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## Comparative Performance of Apple (*Malus domestica* Borkh.) Cultivars For Various Horticultural Traits in Kullu Valley of Himachal Pradesh

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### Abstract

The present investigation was carried out for the evaluation of twelve cultivars of apple namely Red Chief, Vance Delicious, Oregon Spur II, Super Chief, Scarlet Gala, Gale Gala, Red Delicious, Top Red, Scarlet Spur Red Delicious, Early Red One, Red Fuji and Gold Spur for their tree characters, time and duration of flowering, fruiting and chemical characteristics, during 2018-19 at Kullu valley of Himachal Pradesh. Red Fuji recorded maximum tree height (5.59 m) and minimum (2.96 m) in Super Chief. The maximum leaf area (38.57 cm<sup>2</sup>) was recorded in Early Red One. Time of full bloom was found earliest (3<sup>rd</sup> April) in Gale Gala and Scarlet Gala and latest (8<sup>th</sup> April) in Gold Spur. Fruit weight was found maximum (153.49 g) for Scarlet Spur Red Delicious and minimum (114.36 g) was observed in Red Fuji. Yield tree<sup>-1</sup> was maximum (37.32 kg) in Red Delicious V-22 and minimum (21.59 kg) in Red Chief. Total sugars was maximum (12.50%) in Red Fuji and minimum (10.16%) in Gold Spur.

**Keywords:** Apple, characterization, evaluation, flowering, fruit quality, fruiting

### 1. Introduction

Apple (*Malus domestica* Borkh.) is an important fruit crop widely spread in the cold and mild climates of temperate regions in the world. Apple is cultivated worldwide at high elevations in moderate regions (Luby, 2003). Apple is predominant fruit crop of North Western Himalayan region of the country and ranks first in area and production among the temperate fruits. In India, it is cultivated in hilly regions of Himachal Pradesh, Jammu and Kashmir, Uttarakhand and it is successfully grown in some parts of north eastern states including Arunachal Pradesh, Nagaland, Meghalaya and Sikkim. At present, the crop is being cultivated in the country at 301.04 ha area with an annual production of 2326.90 MT (NHB, 2018). In Himachal Pradesh, apple has emerged as a leading cash crop amongst fruit crops. It has revolutionized the socio-economic condition of farmers of the state as 0.2 m families (Directorate of Horticulture, 2017) are involved in its cultivation and account for 49% area and 88% production of total fruits. It is highly nutritious amongst fruits and it is rich in vitamins, carbohydrate and minerals than majority of other temperate fruit.

India has accumulated wide range of variability in this crop. Further, the crop exhibits rich genetic diversity and scope

for improvement for various horticultural traits. Genetic variability is essentially the first step of plant breeding for crop improvement which is immediately available for germplasm which is considered as the reservoir of variability for different characters. The assessment of variability is important in any crop because a wide range of variability always provides more possibility of selecting desired types (Vavilov, 1951). Khan et al. (2015) reported that genetic variability is the basic information needed for the breeders to improve the crops by adopting appropriate method of selection based on variability that exist in the material. The present study was therefore, undertaken to compare the performance of apple cultivars for various important horticultural traits.

### 2. Materials and Methods

The present investigation was carried out during 2018-2019 at Regional Horticultural Research and Training station Bajaura, Seobagh, District Kullu and Dr Y S Parmar University of Horticulture and Forestry, Nauni, Solan (HP). Experimental site is located at Seobagh, about 5 km away from Kullu city at an elevation of 1543 meters above mean sea level lying between latitude 31°99' N and longitude 77°13' E. The apple germplasm genotypes undertaken for studies were: Red Chief, Vance Delicious, Oregon Spur II, Super Chief, Scarlet Gala,



Gala Gala, Red Delicious, Top Red, Scarlet Spur Red Delicious, Early Red One, Red Fuji and Gold Spur. Three plants of each of the accession were selected for various observations. These plants are 12 years old and are grafted on seedling rootstock. The observations on various traits were recorded as follows:

### 2.1. Tree characters

The height of each experimental tree was measured with the help of calibrated staff from the ground level to the tip of tallest branch of the tree and it was expressed in meter (m). The spread of the trees from each replication was measured with the help of a measuring tape across the tree in East-West and North-South directions and average of both the measurements was worked out to express mean value in meters. Tree volume was calculated as per the methodology suggested by Westwood (1978). The trunk girth was measured with the help of measuring tape at a height of 10 cm from graft union. Five shoots were randomly selected around the periphery of the tree from each replication to measure their extension growth before pruning and mean value was worked out to express annual shoot growth of each cultivar. Ten fully expanded leaves were randomly selected from all over the periphery of tree from each replication. The leaf area was measured in  $\text{cm}^2$  with the help of leaf area meter (Licor-model 3100) and average leaf area of each cultivar was calculated.

