

**CHARACTERIZATION AND EVALUATION OF SOME
PEACH [*Prunus persica* (L.) Batsch.]
ACCESSIONS**

Thesis

by

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(H-2016-54-M)**

Submitted to



**Dr. YASHWANT SINGH PARMAR UNIVERSITY
OF HORTICULTURE AND FORESTRY
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partial fulfilment of the requirements for the degree

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**MASTER OF SCIENCE
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CERTIFICATE-I

This is to certify that the thesis titled “**Characterization and evaluation of some peach [*Prunus persica* (L.) Batsch.] accessions**”, submitted in partial fulfilment of the requirements for the award of degree of **Master of Science (Horticulture) Fruit Science** in the discipline of **Horticultural Sciences** of Dr Yashwant Singh Parmar University of Horticulture and Forestry, (Nauni) Solan (HP) – 173 230 is a bonafide research work carried out by **Ms Suman Bodh (H-2016-54-M)** daughter of Sh Tharchan Bodh under my supervision and that no part of this thesis has been submitted for any other degree or diploma.


The assistance and help received during the course of investigations have been fully acknowledged.

Place : Mashobra , Shimla
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CERTIFICATE-II

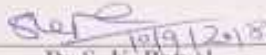
This is to certify that the thesis titled, "Characterization and evaluation of some peach [*Prunus persica* (L.) Batsch.] accessions" submitted by Ms Suman Bodh (H-2016-54-M) daughter of Shri Tharchan Bodh to the Dr. Yashwant Singh Parmar University of Horticulture and Forestry, (Nauni) Solan (HP) - 173 230 India in partial fulfilment of the requirements for the degree of **Master of Science (Horticulture) Fruit Science** in the discipline of **Horticultural Sciences** has been approved by the Advisory Committee after an oral examination of the student in collaboration with an External Examiner.



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Place : Nauni, Solan
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ABBREVIATIONS USED

%	:	Per cent
°Brix	:	Degree Brix
amsl	:	Above mean sea level
ANOVA	:	Analysis of variance
CD	:	Critical difference
cm	:	Centimetre
cv (s)	:	cultivar(s)
<i>et al.</i>	:	Co-workers
E-W	:	East-West
g	:	Gram
ha	:	Hectare
H.P	:	Himachal Pradesh
i.e.	:	That is
kg	:	Kilogram
m	:	Metre
mg	:	Milligram
ml	:	Millilitre
mm	:	Millimetre
MT	:	Metric Tonne
N-S	:	North-South
TSS	:	Total Soluble Solids
viz.	:	Namely

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Chapter-1

INTRODUCTION

Peach [*Prunus persica* (L.) Batsch.] is an important fruit crop of Himachal Pradesh valued for its fresh and canned fruits. The fruits of peach are attractive, delicious and highly nutritious. They are very rich source of potassium, iron, fiber, vitamin A, vitamin C and also contains high concentrations of phytochemicals such as carotenoids, flavonols and anthocyanins (Hancock and Scorza, 2008; Byrne, 2002). In India, peach is grown on a commercial scale in mid hills of Himachal Pradesh, Jammu and Kashmir, hilly area of Uttarakhand and subtropical plains of north India (Uttar Pradesh, Punjab and Haryana) to limited extent in the hill region of eastern states.

The total area under peach cultivation in Himachal Pradesh 5076 hectares (ha) with the production of 4097 metric tonnes (MT) during 2017-2018 (Anonymous, 2018). Peaches have relatively performed well at an altitude ranging between 1200-1500 m amsl and 'July Elberta', 'Redhaven' and 'Sunhaven' Suncrest and Glohaven are popular cultivars. However, peach production in recent times has seen a declining trend associated with number of factors such as diseases, overdependence on a select band of cultivars coupled with global warming. Although, peach is a temperate zone fruit, low chilling peach cultivars have been developed and found suitable for sub-tropical region (Kunden *et al.*, 2004).

It has ushered economic prosperity in the hilly regions of the state, which were completely deprived of modern development practices. Unfortunately, due to monoculture of peach, the pace of development through peach based farming system is stumbling down. Consequently, the profit out of this fruit have started declining due to various factors viz. susceptibility to insect, pests and diseases, climatic vagaries leading to low fruit production, post harvest losses, costly management practices thereby increasing the cost of production.

Moreover, with the sudden upsurge of global warming, standard cultivars of peach because of their inability to meet the requisite chilling requirement in wet temperate region of HP posing the risk of crop failure. Besides, the over dominance of few peach cultivar in peach growing pockets of HP has at times, led to a glut in the market resulting in colossal

economic loss to the farmers. This situation may only be countered by broadening the base of germplasm through introduction and evaluation of new varieties of peaches.

The development of new fruit cultivars has generally been based on genetic resources. Germplasm collection and characterization are essential stages of breeding programs. Main germplasm collection and characterization performed by describing phenological, pomological and morphological characteristics such as tree vigour and growth habit, fruit quality features, leaf, stone, flower, stigma and style, pollen blooming and harvest time (Yilmaz *et al.* 2009).

