

## Phenotypic and nutritional evaluation of low chill peach cultivars

R. Kumar\*<sup>ORCID</sup>, D.C. Dimri, Omveer Singh, A.K. Singh, J.S. Shivran, K. Kusum and M. Rawat

Department of Horticulture, G. B. Pant University of Agriculture and Technology, Pantnagar-263 145, India

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\*Corresponding Author Email: [rajender.horti@gmail.com](mailto:rajender.horti@gmail.com)

\*ORCID: <https://orcid.org/0000-0002-0302-0109>

### Abstract

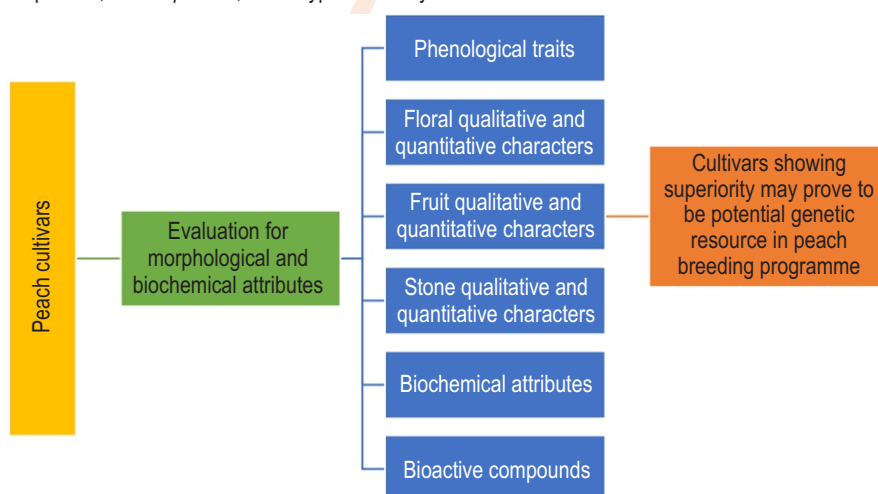
**Aim:** To determine variation among the low chill peach cultivars for various metric and non-metric parameters of flowering and fruiting, with an objective to identify potential genotypes with promising attributes for trait-specific low chill peach breeding.

**Methodology:** The present study was performed at Horticulture Research Centre, Patharchatta, G.B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand, India during the years 2021 and 2022. The qualitative attributes were assessed as per the DUS Guidelines of Protection of Plant Varieties & Farmer's Right Authority. The quantitative and quality attributes were estimated following the standard methodology (AOAC, 2000). The pooled data of 2021 and 2022 were analyzed to test the significance of differences between the means for different parameters through ANOVA.

**Results:** The cultivar Florda Prince performed better in terms of early fruit maturity (69.83 days) and also produced the heaviest (123.70 g) and largest fruit size (66.30 x 62.63 mm). The pulp-to-stone ratio ranged between 9.49 (Selection-12) to 23.32 (Florda Red). The cultivar Shan-i-Punjab was the most productive cultivar (20.52 kg/tree), however, the maximum yield efficiency (0.080 kg cm<sup>-2</sup>) was found in Saharanpur Prabhat variety. In terms of fruit quality, Florda Gold determined the maximum TSS content (13.61°B) while Red June witnessed minimum titratable acidity (0.44%) with maximum antioxidant capacity (72.24%). For major bio-active compounds (total phenols and flavonoids), the cultivar Selection-12 was superior (68.67 mg gallic acid eq. 100 g<sup>-1</sup>; 61.90 mg 100 g<sup>-1</sup>) among all low chill peaches.

**Interpretation:** The findings of the present study will be useful in the selection of peach cultivars that may prove to be valuable genetic resources for the improvement of low chill peaches.

**Key words:** Bioactive compounds, *Prunus persica*, Phenotypic variability



## Introduction

Peach (*Prunus persica*) is a diploid species in the Rosaceae family with  $2n=2x=16$  chromosomes. It is the most popular summer fruit crop with huge number of existing commercial cultivars representing a diverse range of international germplasm (Forcada *et al.*, 2014). Peach is generally considered to have originated in China (Wang, 1985; Faust and Timon, 1995), however, few suggest that it originated in Persia. A primary center of peach diversity is in Tibet and South-west China, while Iran is a secondary center (Kumar *et al.*, 2013). In India, the cultivation of low chill peaches has gained a significant boost over the last two decades because of their precociousness and high productivity. Peaches grown in subtropical climates are harvested a few months earlier than high chill cultivars, resulting in a good economic return (Kumar, 2013). However, in recent years due to varied circumstances like insufficient cooling and erratic weather conditions, low-chill peach yield and quality have declined in certain subtropical terrains (Penso *et al.*, 2020).

Nutrition has traditionally been considered as one of the most important factor in promoting health and preventing diseases. Bioactive compounds, most notably polyphenols play a significant role in boosting immunity due to their antioxidant and anti-inflammatory properties (Gombart *et al.*, 2020). They inhibit certain pro-inflammatory cytokines and regulate immune cells and gene expression (Yahfoufi *et al.*, 2018). Furthermore, our metabolic processes produce free radicals, which are highly reactive, toxic and unstable. Antioxidants play a vital role in inhibiting the formation of these free radicals. Qadri *et al.* (2017) found substantial differences among peach cultivars with regard to phenolics and radicals scavenging activity ranging between 176.20 to 317.72 mg GAE 100 g<sup>-1</sup> and 44.25 to 78.17%, respectively. An analysis by Pandey *et al.* (2020) evaluated six cultivars of subtropical peaches and estimated phenolic content between 10.41 to 25.06 mg 100 g<sup>-1</sup> and antioxidant capacity of 64.25 to 82.99%.