### 2.2. Time and duration of flowering

The times of bud burst was recorded on which first bud opened in each accession. The time of opening of first flower was recorded on which first flower opened in each accession. Date of full bloom was recorded on the date on which about 75% flowers had opened was recorded as the date of full bloom. The duration of flowering was recorded as number of days from the date of opening of first flower to the date of opening of last flower in each accession was determined. The observations on petal fall were recorded as the date on which there was 80-85% petal fall.

### 2.3. Fruiting characteristics

Three branches on different aspects of the tree were tagged for counting flowers and number of fruit set. Fruit set was recorded three weeks after petal fall. Numbers of fruits dropped were calculated by subtracting the total number of fruits retained from total number of fruit set. The over colour developing upon the ground colour was observed using the colour charts of the Royal Horticultural Society, London. The shape of fruit was observed visually as round, ovate, oblong and elongated according to description given by Zielenski (1955). Fruit size was measured with the help of Digital Callipers in terms of length and breadth of fruit. The fruits taken for recording the observation were the same fruits as used to estimate mean fruit weight. Length was measured from calyx end to styler end and breadth was recorded by measuring the distance between cheeks of the fruit. Mean was worked out and expressed in millimetre (mm). Top pan electronic balance was used for recording this trait. Ten

randomly selected fruits were weighed and the readings so obtained were averaged. Volume of fruits was measured by water displacement method. Five selected fruits were immersed in a measuring cylinder (1000 ml capacity) filled with water up to certain graduation. The difference between initial and final readings gave the measure of volume of fruit samples, which were averaged and expressed in cubic centimetre ( $\text{cm}^3$ ) fruit<sup>-1</sup>. Firmness of flesh was determined by a pressure tester (Magness-Taylor) which recorded the pressure necessary for the plunger to penetrate the flesh. Apples crop load was harvested during the month of August from each tree and the yield was recorded as  $\text{kg tree}^{-1}$ . Yield efficiency was calculated by dividing the yield of the plant to the trunk cross-sectional area of the plant in both the years and is expressed in  $\text{kg m}^{-2}$ .

### 2.4. Chemical characteristics

Total soluble solids were determined with the help of digital pocket refractometer (Pal-At ago, Japan) after calibrating it with distilled water. It was expressed in degree Brix ( $^{\circ}\text{B}$ ). Twenty five grams of fruit pulp was taken, homogenized with distilled water in an electric blender and volume made to 250 ml. The mixture was then filtered through 'Whatman No. 1' filter paper and 50 ml of this filtrate was kept separately for titratable acidity. 10ml of extract was titrated against 0.1 NaOH solution using phenolphthalein as an indicator and the appearance of light pink colour indicated the end point. The total titratable acidity was calculated in terms of malic acid on the basis of 1 ml of 0.1 NaOH equivalents to 0.0067 g of anhydrous malic acid. The results were then expressed in terms of % (AOAC, 1970). Twenty five gram of fruit flesh thoroughly homogenized in distilled water was taken in a 250 ml volumetric flask. To this, ten ml of saturated lead acetate was added and the contents were shaken and filtered. Ten ml of potassium oxalate was later added to precipitate the excess of lead and the contents were again filtered, 100 ml of the filtrate was taken in 250 ml volumetric flask and to it 5 ml of concentrated hydrochloric acid was added. The hydrolysis was carried out by keeping it overnight. The excess of acid was then neutralized by adding saturated solution of sodium hydroxide. The hydrolyzed aliquot was then taken in a burette and titrated against a boiling mixture of 5 ml solution each of Fehling A and B. using methylene blue as an indicator (AOAC, 1970). The end point was indicated by the appearance of brick red colour and total sugars were expressed in % on fresh fruit weight basis. Boiling solution mixture containing 5 ml each of Fehling A and B reagents was titrated against un-hydrolyzed but de-leaded and clarified solution using methylene blue as an indicator. The results were expressed as % on fresh fruit weight basis as given in (AOAC, 1970). The amount of non-reducing sugars was calculated by subtracting reducing sugars from total sugars and multiplying the difference by standard factor 0.95. It was calculated by dividing total sugars by titratable acidity.