Germplasm characterization and evaluation of its performance in the target area are the decisive factors for its adoption by the orchardists. Besides, the descriptors so developed are important for the proper identification and characterization of the variety to maintain trueness and check biopiracy.

There is a vast scope to augment peach production in temperate regions of Himachal Pradesh through varietal diversification not only to meet the demand of fresh fruit market but also to provide raw material to the agro-processing units.

Keeping in mind the above and to provide an array of varieties, the present study was carried out on some peach germplasm accessions available in the field genebank of NBPGR, Regional Station Phagli, Shimla with the following objective:

- ❖ To describe and evaluate peach germplasm for growth, floral and fruit characteristics.

Chapter-2

REVIEW OF LITERATURE

The available literature on related aspects of the present studies entitled “Characterization and evaluation of some peach [*Prunus persica* (L.) Batsch.] accessions has been reviewed under the following headings:

2.1 TREE CHARACTERS

Tree growth characters like plant height, trunk girth, tree spread and growth habit have been used to identify and characterize fruit species and cultivars (Crane and Lawrence, 1956; Nitransky, 1980).

Khokhar and Agnihotri (1990) evaluated seven year old five low chilling peach cultivars viz. Bonita, Early Amber, Flordared, Flordasun and Shan-i-Punjab grown at Horticultural Regional Sub-Station, Dhaulakuan. They recorded the highest cumulative trunk girth in Early Amber (58.5 cm) followed by Flordasun (51.8 cm), Flordared (49.8 cm) and the least in Bonita (32.6 cm). The tree spread was recorded highest in Early Amber (581.30 cm) and minimum in Bonita (277.50 cm).

Badiyala and Lakhanpal (1994) observed the comparative performance of five peach cultivars viz. Bonita, Early Amber, Flordared, Flordasun and Shan-i-Punjab under subtropical conditions of Himachal Pradesh. ‘Shan-i-Punjab’ attained maximum tree spread (6.63 m), trunk girth (86.20 cm), tree volume (163.45 m³) and annual shoot extension growth (56.20 cm) while minimum tree spread (4.25 m), trunk girth (46.30 cm), tree volume (51.59 m³) and annual shoot extension growth (37.50 cm) was recorded in cultivar Bonita.

Bali and Singh (2000) studied varietal variation in growth and yield of different subtropical peach cultivars. The data revealed maximum tree height in ‘Pishori Gola’ (4.42 m) and minimum in ‘Ventura’ (3.00 m). Maximum tree spread was recorded in ‘Shan-i-Punjab’ (5.91 m) while minimum in ‘Rochan’ (3.75 m).

Kanwar *et al.* (2002) studied the development of new cultivars of peach for subtropics of India and recorded highest growth in terms of final trunk girth (104 cm) in ‘Flordaprince’

followed by 'Tropic Beauty' (103 cm) and the lowest trunk girth (63 cm) was recorded in 'Flordaprince'.

Dubey (2003) observed the performance of three peach cultivars (TA-170, Flordasun and Sharbati) in Arunachal Pradesh. 'Flordasun' had highest plant height (3.07 m) whereas, lowest (2.94m) in 'Sharbati'.

Singh *et al.* (2005) evaluated some peach cultivars viz. Sharbati, Shan-i-Punjab, Earligrande, Tropic Snow, Flordared, Flordagold, ValleGrande, Tropic Sweet and Flordaprince under Jammu conditions of J & K. Maximum plant height (257.50 cm) was registered with 'Flordasun' and minimum (179.17 cm) in 'Flordagold'. Whereas, maximum stem girth (2.43 cm) was recorded in 'Flordagold' and minimum in 'Tropic Sweet' (1.75 cm).

Tandon (2006) carried out studies on five peach introduction namely 'Early Amber', 'Fire Prince', 'Gold Prince', 'Jewel' and 'Scarlet Pearl' at Nauni, under mid hill conditions of Himachal Pradesh during 2005-2006. Maximum plant height (3.50 m), trunk girth (35.80 cm) was observed in 'Scarlet Pearl' whereas, minimum tree height (1.90 m) and trunk girth (8.70 m) was recorded in 'Gold Prince'.

Saran *et al.* (2010) observed morphological variability for different characters among 11 peach cultivars under Dehradun conditions of Uttarakhand. They classified peach genotypes into different clusters, cluster I to cluster V. Maximum plant height (5.94 m) and spread (7.81 m) was observed in cluster II (Sharbati and Shan-i-Punjab). Whereas, minimum plant height (3.18 m) and spread (3.31 m) was recorded in cluster V (Armking and Sunred).

Yepthomi (2011) studied the performance of ten peach genotypes namely Tropic Sweet, Saharanpur Prabhat, Earligrande, Flordaprince, Tropic Snow, Flordaglo, ValleGrande, Tropic Beauty, Pratap and FlordaGrande at Nauni, under mid hill conditions of Himachal Pradesh during 2010-2011. Plant height was maximum (2.73 m) in ValleGrande and minimum (1.83 m) in Flordaprince.