Since the dawn of fruit breeding, the primary goals have centered on improved fruit quality, increased postharvest life, disease/pest resistance, as well as an expanded length of fruit maturity (Byrne, 2005). However, this growing interest in nutraceuticals and functional foods have prompted fruit breeders to select crops with high bioactive compounds (Cevallos-Casals *et al.*, 2006). Therefore, the quantification of these bioactive compounds present in different fruit crops and their cultivars has gained considerable focus. Based on these considerations, the current study was undertaken to assess different low chill peach cultivars for their pomological significance and health-promoting properties.

## Materials and Methods

**Study area:** The field evaluation work was performed at the Horticulture Research Centre, Patharchatta, G.B. Pant University of Agriculture and Technology, Pantnagar, India during the years 2021

and 2022. Pantnagar is geographically located at 29.5° latitude and 79.3° E longitude in the foothills of Shivalik range of the Himalayas in the Tarai belt (243.84 m above MSL). The highest temperature ranges between 32°C to 45°C in summers and the lowest between 5°C to 10°C in winters with annual rainfall of 1200 mm.

**Experimental material and design:** The experimental material comprised twelve low chill peach cultivars (twenty years old) maintained at Horticulture Research Centre, Patharchatta. The experiment was laid out in a Randomized Complete Block Design by selecting each cultivar of peach as treatment with three replications (1 tree per replicate) and all the trees were maintained under uniform cultural practices throughout the study period.

**Measurements and observations:** Distinctiveness, Uniformity and Stability (DUS) Guidelines of Protection of Plant Varieties and Farmer's Right Authority (PPV&FRA) were followed to evaluate the qualitative attributes of fruit and stone. The observations were recorded on duration of flowering (days), fruit set percentage (%), fruit retention percentage (%), days to maturity (days), fruit length (mm), fruit diameter (mm), fruit weight (g), stone length (mm), stone diameter (mm), stone weight (g), pulp to stone ratio, yield (kg/tree) and yield efficiency (kg cm<sup>-2</sup>). The observations on metric traits were recorded using electronic equipment. Total soluble solids (TSS) content was determined with the help of an Erma hand refractometer (Model Name ERB, Material Number 3, Japan) and expressed in °Brix after making the temperature correction at 20°C. Other quality parameters viz. titratable acidity, total sugars, reducing sugars and ascorbic acid were assessed following standard methodology (AOAC, 2000). Anthocyanins content was estimated by calorimetric method described by Ranganna (2007). The phenol content was determined following the standard methods of Singleton *et al.* (1999). Flavonoids in fresh fruit samples were evaluated as per aluminium chloride method (Zhishen *et al.*, 1999). The DPPH (2,2-diphenyl-1-picrylhydrazyl) radical scavenging activity was estimated by the method of Brand-Williams (1995).

**Statistical analysis:** The pooled data of 2021 and 2022 were analyzed to test significant differences between the means for different parameters through ANOVA. Using Duncan's Multiple Range Tests, significant differences were identified between the cultivars at  $p < 0.05$ . Data analysis and computations were performed using IBM SPSS Statistics 19 (IBM, NY, USA) software.

## Results and Discussion

The low chill peach cultivars exhibited a considerable variation in the date of pink bud emergence in 2021, ranging from January 15<sup>th</sup> (Florida Gold) to February 1<sup>st</sup> (Selection-12), as shown in Fig. 1. However, during 2022 the delayed pink bud stage was noticed which overspread from January 23<sup>rd</sup> (Florida Prince) to February 12<sup>th</sup> (Selection-12). The full bloom stage was observed on various dates, ranging from 9<sup>th</sup> February (Florida Gold) to 25<sup>th</sup> February (Selection-12) in the year 2021. In 2022, it