### 2.5. Statistical analysis

Field experiment was conducted with 3 replications. Results were statistically analysed by using Randomised Complete Block Design (RCBD).

#### 2.5.1. Analysis of variance

The data collected on different quantitative traits was processed for the Analysis of variance as suggested by Panse and Sukhatme (1985).

$$Y_{ij} = \mu + g_i + r_j + e_{ij}$$

Where,

$Y_{ij}$  = Phenotypic observation of  $i^{\text{th}}$  entry grown in  $j^{\text{th}}$  replication

$\mu$  = General population mean

$g_i$  = Effect of  $i^{\text{th}}$  entry

$r_j$  = Effect of  $j^{\text{th}}$  replication

$e_{ij}$  = Error component

Source of variation	Degree of freedom	Sum of squares	Mean sum of squares	F (cal)
Replication (r)	r-1	Sr	$Sr \div (r-1) = Mr$	$Mr \div Me$
Genotypes (g)	g-1	Sg	$Sg \div (g-1) = Mg$	$Mg \div Me$
Error (e)	(r-1)(g-1)	Se	$Se \div (r-1)(g-1) = Me$	

Where,

g = Number of genotypes

r = Number of replications

Sg = Sum of squares due to genotypes

Sr = Sum of squares due to replications

Se = Sum of squares due to error

Mg = Mean sum of squares due to genotypes

Mr = Mean sum of squares due to replications

Me = Mean sum of squares due to error

The genotypes and replications mean sum of square were tested against error mean squares by 'F' test for (r-1), (r-1)(g-1) and (g-1), (r-1)(g-1) degree of freedom at  $p = 0.05$ . The calculated F-value was compared with tabulated F-value. When F-test was found significant, critical difference was calculated to find out the superiority of one genotype over the other.

The standard error and critical differences were calculated as follows:

$$SE(m) \pm = \sqrt{Me} \div r$$

$$SE(d) \pm = \sqrt{2Me} \div r$$

$$CD(p=0.05) = S.E.(d) \times t_{(0.05)}(r-1)(g-1) \text{ df}$$

Where,

SE (m)  $\pm$  = Standard error of mean

SE (d)  $\pm$  = Standard error of difference

CD ( $p=0.05$ ) = Critical difference at 5% level of significance

### 3. Results and Discussion

#### 3.1. Tree characters

Red Fuji recorded maximum tree height (5.59 m), tree spread (3.68 m), trunk girth (43.46 cm) and tree volume (40.48 m<sup>3</sup>), Red Delicious V-22 recorded maximum annual shoot growth (38.71 cm), maximum leaf area (38.57 cm<sup>2</sup>) was recorded in cultivar Early Red One. While, minimum tree height (2.96 m), tree spread (1.62 m), trunk girth (17.77 cm) and tree volume (4.21 m<sup>3</sup>) was recorded in Super Chief, minimum annual shoot growth (23.55 cm) was obtained in Gale Gala, and minimum leaf area (28.80 cm<sup>2</sup>) was recorded for the cultivar Super Chief, respectively (Table 1). A similar variation in tree volume was also reported by (Sharma et al., 2004; Kumar et al., 2016; Sharma et al., 2017) considerable variation in growth parameters was influenced by cultivar plantation site, climate change, genetic makeup of the cultivar used in the study.