Jana (2015) recorded variation among tree growth habit of six peach cultivars under Eastern Plateau region of India. He observed considerable variation in growth habit as vigorous (Flordasun, Shan-i-Punjab, Flordaprince), small (Pratap) and semi-vigorous (Prabhat) type.

Kumar (2015) studied variability on some genotype of peach under Solan conditions of Himachal Pradesh. He observed that tree height was maximum (3.60 m) in 'ValleGrande' and minimum (2.80 m) in 'Flordaprince'. Tree spread was maximum (2.15 m) in 'ValleGrande' while minimum (2.15 m) in 'Flordaglo'. Trunk girth was recorded maximum (37.90 cm) in 'Flordaprince' and minimum (37.12 cm) in 'Earligrande'

Anonymous (2015) characterized different peach varieties as per PPV & FRA guidelines. Vigour of the tree varied from weak (Kanto-5, Summerglo), medium (Fantasia, Snow and Queen) and strong (Red Globe, Cresthaven). According to these guidelines, growth of tree was found to vary as upright (Red Globe, Cresthaven), semi spreading, spreading (Nimla, Early Red June), drooping (Kanto-5) and weeping (Elberta) type.

Chauhan (2016) evaluated the performance of 15 peach cultivars under solan (Nuani) conditions. Tree height was maximum (3.78 m) in Shan-i-Punjab and minimum (1.28 m) in Suncrest. Whereas, trunk girth was maximum (21.95 cm) in Flordaprince and minimum (12.80 cm) in Saharanpur Prabhat. .

Chaurasiya and Mishra (2017) characterized different peach cultivars for morphological traits at Potato & Temperate Horticulture Research Station, Mainpat, Surguja, Chhattisgarh under university of Indira Gandhi Krishi Vishwavidyalaya in the year 2016-17. They observed that tree growth was vigorous in Shan-i-Punjab, Flordaprince and Earligrande while semi-vigorous growth habit was in Pratap, Glohaven and Suncrest.

2.2 FOLIAGE CHARACTERS

Leaf characters are considered distinguishing features for identification and description of fruit species and cultivars.

Deol and Singh (1986) recorded leaf characters of different peach cultivars viz. Shan-i-Punjab, Sharbati and Flordasun. The leaf length varied from 10.02 cm (Shan-i-Punjab) to 14.56 cm (Flordasun) and breadth from 2.40 cm (Shan-i-Punjab) to 3.38 cm (Sharbati). The leaf shape was recorded as lanceolate reflexed with serrulate margin in all the three cultivars. The petiole length was recorded as 0.97 cm in Sharbati, 1.16 cm in Flordasun and 1.28 cm in Shan-i-Punjab. The glands were reniform in both Shan-i-Punjab and Flordasun, whereas, mixed in Sharbati.

Sharma and Mehta (1992) recorded the time of leaf fall in seven peach cultivars viz. Dawne, Flat Peach, Kanto-5, Quetta, Shaftaloo, Sommerset and Star Early Flame at Solan (Nauni) conditions of H.P. Leaf fall initiation was earliest (3rd October) in Flat Peach and last (15th October) in Quetta. The complete leaf fall occurred between 1st December (Sommerset) to 15th December (Kanto-5). The dates of complete leaf fall in other cultivars were 2nd December (Dawne), 4th December (Flat Peach), 12th December (Shaftaloo and Stark Early Flame) and 14th December (Quetta).

Singh *et al.* (2005) evaluated different peach cultivars viz. Sharbati, Shan-i-Punjab, Earligrande, Tropic Snow, Flordagold, ValleGrande, Tropic Sweet and Flordaprince under sub-tropics of Jammu region. Bud sprouting was observed between 1st February (Flordaprince) to 14th March (Shan-i-Punjab) and the leaf area ranged from 50.48 cm² in Sharbati to 54.10 cm² in Shan-i-Punjab.

Tandon (2006) observed no marked variation in leaf shape except for leaf size and leaf area among different peach introductions. Time of leaf emergence was early (2nd February) in Jewel and late (24th February) in Gold Prince and Early Amber. Leaf size was maximum (11.11 cm × 3.27 cm) in Gold Prince and minimum (8.94 cm × 2.53 cm) in Jewel. Leaf area was maximum (22.21 cm²) in Gold Prince and minimum (14.37 cm²) in Jewel.

Wolfe and Strang (2010) studied leaf colour and type of glands in different peach accessions and reported that the leaf colour indicate whether fruit is yellow fleshed or white fleshed. They also observed serrated and globose type of leaf gland besides observing absence of glands in some peach cultivars.

Kumari (2011) studied performance of some peach cultivars under mid hill conditions of Himachal Pradesh during 2009-2010. She observed that leaf area was maximum (53.68 cm²) in Early Elberta followed by (50.73 cm²) in Glohaven and minimum (40.58 cm²) in July Elberta.

Byrne and Anderson (2012) reported moderately large lanceolate leaves with acute bases, sharply acute apices, crenulate margins and reniform petiolar glands in “TexFirst” peach.