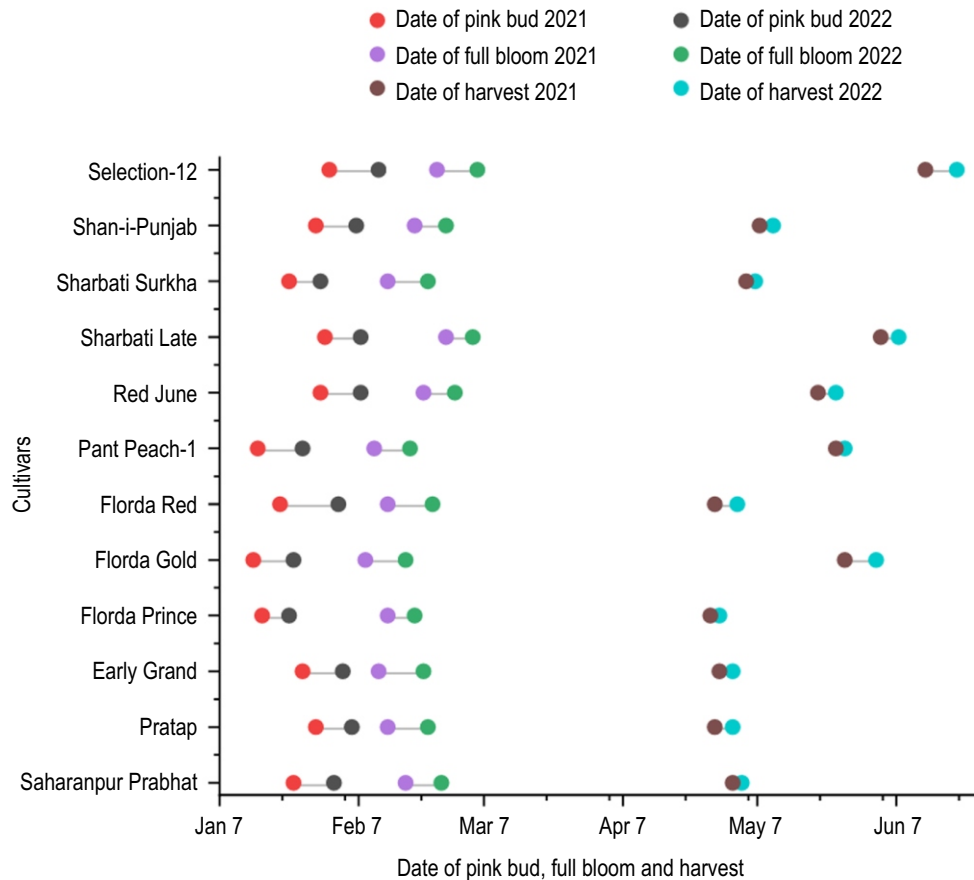


Fig. 1: Date of pink bud, full bloom, and harvesting of low chill peach cultivars under *Tarai* conditions.

was estimated earliest in Florda Gold and Florda Prince on 18<sup>th</sup> and 19<sup>th</sup> February, respectively, while the most delayed blooming was marked in cultivar Selection-12 on 6<sup>th</sup> March. The date of fruit harvest also varied greatly, wherein the cultivar Florda Prince was harvested earliest on 27<sup>th</sup> April, while Selection-12 on 14<sup>th</sup> of June in 2021. The harvest date ranged from April 29<sup>th</sup> (Florda Prince) to June 21<sup>st</sup> (Selection-12) during 2022.

The low chill peach cultivars showed considerable variability for different qualitative attributes of fruit and stone (Table 1; Fig. 2). The ground colour of the fruit was observed to be pinkish white in 3 cultivars; orange yellow in 7 and greenish yellow in 2 peach cultivars. The pulp colour was categorized as orange yellow for cultivar Pratap, Early Grand, Florda Prince, Florda Red, Pant Peach-1, Red June; light yellow for Shan-i-Punjab and creamish white for Saharanpur Prabhat, Florda Gold, Sharbati Late, Sharbati Surkha and Selection-12 cultivars, respectively. Fruits having large area of over colour of skin were reported in four cultivars and medium in five. While the cultivar Selection-12 displayed small over colour while very small over colour was seen in cultivars Florda Gold and Sharbati Late. The density of skin

pubescence varied from medium in cultivars Florda Gold and Sharbati Late to highly dense in the remaining varieties.

The adherence of skin to flesh was medium in Pratap, Early Grand, Florda Prince, Florda Red, Pant Peach-1, Sharbati Surkha and Shan-i-Punjab and; strong for Saharanpur Prabhat, Florda Gold, Red June, Sharbati Late and Selection-12. The anthocyanin colouration of flesh next to skin was also scored visually and was noted as strong (Saharanpur Prabhat), medium (Florda Gold) and weak for most peach accessions. The intensity of anthocyanin colouration was observed weak in the central part of in most cultivars, whereas, it was categorized as medium in Florda Gold and Red June. The anthocyanin colouration of flesh around the stone was found to be strong for Florda Gold; medium for Pant Peach-1 and Sharbati Late, and weak for the remaining cultivars. The stone size in relation to fruit was found to be small in Saharanpur Prabhat; medium in Pratap, Early Grand, Florda Prince and Sharbati Surkha and; large in Florda Gold, Florda Red, Pant Peach-1, Red June, Sharbati Late, Shan-i-Punjab and Selection-12 cultivars. Stone shape of cultivars under study varied from elliptic (Pratap, Florda Prince, Florda Gold), obovate (Saharanpur Prabhat, Early Grand, Pant Peach-1, Red June,

Table 1: Qualitative fruit and stone characters of low chill peach cultivars under Tarai conditions

Cultivars	Ground colour of skin	Flesh colour	Relative area of skin over	Density of skin pubescence	Adherence of skin to flesh	Anthocyanin colouration of flesh next to skin	Anthocyanin colouration of flesh in central part of flesh	Anthocyanin colouration of flesh around stone	Stone size compared to fruit	Stone shape (lateral view)	Stone adherence to flesh
Saharanpur Prabhat	Pink white	Cream white	Very large	Very dense	Strong	Strong	Weak	Weak	Small	Obovate	Freestone
Pratap	Orange yellow	Orange yellow	Medium	Very dense	Medium	Weak	Weak	Weak	Medium	Elliptic	Semi-clingstone
Early Grand	Orange yellow	Orange yellow	Medium	Very dense	Medium	Weak	Weak	Weak	Medium	Obovate	Freestone
Florida Prince	Orange yellow	Orange yellow	Medium	Very dense	Medium	Weak	Weak	Weak	Medium	Elliptic	Freestone
Florida Gold	Greenish yellow	Cream white	Very small	Medium dense	Strong	Medium	Medium	Strong	Large	Elliptic	Freestone
Florida Red	Orange yellow	Orange yellow	Very large	Very dense	Medium	Weak	Weak	Weak	Large	Oblate	Freestone
Pant Peach-1	Orange yellow	Orange yellow	Very large	Very dense	Medium	Weak	Weak	Medium	Large	Obovate	Freestone
Red June	Orange yellow	Orange yellow	Medium	Very dense	Strong	Weak	Medium	Weak	Large	Obovate	Freestone
Sharbati Late	Greenish yellow	Cream white	Very small	Medium dense	Strong	Weak	Weak	Weak	Large	Obovate	Semi-clingstone
Sharbati Surkha	Pink white	Cream white	Very large	Very dense	Medium	Weak	Weak	Weak	Medium	Obovate	Clingstone
Shan-i-Punjab	Orange yellow	Yellow	Medium	Very dense	Medium	Weak	Weak	Weak	Large	Obovate	Freestone
Selection-12	Pink white	Cream white	Small	Very dense	Strong	Weak	Weak	Weak	Large	Obovate	Clingstone