#### 3.2. Time and duration of flowering

Bud burst was earliest in Gale Gala on 23<sup>rd</sup> March followed by Scarlet Gala on 24<sup>th</sup> March whereas, Gold Spur was the latest to bud burst on 29<sup>th</sup> March. Date of opening of first flower was earliest in Scarlet Gala on 27<sup>th</sup> March followed by Red Chief V-22, Super Chief and Gale gala on 28<sup>th</sup> March while, Gold Spur was the latest to date of opening of first flower on 3<sup>rd</sup> April. The date of full bloom was earliest in Gale Gala and Scarlet Gala on 3<sup>rd</sup> April followed by Red Chief, Oregon Spur II, Scarlet Spur Red Delicious and Super Chief on 5<sup>th</sup> April while, Gold Spur was the latest to date of full bloom on 8<sup>th</sup> April. Petal fall was earliest in Oregon Spur II, Scarlet Gala and Gale Gala on 10<sup>th</sup> April followed by Red Chief, Red Delicious V-22, Scarlet Spur Red Delicious and Super Chief on 11<sup>th</sup> April whereas, Gold Spur was the latest to petal fall 14<sup>th</sup> April. Duration of flowering was maximum in Red Fuji, Scarlet Gala, Red Delicious V-22 and Super Chief 15 days while, duration of flowering was minimum in Gold Spur 12 days, respectively (Table 2). The study under consideration is similar to the work of (Sharma et al., 2004; Singh et al., 2005; Sharma et al., 2017) the difference in the time and duration of flowering may be attributed to the genetic make-up of different cultivars studied, management practices, and varying climatic conditions in site of plantation.

#### 3.3. Fruiting characteristics

Gold Spur recorded maximum fruit set (78.13%), maximum fruit drop was recorded (42.23%) in Gale Gala, Scarlet Spur Red Delicious recorded maximum fruit length (68.29 mm), breadth (75.31 mm), fruit weight (153.49 g) and fruit volume (171.82 cc), Red Delicious V-22 recorded maximum yield (37.32 kg tree<sup>-1</sup>), Super Chief recorded maximum yield efficiency (9.44 kg m<sup>-2</sup>) while, Red Fuji recorded minimum fruit set (41.45%), minimum fruit drop was recorded (20.32%) in



Table 1: Performance of apple cultivars for vegetative growth characteristics

Genotypes	Tree height (m)	Tree spread (m)	Trunk girth (cm)	Annual shoot growth (cm)	Tree volume (m <sup>3</sup> )	Leaf area (cm <sup>2</sup> )
Early Red One	3.22	2.86	28.83	26.27	13.97	38.57
Red Chief	3.24	2.33	27.43	28.65	9.44	34.63
Red Delicious V-22	4.68	2.75	37.86	38.71	18.75	34.63
Vance Delicious	5.00	2.86	32.66	35.58	23.15	36.57
Gold Spur	4.19	2.48	32.03	29.94	13.64	34.17
Top Red	4.08	2.34	29.80	31.44	12.08	33.57
Oregon Spur II	3.16	2.35	24.00	33.39	9.30	32.70
Scarlet Spur Red Delicious	3.67	2.17	29.33	28.83	9.10	29.78
Red Fuji	5.59	3.68	43.46	36.05	40.48	34.42
Scarlet Gala	3.55	2.16	24.60	33.77	8.80	29.85
Super Chief	2.96	1.62	17.77	26.90	4.21	28.80
Gale Gala	3.14	2.14	24.13	23.55	7.92	34.52
CD ( $p=0.05$ )	0.80	0.59	7.58	6.88	1.87	3.19

Table 2: Performance of apple cultivar for date of bud burst, time and duration of flowering

Genotypes	Bud burst (date)	1st flower open (date)	Full bloom (date)	Petal fall (date)	Duration of flowering (Days)
Early Red One	27-Mar	31-Mar	06-Apr	12-Apr	13.00
Red Chief	26-Mar	30-Mar	05-Apr	11-Apr	13.00
Red Delicious V-22	25-Mar	28-Mar	06-Apr	11-Apr	15.00
Vance Delicious	26-Mar	30-Mar	06-Apr	12-Apr	14.00
Gold Spur	29-Mar	03-04	08-Apr	14-Apr	12.00
Top Red	26-Mar	30-Mar	07-Apr	12-Apr	14.00
Oregon Spur II	25-Mar	29-Mar	05-Apr	10-Apr	13.00
Scarlet Spur Red Delicious	25-Mar	29-Mar	05-Apr	11-Apr	14.00
Red Fuji	26-Mar	29-Mar	06-Apr	12-Apr	15.00
Scarlet Gala	24-Mar	27-Mar	03-Apr	10-Apr	15.00
Super Chief	25-Mar	28-Mar	05-Apr	11-Apr	15.00
Gale Gala	23-Mar	28-Mar	03-Apr	10-Apr	14.00
CD ( $p=0.05$ )					1.87