Leaf glands were categorized as present (Redhaven) or absent (Crimson Glo, Tejon) as per UPOV (2014) guidelines. According to guidelines, shape of the glands are reniform in 'Redhaven' whereas, globose (round) in 'Springtime'.

Anonymous (2015) reported different leaf characters as per PPV & FRA guidelines. Margin of leaf blade varied from crenate (Peshawari) to shallow serrate (Glohaven, Red Globe) to deep serrate (Earligrande, Andross, Kanto-5).

Chauhan (2016) characterized different peach cultivars and observed maximum leaf blade length (17.1 cm) in Tropic Beauty and minimum (13.8 cm) in Glohaven. Leaf blade width was maximum (4.03 cm) in Tropic Beauty and minimum (2.32 cm) in Saharanpur Prabhat. Petiole length was maximum (1.09) in Flordaglo and minimum (0.67 cm) in Earligrande.

2.3 TIME AND DURATION OF FLOWERING

Mehta (1983) recorded the time and duration of flowering in peach cultivars viz. Dawne, Flat Peach, Kanto-5, Quetta, Shaftaloo, Somerset and Stark Early Flame under mid-hill conditions of Himachal Pradesh during 1982-1983. The flowering started in the second week of March and continued till the first week of April. Cultivars Somerset and Stark Early Flame were the earliest (8th March) and Quetta was the last (15th March) to come in Flowering. The longest duration of flowering (24 days) was in Shaftaloo and Flat Peach followed by (23 days) Kanto-5. Stark Early Flame and Quetta had flowering durations 20 and 19 days, respectively.

Khokhar and Agnihotri (1990) studied the full bloom period in different peach cultivars under Dhaulakuan (Himachal Pradesh) conditions. They reported that time of full bloom varied from 23rd February to 12th March in Flordared and Bonita, respectively.

Tosun *et al.* (2001) reported the duration of flowering time in 'Goldhaven', 'JuneGold', 'Redhaven' and 'Dixred' alongwith other fourteen peach cultivars. The duration of flowering varied between 16th March to 26th March.

Kanwar *et al.* (2002) reported the variability in low chilling cultivars of peach for the sub-tropical region of Punjab in India. They found that 'FlordaGrande' was earliest to flower (10th February) and 'TropicSweet' was last to flower (15th February).

Tsipourdis *et al.* (2005) observed considerable variation in flowering period from 1st March to 30th March in different peach cultivars grown in Northern Greece.

Tandon (2006) evaluated five peach cultivars viz. Gold Prince, Scarlet Pearl, Early Amber, Jewel and Fire Prince under Solan (Nauni) conditions and observed the time of full bloom extending from 17th February (Jewel) to 10th March (Gold Prince).

Boonprakob (2008) evaluated some Thai TigerTM series of low chilling peaches viz. TXW-1113-1, TXW-1C4, TXW-1490 and TXW-1491-1 in subtropical highland regions of Thailand. The time of full bloom was recorded from 27th January (TXW-1C4) to 5th February (TXW-1490 and TXW-1491).

Singh *et al.* (2009) recorded the data on flowering in six peach varieties Earligrande, Flordaprince, Shan-i-Punjab, Flordasun, Prabhat and Sharbati under Punjab conditions. The period of full bloom varied between 10th February to 27th February whereas duration of flowering varied from 33 days (Earligrande and Shan-i-Punjab) to 46 days (Flordaprince). They also observed that flowering was earliest in Flordaprince, Flordasun and Prabhat and late in Earligrande and Shan-i-Punjab.

Kumari (2011) reported in peach cultivars that time of flowering varied from 1st March (Suncrest) to 7th March (Glohaven) under Solan conditions of Himachal Pradesh. The flowering duration varied from 11 to 16 days.

Meena *et al.* (2011) observed variability in floral characters in peach cultivars under Rajasthan conditions. The cultivar Pratap (7th February) was found to be earliest to flower while Shan-i-Punjab was found to be late in flowering (15th February).

Yepthomi (2011) characterized and evaluated some low chilling peach cultivars viz. Tropic Sweet, Saharanpur Prabhat, Earligrande, Flordaprince, ValleGrande, Tropic Snow, Flordaglo, Tropic Beauty and Pratap under Nauni, Solan conditions of HP. The flowering period started from 17th January and extended till 26th February. The flowering duration was recorded from 28 to 39 days.

Sharma *et al.* (2012) made a comparative study on flowering of four peach cultivars under Solan conditions during 2010 and 2011. They reported that all the cultivars started

flowering in first week of March. The flowering varied from 1st March (Suncrest) to 7th March (Glohaven). The flowering period varied from 11 to 16 days in respective years.

Sharma and Verma (2014) determined the variation in date of the first bloom, full bloom, yield and quality of ten peach cultivars in the lower Shivalik Himalayas. 'Prabhat' was found to be earliest in blooming (27th January) followed by 'Flordaprince', 'Earligrande' and 'Flordasun'. The cultivars 'Pratap', 'Shan-i-Punjab' and 'MayFire' were found to be in the middle segment in blooming (5th-8th February) whereas 'Redhaven', 'Snow Queen' and 'July Elberta' were comparatively late (15th-24th February) in first bloom.