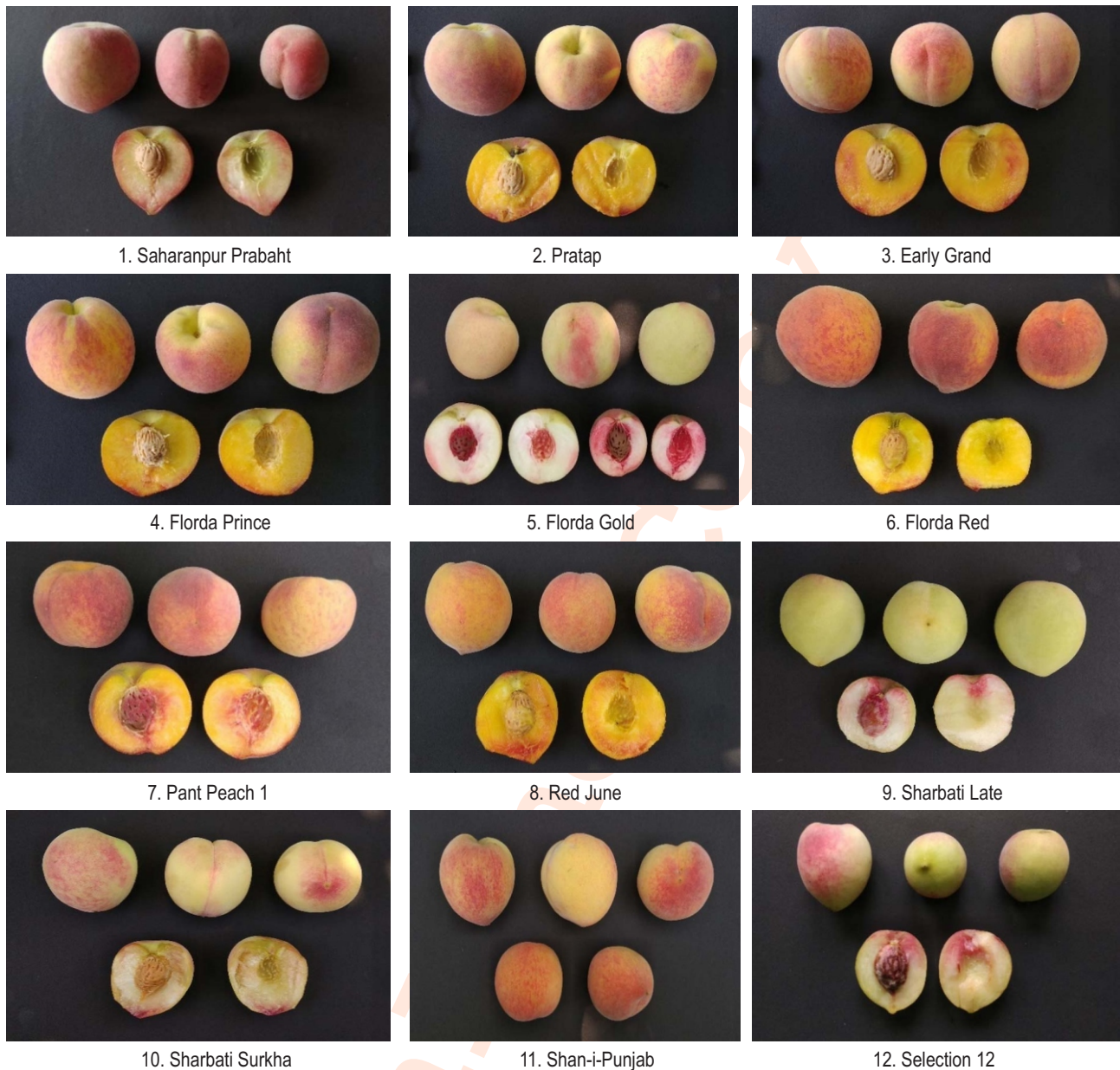


Fig. 2: Variability in fruit characters of low chill peach cultivars under *Tarai* conditions.