Gold Spur, Scarlet Gala recorded minimum fruit length (57.86 mm), Red Fuji recorded minimum fruit breadth (65.40 mm), Red Fuji recorded minimum fruit weight (114.36 g) and fruit volume (125.19 cc), Red Chief recorded minimum yield (21.59 kg tree<sup>-1</sup>) and Red Fuji recorded minimum yield efficiency (2.04 kg m<sup>-2</sup>). Early Red One, Red Chief, Red Delicious V-22, Vance Delicious, Top Red, Oregon Spur II and Scarlet Spur Red Delicious has globose conical shape while cultivars with globose shape were Gold Spur and Scarlet Gala whereas Red Fuji were obloid and Gale Gala has obloid to globose shape. Fruit ground colour was observed to be Red Group 45 (A) in Early Red One, Red Delicious V-22 and Oregon Spur II, Red

Group 46 (A) in Red Chief, Vance Delicious, Scarlet Spur Red Delicious and Super Chief, Yellow Green group 150 (A) in Gold Spur, Red Group 53 (A) in Top Red, Red Group 37 (A) in Red Fuji and Orange Red Group 32 (A) in Scarlet Gala. Early Red One, Top Red, Oregon Spur II and Scarlet Gala had bearing fruit on spur and Red Chief, Red Delicious V-22, Vance Delicious, Gold Spur, Scarlet Spur Red Delicious, Red Fuji, Super Chief and Gale Gala bearing habit was observed in shoot and spur, respectively (Table 3 and 4). The present investigation is in agreement with the work of (Kumar et al., 2006; Singh 2013; Sharma et al., 2017; Verma et al., 2018) the trait is influenced by genetic and environmental factors, hence the fruit trees



Table 3: Performance of apple cultivars for fruiting characteristics

Genotypes	Fruit set (%)	Fruit drop (%)	Fruit length (mm)	Fruit breadth (mm)	Fruit weight (g)	Fruit volume (cm <sup>3</sup> )
Early Red One	58.26	31.84	65.40	70.86	135.71	157.04
Red Chief	65.41	29.23	65.57	70.10	145.16	161.66
Red Delicious V-22	60.41	30.31	62.27	68.31	138.80	152.13
Vance Delicious	62.32	27.98	63.61	68.51	140.43	154.76
Gold Spur	78.12	20.32	61.71	66.81	129.07	141.04
Top Red	59.55	32.37	62.71	68.14	144.94	162.27
Oregon Spur II	65.64	25.37	63.99	70.18	142.84	157.01
Scarlet Spur Red Delicious	65.59	33.20	68.29	75.31	153.49	171.82
Red Fuji	41.45	36.10	57.86	65.40	114.36	125.19
Scarlet Gala	71.54	27.30	57.92	66.60	122.24	132.04
Super Chief	70.14	28.63	63.00	71.07	147.35	163.51
Gale Gala	56.84	42.23	61.19	67.13	133.25	148.75
CD ( $p=0.05$ )	5.52	4.91	4.53	4.73	8.96	9.03

Table 4: Performance of apple cultivar for yield, yield efficiency, fruit shape, bearing habit and fruit colour