According to UPOV (2014) test guidelines, variation in time of flowering is categorized as very early (Zaibop, Zaitoio), early (Rich Lady, Springtime), medium (Monnude, Zaitabo), late (Mailartflat, Mailarlau) and very late (Summerqueen).

Kumar (2015) recorded the variation on time and duration of flowering in different peach cultivars. He observed that the 'Pratap' had longest duration of flowering (37.00 days) and 'Tropic Sweet', 'Saharanpur Prabhat' and 'Earligrande' had minimum duration of flowering (28.00 days). The flowering initiation was earliest in 'Saharanpur Prabhat'. 'Pratap' came to flowering in 3rd week of January and 'Tropic Snow' and 'Tropic Sweet' were last to do so in 4th week of January.

Joshi *et al.* (2017) observed that the flower initiation in 2013 was earliest in Tropic Beauty on 10th January followed by Pratap on 13th January, Saharanpur Prabhat on 25th January. July Elberta and Redhaven were the last to initiate flowering on 2nd and 3rd March, respectively. In the next season the flower initiation was earliest in Tropic Beauty and Pratap on 28th December followed by Saharanpur Prabhat on 21st January. July Elberta and Redhaven were the last to initiate flowering on 12th March and 15th March, respectively.

2.4 POLLEN STUDIES

Pollen grains are tested to determine their capacity of germination, growth and fertilization. Although not as reliable as *in vitro* germination tests, the non-germination or staining tests are rapid and simple.

Kahlon and Chatwal (1978) studied pollen viability and *in vitro* pollen germination of three peach cultivars viz., Flordasun, Peshawari Gola and Sun Red under . The viability of pollen was tested with acetocarmine stain. The maximum pollen viability was observed in

Flordasun (93.10%) whereas minimum was recorded in Peshawari Gola (86.70%). 10 per cent sucrose solution gave highest pollen germination in all the three cultivars studied. Maximum pollen germination was observed in Flordasun (28.42%).

Sharma and Tripathi (1979) studied pollen viability and germination of peach cultivars viz. July Elberta, C.O. Smith, Stark Early, White Giant, Elberta's Queen's Strain, Starking Delectious, Stark Early Elberta, Elberta and Kateroo. The pollen viability was studied in 0.5 per cent acetocarmine solution. Pollen germination studies were conducted in different sucrose concentration (5%, 10%, 15%, 20% and 25%). The progress of germination was studied at 12 hours interval and final count was taken after 48 hours. Maximum pollen viability was observed in Kateroo (98.20%) whereas, minimum was observed in July Elberta (81.45%). The pollen germination ranging between 59.47 per cent in Elberta Queen's strain to 91.18 per cent in Stark Early Elberta under 10 per cent sucrose solution

Josan and Chohan (1980) studied the floral biology of peach cultivars viz. Flordasun, Sharbati and Chakli under arid-irrigated conditions of Punjab. They recorded pollen viability in peach cultivars under 2 per cent acetocarmine ranging from 66.25 per cent in Chakli and 88.57 per cent in Flordasun.

Sharma and Mehta (1992) observed pollen viability in peach cultivars viz. Dawne, Flat Peach, Kanto-5, Quetta, Shaftaloo, Sommerset and Stark Early Flame at Solan (Nauni) and recorded pollen viability ranging from 79.56 per cent (Shaftaloo) to 88.90 per cent (Dawne) when tested by acetocarmine.

Kumar *et al.* (2004) investigated the pollen germinability of six peach cultivars namely Tessia Samisto, Early White Giant, Early Giant, Hales Early, Crawford Early and July Elberta. The highest (71.48 %) pollen germination was recorded in July Elberta and lowest (40.19 %) in Hales Early.

Tandon (2006) recorded highest pollen viability (90.32%) in Jewel and lowest (70.45%) in Gold Prince at 1.0 per cent acetocarmine. Highest pollen viability (84.30%) was noticed in Early Amber and lowest (66.40%) in Gold Prince at 0.1 per cent erythrosine B. Pollen germination under *in vitro* at 10% sucrose and 100 ppm boric acid solution was maximum (82.47%) in Early Amber and minimum (59.77%) in Gold Prince.

Fakim *et al.* (2011) studied pollen germination and pistil performance of different Iranian peach cultivars in viz. Makhmali, Anjiri-ye-tabestane, Anjiri-ye-maleki, Haj-kazemi and Zoordas. The study was carried out in University of Tabriz, Iran. The highest *in vitro* pollen germination was observed in Anjiri-ye-maleki (55.20%) and lowest (19.55%) in Anjiri-ye-tabestane.

Yepthomi (2011) recorded highest pollen viability (98.93%) in Pratap followed by (98.79%) Tropic Beauty and lowest (93.82%) in ValleGrande under 1.0 per cent acetocarmine. Pollen viability was highest (97.70%) in Tropic Beauty followed by (96.98%) ValleGrande and lowest (84.19%) in FlordaGrande under 0.1 per cent erythrosine B. Pollen germination under *in vitro* conditions was maximum (90.39%) in Saharanpur Prabhat and minimum (62.26%) in Frordaprince under sucrose (10%) and boric acid (100 ppm).