Sharbati Late, Sharbati Surkha, Shan-i-Punjab and Selection-12) to oblate in Florda Red. The adherence of stone to the flesh was noted freestone type in Saharanpur Prabhat, Early Grand, Florda Prince, Florda Gold, Florda Red, Pant Peach-1, Sharbati Surkha and Shan-i-Punjab; semi-cling in Pratap and Red June, and clingstone type in Sharbati Late and Selection-12. The observed variation among different low chill peach cultivars for date of pink bud and date of full bloom could be attributed to the difference in number of chilling hours accumulated to overcome bud dormancy (Simonetto *et al.*, 2004). In addition to the genetic variability, factors influencing these phenological phase includes daily mean

temperature, diurnal variations in temperature, light conditions, rainfall, altitude, latitude, relative humidity etc (Fishman and Genard 1998; Tsipouridis *et al.*, 2002). The results obtained are in close conformity with the findings of Srivastava *et al.* (2020). Under Lucknow conditions, they noted initiation of flowering between first to last week of February and full bloom from mid-February to first week of March among the eight low chill peach cultivars evaluated. The differences in the cultivars for the qualitative fruit attributes might be due to their genotypic variations. Previous studies on peaches also noted considerable variability in qualitative fruit and stone attributes (Singh *et al.*,

**Table 2:** Variability among low chill peach cultivars for flowering and fruiting attributes under *Tarai* conditions

Cultivars	Duration of flowering (days)	Fruit set (%)	Fruit retention (%)	Days to maturity (days)	Fruit length (mm)	Fruit diameter (mm)	Fruit weight (g)
Saharanpur Prabhat	26.00±0.58 <sup>a</sup>	72.64±1.49 <sup>a</sup>	37.00±1.19 <sup>g</sup>	70.17±0.60 <sup>h</sup>	53.06±0.73 <sup>d</sup>	51.11±0.80 <sup>c</sup>	81.77±0.24 <sup>e</sup>
Pratap	18.83±0.93 <sup>de</sup>	57.74±1.95 <sup>de</sup>	53.72±2.31 <sup>bc</sup>	71.00±0.76 <sup>h</sup>	63.82±0.54 <sup>ab</sup>	62.18±0.50 <sup>a</sup>	118.70±1.77 <sup>b</sup>
Early Grand	18.50±0.76 <sup>e</sup>	48.33±1.67 <sup>fg</sup>	44.41±0.56 <sup>def</sup>	74.00±0.50 <sup>g</sup>	64.41±1.13 <sup>ab</sup>	60.92±0.13 <sup>a</sup>	115.31±2.30 <sup>b</sup>
Florda Prince	25.17±0.44 <sup>ab</sup>	52.50±1.27 <sup>ef</sup>	41.68±1.87 <sup>fg</sup>	69.83±0.73 <sup>h</sup>	66.30±0.48 <sup>a</sup>	62.63±0.54 <sup>a</sup>	123.70±0.52 <sup>a</sup>
Florda Gold	23.50±0.29 <sup>bc</sup>	48.57±3.51 <sup>fg</sup>	48.59±1.81 <sup>cd</sup>	104.50±0.29 <sup>b</sup>	51.22±1.48 <sup>d</sup>	50.00±1.37 <sup>c</sup>	64.52±0.47 <sup>a</sup>
Florda Red	24.00±0.29 <sup>bc</sup>	69.92±2.16 <sup>ab</sup>	46.20±1.00 <sup>def</sup>	70.50±1.26 <sup>h</sup>	56.99±0.67 <sup>c</sup>	55.18±1.10 <sup>b</sup>	79.36±1.13 <sup>a</sup>
Pant Peach-1	22.67±0.17 <sup>c</sup>	65.76±3.06 <sup>bc</sup>	56.25±3.42 <sup>b</sup>	100.67±0.73 <sup>c</sup>	48.13±1.17 <sup>e</sup>	47.10±0.83 <sup>d</sup>	72.50±0.86 <sup>f</sup>
Red June	22.67±0.44 <sup>c</sup>	66.02±1.85 <sup>bc</sup>	44.32±3.48 <sup>def</sup>	86.50±1.15 <sup>e</sup>	63.29±0.50 <sup>ab</sup>	55.29±1.48 <sup>b</sup>	92.32±0.78 <sup>d</sup>
Sharbati Late	26.50±1.04 <sup>a</sup>	68.75±1.20 <sup>ab</sup>	47.38±2.25 <sup>cd</sup>	96.83±0.93 <sup>d</sup>	65.75±1.59 <sup>d</sup>	61.33±1.10 <sup>a</sup>	117.23±0.72 <sup>b</sup>
Sharbati Surkha	22.33±0.44 <sup>c</sup>	43.71±0.81 <sup>g</sup>	42.70±1.07 <sup>efg</sup>	76.67±0.83 <sup>f</sup>	56.50±0.81 <sup>c</sup>	50.60±0.73 <sup>c</sup>	74.98±1.12 <sup>f</sup>
Shan-i-Punjab	20.50±0.50 <sup>d</sup>	61.89±0.15 <sup>cd</sup>	62.42±0.88 <sup>a</sup>	76.17±1.01 <sup>fg</sup>	62.34±0.36 <sup>b</sup>	56.41±0.41 <sup>b</sup>	103.52±1.67 <sup>c</sup>
Selection-12	23.67±0.17 <sup>bc</sup>	61.63±0.52 <sup>cd</sup>	50.67±2.27 <sup>bcd</sup>	107.67±1.09 <sup>a</sup>	39.14±1.69 <sup>f</sup>	32.82±0.34 <sup>e</sup>	30.24±0.41 <sup>h</sup>

\*Each value is expressed as mean of three replicates ±S.E. and means with same letter within a column shows non-significant differences (at  $p \leq 0.05$ ) as per Duncan's Multiple Range Test

