperate mid hill conditions of Himachal Pradesh. *Indian J. Hort.* **74**: 162-67.
 15. Singh, S.C. 2001. Comparative studies on flowering, fruiting and fruit quality of commercial apple (*Malus × domestica* borkh.) cultivars. M.Sc. thesis, GBPUA&T, Pantnagar, 120 p.
 16. Thakur, S., Sharma, D.P. and Sharma, N. 2015. Studies on growth, yield and physico-chemical characteristics of some peach cultivars under mid-hill conditions of Himachal Pradesh. *Indian J. Hort.* **72**: 416-18.
 17. Usenik, V., Stampar, F. and Veberic, R. 2009. Anthocyanins and fruit colour in plums (*Prunus domestica* L.) during ripening. *Food Chem.* **114**: 529-34.
 18. Wu, J., Gao, H., Zhao, L., Liao, X., Chen, F., Wang, Z. and Hu, X. 2007. Chemical compositional characterization of some apple cultivars. *Food Chem.* **103**: 88-93.

Received : March, 2017; Revised : October, 2017;
Accepted : January, 2018