Joshi *et al.* (2017) assessed the pollen viability and pollen germination of different peach cultivars under Himachal Pradesh, Solan conditions. Under acetocarmine (2%) test maximum pollen viability in 2013 (97.34%) and 2014 (94.33%) was observed in Saharanpur Prabhat. Pollen viability was recorded to be minimum (93.99%) in Pratap in 2013 whereas it was minimum (90.99%) in 2014 in Tropic Beauty. Under erythrosine B (0.04%) test maximum pollen viability to the extent of 96.30 per cent and 94.53 per cent was observed in Pratap in 2013 and 2014, respectively. In Saharanpur Prabhat, pollen viability was 94.54 per cent and 93.96 per cent in 2013 and 2014, respectively. Minimum pollen viability was observed in Tropic Beauty during 2013 (92.46%) and 2014 (90.24%). In *in vitro* pollen germination after 24 hours in 10 per cent sucrose was recorded significantly higher in Saharanpur Prabhat i.e., 41.70 per cent (2013), 45.44 per cent (2014) and 43.57 per cent (pooled). But in 2014, Tropic Beauty was found to be at par with Saharanpur Prabhat.

2.5 FRUIT CHARACTERS

Variability in several fruit characters such as shape, size, skin, colour and quality have been utilized as parameters for varietal identification in many fruit crops by several workers (Sefick and Blake, 1936).

Mishra *et al.* (1984) studied variability in fruit quality characteristics of different peach cultivars in the Almora hills of Uttar Pradesh. The data revealed that maximum fruit size was obtained for 'Peshawari' (6 × 6 cm) and minimum for 'World Earliest' (4.1 × 3.8 cm).

Khokhar and Agnihotri (1990) observed the following physical characters of fruits in some low chilling peach cultivars: length- 5.23 cm, 5.63 cm, 4.75 cm, 5.76 cm and 5.86 cm; diameter- 5.12 cm, 5.41 cm, 4.97 cm, 5.35 cm and 5.29 cm and weight- 84 g, 95 g, 84 g, 101 g and 106 g in Bonita, Early Amber, Flordared, Flordasun and Shan-i-Punjab, respectively.

Chanana *et al.* (1992) evaluated some low chilling peach introductions under Punjab conditions. The fruits of 'TA-170' were earliest to mature (19th April-25th April) followed by '5-2' peach (20th April -28th April) and delayed maturity was found in the fruits of '3-2' peach (18th May-22nd May). Maximum mean yield (75 kg/tree) was recorded in 'Flordasun' followed by 'TA-170' (73.8 kg/tree) and least in '5-2' (62.8 kg/tree).

Verona *et al.* (1993) studied the performance of different cultivars of peach growing in the subtropical humid climate of western Santa Catarina. The peach cultivar Premier had the earliest harvesting date (10th to 20th October) and produced good quality fruits. Average annual yield was highest in the processing cultivar Onix (36.9 kg/tree) followed by 'Diamante' (35.9 kg/tree), while peaches grown for the fresh market, average annual yield was highest in cultivars Premier (34.3 kg/tree) and Chula (32.8 kg/tree), respectively. Cultivars Coral (for processing) and Agata (for processing or the fresh market) had average annual yields of 23.0 and 21.3 kg/tree, respectively. On the other hand, cultivars Bolinha (for processing), and Escarlata and Chiripa (both for the fresh market), had the lowest yields.

Badiyala and Lakhanpal (1994) assessed the performance of ten years old peach cultivars. The fruit maturity was recorded earliest (5th May) in 'Flordasun' followed by 'Shan-i-Punjab' (17th May) and the maturity periods of different cultivars ranged between 58-116 days showing significant variation under Poanta valley conditions of Himachal Pradesh. They also observed that the maximum yield (98.00 kg) was produced by 'Shan-i-Punjab' while 'Bonita' produced significantly lower yield (44.00 kg).

Chahill *et al.* (1997) evaluated some low chill peach and nectarine cultivars under arid irrigated region of Punjab. The fruits of 'Flordaking' were earliest to mature (19th to 27th April) followed by 'Flordasun' (27th April to 4th May) while fruits of 'FlordaGrande' and 'Shan-i-Punjab' matured simultaneously in May (15th-30th May and 13th-29th May respectively) and highest fruit yield (70.7 kg/ha) was obtained from '9-14' followed by 'F-10' (66.6 kg/ha).

Kher and Dorjay (2001) investigated some low chilling peach cultivars under Jammu conditions for different fruit quality characteristics. Cultivar Shan-i-Punjab produced the largest and heaviest fruit with 5.80 cm length, 5.24 cm breadth and 80.86 g weight, respectively. Whereas, 'Flordasun' produced smallest fruit with 4.74 cm length, 4.44 cm breadth and medium fruit weight (56.95 g).