**Table 3:** Variability among low chill peach cultivars for fruit stone and yield attributes under *Tarai* conditions

Cultivars	Stone length (mm)	Stone diameter (mm)	Stone weight (g)	Pulp to stone ratio	Yield (kg per tree)	Yield efficiency (kg cm <sup>-2</sup> )
Saharanpur Prabhat	24.56±0.25 <sup>j</sup>	17.15±0.22 <sup>e</sup>	3.43±0.18 <sup>de</sup>	23.13±1.40 <sup>ab</sup>	8.82±0.15 <sup>f</sup>	0.080 <sup>a</sup>
Pratap	28.70±0.67 <sup>f</sup>	20.88±0.63 <sup>c</sup>	5.14±0.09 <sup>b</sup>	22.16±0.70 <sup>abc</sup>	11.93±0.32 <sup>cd</sup>	0.047 <sup>b</sup>
Early Grand	31.13±0.16 <sup>cd</sup>	21.95±0.08 <sup>abc</sup>	5.45±0.15 <sup>b</sup>	20.19±0.75 <sup>cd</sup>	12.81±0.11 <sup>cd</sup>	0.040 <sup>bc</sup>
Florda Prince	32.14±0.31 <sup>bc</sup>	22.15±0.65 <sup>ab</sup>	5.59±0.15 <sup>b</sup>	21.22±0.69 <sup>abcd</sup>	13.72±0.90 <sup>bc</sup>	0.025 <sup>g</sup>
Florda Gold	30.06±0.16 <sup>de</sup>	21.98±0.12 <sup>abc</sup>	4.16±0.10 <sup>c</sup>	14.67±0.40 <sup>e</sup>	15.38±0.29 <sup>b</sup>	0.043 <sup>bc</sup>
Florda Red	27.43±0.15 <sup>g</sup>	16.94±0.35 <sup>e</sup>	3.30±0.18 <sup>de</sup>	23.41±1.39 <sup>a</sup>	11.76±0.63 <sup>cd</sup>	0.039 <sup>bcd</sup>
Pant Peach-1	29.77±0.11 <sup>ef</sup>	22.05±0.59 <sup>ab</sup>	5.16±0.25 <sup>b</sup>	13.15±0.52 <sup>e</sup>	12.67±1.42 <sup>cd</sup>	0.041 <sup>bc</sup>
Red June	33.07±0.08 <sup>b</sup>	21.87±0.30 <sup>bc</sup>	5.66±0.10 <sup>b</sup>	15.44±0.45 <sup>e</sup>	11.03±0.29 <sup>de</sup>	0.026 <sup>efg</sup>
Sharbati Late	33.13±0.54 <sup>h</sup>	22.50±0.09 <sup>ab</sup>	5.55±0.31 <sup>b</sup>	20.37±1.37 <sup>bcd</sup>	12.23±0.81 <sup>cd</sup>	0.035 <sup>cd</sup>
Sharbati Surkha	26.07±0.45 <sup>h</sup>	19.18±0.12 <sup>d</sup>	3.81±0.16 <sup>cd</sup>	18.85±0.79 <sup>d</sup>	9.52±0.32 <sup>ef</sup>	0.031 <sup>def</sup>
Shan-i-Punjab	34.63±0.26 <sup>a</sup>	23.13±0.29 <sup>a</sup>	6.21±0.22 <sup>a</sup>	15.78±0.76 <sup>e</sup>	20.52±0.51 <sup>a</sup>	0.045 <sup>b</sup>
Selection-12	22.83±0.76 <sup>j</sup>	16.40±0.17 <sup>e</sup>	2.90±0.04 <sup>e</sup>	9.47±0.13 <sup>f</sup>	6.82±0.30 <sup>g</sup>	0.019 <sup>g</sup>

\* Each value is expressed as mean of three replicates ±S.E. and means with same letter within a column show non-significant differences (at  $p \leq 0.05$ ) as per Duncan's Multiple Range Test

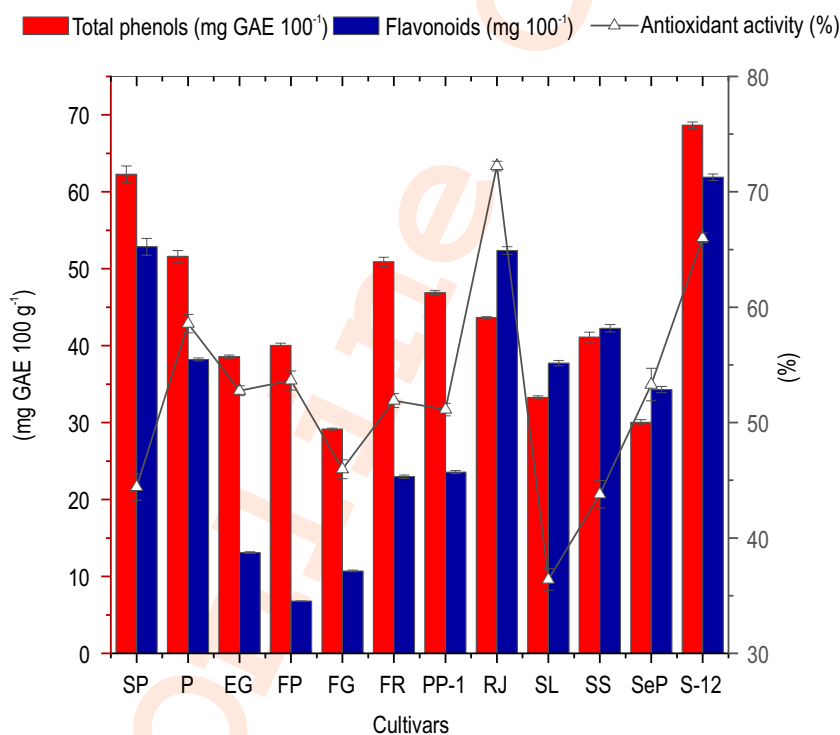
2014). There were significant differences among the low chill peach cultivars for different quantitative attributes (Table 2). The cultivar Sharbati Late exhibited the longest (26.50 days) flowering duration which was statistically at *par* with Saharanpur Prabhat (26.00 days) and Florda Prince (25.17 days) whereas the shortest flowering duration was noted (18.50 days) in Early Grand. The highest fruit set was found in Saharanpur Prabhat (72.64%) and the lowest (43.71%) in Sharbati Surkha. However, the maximum fruit retention was noted in Shan-i-Punjab (62.42%) followed by Pant Peach-1 (56.25%) while minimum fruit retention was found in Saharanpur Prabhat (37.00%). Days to maturity showed wide variability during both years of investigation, and was estimated longest for the cultivar Selection-12 (107.67 days) followed by Florda Gold (102.33 days) and minimum for Florda Prince (69.83 days). The maximum fruit length was found in Florda Prince