Genotypes	Yield (kg tree <sup>-1</sup> )	Yield efficiency (kg m <sup>-2</sup> )	Fruit shape	Bearing habit	Fruit colour
Early Red One	32.19	5.02	Globose conical	Shoot and Spur	Red Group 45 A
Red Chief	21.59	3.78	Globose conical	Spur	Red Group 46 A
Red Delicious V-22	37.32	3.34	Globose conical	Shoot and Spur	Red Group 45 A
Vance Delicious	35.90	5.00	Globose conical	Shoot and Spur	Red Group 46 A
Gold Spur	31.04	4.23	Globose	Spur	Yellow Green Group 150 A
Top Red	32.82	4.87	Globose conical	Spur	Red Group 53 A
Oregon Spur II	30.08	6.85	Globose conical	Spur	Red Group 45 A
Scarlet Spur Red Delicious	29.78	4.40	Globose conical	Shoot and Spur	Red Group 46 A
Red Fuji	30.25	2.04	Obloid	Shoot and Spur	Red Group 37 A
Scarlet Gala	28.90	6.70	Globose	Shoot and Spur	Orange Red Group 32 A
Super Chief	22.61	9.44	Globose conical	Spur	Red Group 46 A
Gale Gala	25.44	5.62	Obloid to Globose	Shoot and Spur	Red Group 47 A
CD ( $p=0.05$ )	8.13	2.53			

growing condition, such as soil fertility, irrigation, pruning and other agricultural operations have direct effect on fruiting characteristics.

### 3.4. Chemical characteristics

Total soluble solids were recorded maximum (14.16 °Brix) in Gale Gala, Top Red recorded maximum fruit firmness (15.26 kg m<sup>-2</sup>), Gold Spur recorded maximum titratable acidity (0.34%), sugar acid ratio was recorded Maximum (50.15) in

Red Chief, total sugars was recorded maximum (11.85%) in Super chief, Gold Spur recorded maximum reducing sugars (7.27%) and non-reducing sugars was recorded maximum (5.02%) for Spur Chief whereas, total soluble solids were recorded minimum (10.82 °Brix) for Red Fuji, fruit firmness was recorded minimum (11.87 kg m<sup>-2</sup>) for Early Red One, titratable acidity was recorded minimum (0.19%) in Scarlet Spur Red Delicious, Sugar acid ratio was recorded minimum (29.90) in Gold Spur, total sugars was recorded minimum



(8.63%) in Scarlet Spur Red Delicious, reducing sugars was recorded minimum (5.44%) in Red Fuji and non-reducing sugars was recorded minimum (1.57%) in Scarlet Spur Red Delicious, respectively (Table 5). These results are in close conformity with the findings of (Kumar et al., 2006; Sharma et

al., 2017; Mir et al., 2017; Verma et al., 2018) these differences among the apple cultivars could be due to genetic variability, climatic condition, and harvesting of fruit at different time of maturity.

Table 5: Performance of apple cultivars for chemical characteristics

Genotypes	TSS (°Brix)	Firmness (kg cm <sup>-2</sup> )	Titratable acidity (%)	Sugar acid ratio	Total sugars (%)	Reducing sugars (%)	Non-reducing sugars (%)
Early Red One	11.42	11.87	0.29	36.24	10.35	6.26	3.89
Red Chief	13.76	12.20	0.23	50.15	11.47	6.71	4.52
Red Delicious V-22	12.79	14.50	0.27	41.33	11.14	7.12	3.81
Vance Delicious	12.14	13.20	0.24	45.20	10.64	6.75	3.69
Gold Spur	12.60	13.00	0.34	30.05	10.16	7.27	2.75
Top Red	11.73	15.26	0.31	36.50	11.23	6.90	4.11
Oregon Spur II	12.76	12.70	0.23	48.17	10.86	6.55	4.09
Scarlet Spur Red Delicious	13.53	12.30	0.19	45.03	10.80	6.97	2.57
Red Fuji	14.46	13.95	0.23	48.90	12.50	5.44	3.79
Scarlet Gala	12.22	12.50	0.21	50.06	10.23	6.95	3.11
Super Chief	13.76	13.50	0.24	49.44	11.85	6.57	5.02
Gale Gala	14.16	14.43	0.23	48.65	11.13	7.05	3.87
CD ( $p=0.05$ )	0.37	0.65	0.04	6.55	0.21	0.19	0.27

#### 4. Conclusion

The present study revealed ample variability for all the tree characteristics, time and duration of flowering, fruiting and chemical characteristics. However, the cultivars Scarlet Spur Red Delicious followed by Red Chief, Super Chief were found best for fruit length, fruit breadth, fruit weight, fruit volume, titratable acidity and non-reducing sugars whereas Red Delicious V-22 showed maximum yield (kg plant<sup>-1</sup>). Among these best cultivars Scarlet Spur Red Delicious was found to be most promising.

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