Nicotra *et al.* (2002) assessed the performance of six flat peach varieties and three new peach cultivars. They named flat peach variety as UFO-1 to UFO-6 and three new peach variety as Ghiaccio-1 to Ghiaccio- 3. It was observed that the flat peach varieties started ripening from 2 to 43 days before 'Redhaven'.

Kaul (2002) observed the growth pattern of peach cultivars viz. Pratap, Flordasun and Shan-i-Punjab in Sri Ganganagar, Rajasthan. They recorded a considerable variation in stone weight ranged from 1.08 gram in 'Shan-i-Punjab' to 1.89 gram in 'Pratap'.

Kumar *et al.* (2004) characterized the different varieties of peach. On the basis of maturity duration 'Tessia Samisto' and 'Early White Giant' were classified as early maturing, 'Stark Early Giant' and 'Hales Early' as mid season maturing and 'Crawford Early' and 'July Elberta' as late maturing cultivars.

Kunden *et al.* (2004) explored the possibility of growing peach under subtropical conditions of Turkey and North Cyprus. They recorded earliest ripening in 'Francoise' variety followed by 'MayCrest' and 'Early MayCrest'. However, it was observed that 'Francoise' and 'MayCrest' ripen 14 and 12 days earlier in Andana region.

Tandon (2006) evaluated five peach cultivars viz. Gold Prince, Scarlet Pearl, Early Amber, Jewel and Fire Prince under Solan (Nauni) conditions for fruit quality characteristics. The heaviest fruit weight (36.92 g) was observed in Early Amber and lightest (12.92 g) in Jewel. Highest pulp-stone ratio (9.47) was observed in Early Amber and least (5.68) in Gold Prince. Stone weight was found to be highest (4.93 g) in Gold Prince and least (1.98 g) in Jewel. Fruit firmness varied from 1.05 kg/cm² (Jewel) to 1.20 kg/cm² (Gold Prince).

Dumitru *et al.* (2007) reported that 'Cecila' had the lowest yield of 12.5 kg/tree while 'Catherine' had highest yield of 45 kg/tree.

Patel *et al.* (2007) studied the performance of low chilling peach cultivars viz. TA-170, Flordasun, Shan-i-Punjab and Meghalaya Local under mid hills of Meghalaya. They observed that TA-170, Flordasun and Shan-i-Punjab mature early in the last week of April to the first week of May while Meghalaya Local matures in second week of June. The maximum yield (20.33 kg/tree), fruit weight (61.96 g), fruit length (4.83 cm), fruit diameter (4.80 cm) and pulp:stone ratio (13.83) was recorded in TA-170.

Byrne and Boonprakob (2008) characterized and evaluated the Thai Tiger series of peach and described “Earligrande” as yellow fleshed, sweet and low chill peach.

Ferguson *et al.* (2008) observed variation in different peach and nectarine varieties in terms of their fruiting characters. They observed flesh type as melting in “Flordacrest”, “Tropic Beauty”, “Flordaglo” and non-melting in “Gulfking” and “Gulcrest” peach. Fruit size ranged from 92 g (Flordacrest) to 160 g (UF Gold).

Taheri and Hajnajari (2010) observed the variation in 22 peach cultivars for their physical, chemical and vegetative characteristics under Iranian conditions. They found ‘J.H. Hale’, ‘Robin’, ‘Springtime’ as white flesh peach cultivars. On free or cling stone type it was shown that ‘Springcrest’, ‘Robin’, ‘Earliglu’, ‘Dixired’, ‘Redhaven’, ‘J.H. Hale’ and ‘Red Skin’ were free stone type while ‘springtime’, ‘Earlired’ and ‘Anjiri’ were semi free stone type.

Byrne and Anderson (2012) reported round fruit with a flattened tip, yellow ground colour, 40 per cent to 80 per cent striped orange colour and medium sized stone with dimensions of 27 to 30 mm in length, 23 to 25 mm in width and 17 mm in thickness in “TexFirst” peach.

Devi *et al.* (2012) recorded considerable variation in physical characters of fruit of some peach hybrids under Nauni conditions of Himachal Pradesh. Fruit shape was found to vary from round, ovate, oblong to elongated. Considerable variation in respect of physical characters of fruits in the progenies of different crosses of peach was observed. Mean fruit length varied from 43.64 to 58.10 mm, fruit breadth from 43.88 to 61.34 mm and fruit weight from 50.13 g to 94.65 g. The ground colour of fruit was observed to be of yellowish green group.

Topp *et al.* (2012) evaluated and characterized the germplasm of peach from Australia, America and Europe for fruit characters such as size, flavor, flesh and ripening time with standard “Tropic Beauty” peach. They observed highest fruit weight (158 g) in “Q53-4” followed by “Tropic Beauty” (85 g) and lowest (60 g) in “Q17-20”. Fuzziness was found to be heavy in “Q32-59”, “Q53-4” and light in “Q17-20”. Fruit shape varied from oblong (Q32-59) to ovate (Q17-20) (Tropic Beauty) type.