(66.30 mm), followed by Sharbati Late (65.75 mm), Early Grand (64.41 mm), while the shortest fruit length was found in Pratap (63.82 mm); and Selection-12 (39.14 mm) cultivars. The maximum fruit diameter (62.23 mm) was noted in the cultivar Florda Prince while the minimum fruit diameter (32.82 mm) was noted in the cultivar Selection-12. The cultivar Florda Prince produced the heaviest fruit (123.70 g) which differs significantly from the remaining cultivars, it was minimum in (30.24 g) Selection-12. The maximum stone length (34.63 mm) was noticed in the cultivar Shan-i-Punjab while the minimum stone length (22.83 mm) was noticed in the cultivar Selection-12. The maximum stone diameter was reported in Shan-i-Punjab (23.13 mm) followed by Sharbati Late (22.50 mm) and Florda Prince (22.15 mm) whereas the minimum stone diameter (16.40 mm) was reported in Selection-12. The maximum stone weight (6.21 g)

**Table 4:** Biochemical attributes of low chill peach cultivars under *Tarai* conditions

Cultivars	TSS (°B)	Titrateable acidity (%)	Ascorbic acid (mg 100 g <sup>-1</sup> )	Total sugars (%)	Reducing sugars (%)	Anthocyanin (mg 100 g <sup>-1</sup> )
Saharanpur Prabhat	11.94±0.05 <sup>ab</sup>	0.48±0.02 <sup>f</sup>	11.00±0.11 <sup>e</sup>	10.64±0.04 <sup>b</sup>	6.79±0.04 <sup>de</sup>	2.11±0.014 <sup>b</sup>
Pratap	10.83±0.16 <sup>de</sup>	0.70±0.05 <sup>c</sup>	12.68±0.20 <sup>b</sup>	9.85±0.11 <sup>c</sup>	6.23±0.02 <sup>f</sup>	0.70±0.004 <sup>d</sup>
Early Grand	10.52±0.13 <sup>ef</sup>	0.63±0.01 <sup>d</sup>	12.07±0.07 <sup>c</sup>	9.35±0.06 <sup>d</sup>	5.79±0.18 <sup>g</sup>	0.53±0.007 <sup>g</sup>
Florda Prince	10.50±0.17 <sup>ef</sup>	0.45±0.01 <sup>f</sup>	12.68±0.19 <sup>b</sup>	9.71±0.25 <sup>cd</sup>	6.53±0.09 <sup>ef</sup>	0.70±0.012 <sup>e</sup>
Florda Gold	13.61±0.13 <sup>a</sup>	0.85±0.02 <sup>b</sup>	10.75±0.06 <sup>e</sup>	12.06±0.05 <sup>a</sup>	7.49±0.23 <sup>c</sup>	0.33±0.002 <sup>j</sup>
Florda Red	11.69±0.08 <sup>c</sup>	0.73±0.02 <sup>c</sup>	14.59±0.13 <sup>a</sup>	8.69±0.05 <sup>e</sup>	4.00±0.07 <sup>h</sup>	2.33±0.022 <sup>a</sup>
Pant Peach-1	13.59±0.11 <sup>a</sup>	0.72±0.01 <sup>c</sup>	10.21±0.07 <sup>f</sup>	10.73±0.14 <sup>b</sup>	8.73±0.12 <sup>a</sup>	1.21±0.005 <sup>c</sup>
Red June	11.58±0.05 <sup>c</sup>	0.44±0.01 <sup>f</sup>	11.17±0.11 <sup>cd</sup>	10.70±0.07 <sup>b</sup>	7.02±0.09 <sup>d</sup>	0.53±0.007 <sup>g</sup>
Sharbati Late	11.66±0.13 <sup>c</sup>	0.98±0.01 <sup>a</sup>	11.77±0.15 <sup>e</sup>	10.46±0.11 <sup>b</sup>	8.21±0.19 <sup>b</sup>	0.36±0.003 <sup>i</sup>
Sharbati Surkha	10.34±0.19 <sup>f</sup>	0.44±0.02 <sup>f</sup>	11.60±0.20 <sup>d</sup>	9.57±0.32 <sup>cd</sup>	7.03±0.11 <sup>d</sup>	0.77±0.005 <sup>e</sup>
Shan-i-Punjab	11.18±0.14 <sup>d</sup>	0.74±0.01 <sup>c</sup>	10.82±0.09 <sup>e</sup>	10.44±0.14 <sup>b</sup>	7.92±0.16 <sup>b</sup>	0.56±0.002 <sup>f</sup>
Selection-12	12.26±0.13 <sup>b</sup>	0.57±0.01 <sup>e</sup>	9.58±0.10 <sup>g</sup>	10.45±0.12 <sup>b</sup>	8.25±0.10 <sup>b</sup>	0.39±0.003 <sup>h</sup>

\*Each value is expressed as mean of three replicates ± S.E. and means with same letter within a column shows non-significant differences (at p ≤ 0.05) as per Duncan's Multiple Range Test



**Fig. 3:** Total phenolic content, flavonoids and antioxidant activity in low chill peach cultivars under *Tarai* conditions. Data shown are mean of three replicates, vertical bar represents ± standard error.

was found in Shan-i-Punjab and minimum (2.90 g) in Selection-12. The pulp to stone ratio varied from 9.49 (Selection-12) to 23.32 (Florda Red).

The cultivar Florda Red followed by Saharanpur Prabhat (23.13), Pratap (22.15) and Florda Prince (21.20) were found

superior for this parameter. Concerning yield, Shan-i-Punjab proved to be the most productive (20.52 kg tree<sup>-1</sup>) which differ significantly with rest all cultivars whereas Selection-12 recoded the lowest yield (6.82 kg tree<sup>-1</sup>). For yield efficiency the cultivar Saharanpur Prabhat exhibited the highest value (0.080 kg cm<sup>-2</sup>) and Selection-12 (0.019 kg cm<sup>-2</sup>) the lowest. The differences in the

fruit development period for a given variety could be explained based on the differences in their heat unit requirement (Kanwar et al., 2002). There may be differences in the genetic constitutions of different cultivars, which could explain the variability present. Earlier researchers had also reported more or less similar variability in the fruiting attributes of different subtropical peaches (Madhumala et al., 2019; Rana et al., 2022). Yield is a principal objective of breeding but at the same time very complex phenomenon influenced by various biotic and abiotic factors. Compare to high chill peach cultivars grown in the sub-temperate region, a lesser yield was estimated in the present study. Perez et al. (2004) stated that low fruit yields under subtropical conditions could be attributed to relatively high temperatures and dry winds during flowering, as well as desiccation of the pedicel after fruit set, drying of pollen grains, and excessive fruit drop. Furthermore, high temperature may affect the development of buds, including floral buds that do not develop fully and form 'blind nodes' (Dennis et al., 2000). Penso et al. (2020) also described that peach tree developmental stages such as dormancy and dormancy break are most affected under subtropical and tropical conditions, which results in alterations of flowering which consequently affects fruiting.

The estimate of biochemical and bioactive compounds presented in Table 3 and Fig. 3 clearly demonstrate the significant differences among the cultivars for these attributes. The TSS content was maximum in cultivars Florda Gold (13.61°B) followed by Pant Peach-1 (13.59 °B) and minimum in Sharbati Surkha (10.34°B). The maximum titratable acidity, was reported in Sharbati Late (0.98%) and minimum in Red June (0.44%) which differed non-significantly to Sharbati Late, Florda Prince (0.45%) and Saharanpur Prabhat (0.48%). The ascorbic acid content was maximum in Florda Red (14.59 mg 100 g<sup>-1</sup>) and minimum (9.58 mg 100 g<sup>-1</sup>) in Selection-12. The total sugars content varied from 8.69% (Florda Red) to 12.06% (Florda Gold) for the pooled estimate of both the years. The anthocyanins content was maximum in cultivar Florda Red (2.33 mg 100 g<sup>-1</sup>) and minimum in Florda Gold (0.33 mg 100 g<sup>-1</sup>). The phenol content was maximum in Selection-12 (68.67 mg gallic acid eq. 100 g<sup>-1</sup>) and minimum in Florda Gold (29.16 mg gallic acid eq. 100 g<sup>-1</sup>). The flavonoid content was maximum in Selection-12 (61.90 mg 100 g<sup>-1</sup>) and minimum in Florda Prince (6.79 mg 100 g<sup>-1</sup>). The antioxidant activity was highest (72.24%) in Red June and minimum (36.40%) in Sharbati Late (Fig. 3). As a quality trait, sugar content in fruit is highly associated with the aroma and taste of peaches and nectarines (Colarič et al., 2005). In the present study, a significantly higher difference among the cultivars was noticed for total phenols, flavonoids and antioxidant activity. Variations in bioactive compounds could be attributed to the maturity at harvest, cultural and environmental conditions, and fruit location on the tree (Kirakosyan et al., 2004). However, most researchers have ascribed these variations to be largely influenced by genotypic factors (Vizzotto et al., 2006; Cantin et al., 2009).

The phenolic compounds have been proven to be extremely beneficial to human health as antioxidants, anticancer

and anti-inflammatory agents and also as immunostimulants (Gao et al., 2013). Moreover, Liu et al. (2015) reported higher phenolic content in late-maturing peach cultivars in comparison to early-maturing ones. The high radical scavenging activity of the sample is associated with its superior antioxidant activity (Ghafar et al., 2010). Previous studies on peaches also reported a significant variability among peach cultivars for different bioactive compounds (Pandey et al., 2020).

Based on the findings of the present study, it can be concluded that the peach germplasm maintained at HRC, Patharchatta, G.B. Pant University of Agriculture and Technology exhibits significant variations in terms of different flowering, fruiting and biochemical traits. The cultivars identified to be promising in the investigation may prove to be a potential genetic resource in the low chill peach improvement programme.

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