Singh *et al.* (2014) observed 10 low chill peach germplasm accessions to assess their performance for fruit quality traits under Nauni, Solan conditions of Himachal Pradesh during 2010-2011. Maximum fruit length (56.18 mm) and fruit breadth (59.30 mm) were recorded in Flordaglo. Whereas, minimum fruit length (36.01 mm) and fruit breadth (40.52 mm) in ValleGrande. Heaviest fruits were found in Flordaglo (96.45 g) and lightest fruits were observed in ValleGrande (34.50 g). Average stone length ranged from 23.00 mm in ValleGrande to 42.02 mm in Saharanpur Prabhat. The average breadth of stone was maximum (22.84 mm) in Flordaprince and minimum (18.14 mm) in ValleGrande. Maximum stone width was recorded in Earligrande (18.86 mm) and minimum in Saharanpur Prabhat (13.11 mm). Maximum pulp/stone ratio (24.31) in Flordaglo and minimum (9.38) in ValleGrande.

Anonymous (2015) characterized different peach varieties for their fruit characters as per PPV & FRA guidelines. Flesh colour in peach fruit varied from greenish white (Nimla, Earligrande), white (Peshawari, Stark Early, Cream White), light yellow (CITH-P-1, Paradelux, Southland-1), yellow (Elebrta, Quetta, Early Red June), orange yellow (Cresthaven, Silver King, Fantasia) to orange. Similarly, shape of stone varied as oblate, circular in Cresthaven and Nimla, elliptic in Glohaven and Elberta whereas obovate in Peshawari and Quetta.

Chaurasiya and Mishra (2017) studied the varietal performance of seven peach cultivar for flowering, fruiting and fruit quality parameters. The fruit and stone weight was maximum (120.25 g and 25.62 g) in Earligrande and minimum (51.68 g and 13.96 g) in Suncrest respectively. The pulp weight was maximum (79.40 g) in Earligrande and minimum (33.30 g) in Glohaven.

Kishor *et al.* (2017) studied the comparative performance of physico-chemicals characteristics of fruits among different peach cultivars under mid hill conditions of

Uttarakhand. They observed that the highest fruit weight (188.92 g), fruit diameter (7.60 cm), pulp weight (179.56 g) and pulp: stone ratio (20.78) was recorded in Red June, while the highest fruit length (7.31 cm) and seed weight (12.47 g) were recorded in Paradelux. The lowest fruit weight (64.96 g), fruit length (4.75 cm), pulp weight (60.67 g) and seed weight (4.29 g) was recorded in Flordaking. However, the lowest fruit diameter (4.43 cm) and pulp: stone ratio (8.21) was recorded in Asariya.

2.6 BIOCHEMICAL CHARACTERS

Chadha and Sankhyayan (1974) evaluated some promising peach cultivars for tree and fruit characteristics in HP. They observed that total sugars ranged between 7.36 to 13.56 per cent and TSS valued as 11, 16.2, 17, 13.4, 13.2 and 11.9 per cent in different peach cultivars viz. Word's Earliest, Early White Giant, July Elberta, Foster, Elberta and J.H. Hale peach, respectively.

Mijacika (1976) analyzed ripened peach fruits of different varieties viz. 'Morettini-1', 'Triumph' and 'Halberta' and observed that the per cent acidity was 0.39, 0.57 and 0.47 and total sugars were 8.04, 8.14 and 10.84 per cent respectively.

Dhuria *et al.* (1978) studied the maturity standards of 'Elberta' peach and reported 12.40 per cent TSS and 0.24 per cent acidity at full maturity.

Mishra *et al.* (1984) assessed the performance of different newly introduced peach cultivars in the Almora hills of Uttar Pradesh. They observed that total soluble solids were found maximum in 'Early Stark Glo' (12.82%) and minimum in 'Tossia Sumitso' (8.0%).

Khokhar and Agnihotri (1990) studied the comparative performance of low chill peaches in HP. They recorded maximum TSS content (13%) in 'Flordared' and minimum in Flordasun (10%) and total titratable acidity content was highest in 'Shan-i-Punjab' (0.78%) and lowest in 'Early Amber' (0.69%).

Miljkovic and Ivekovic (1995) evaluated four cultivars grown in irrigated orchards of Ravni Kotri and found that total sugars content was 8.22 per cent in cultivar 'Fayette', 7.95 per cent in both 'Redhaven' and 'Suncrest' and 5.83 per cent in 'SpringGold'. Whereas, total soluble solids were obtained highest (12.26 %) in 'Redhaven' and lowest (9.89 %) in 'SpringGold'.

Son *et al.* (1995) characterized some peach varieties for different pomological characters and reported 15.20, 11.19 and 10.00 per cent TSS, 0.81, 0.50 and 0.36 per cent acidity and 12.58, 14.97 in cultivars J. H. Hale, Dixired and Earlyred, respectively under Adana conditions.

Chahill *et al.* (1997) reported that the highest TSS (11.2⁰B) content was recorded in '9-14' and the lowest in 'Flordasun' (9.31⁰B), highest acidity in 'Sunlight' nectarine (0.97%) and lowest in 'Flordking' (0.61%).

Singh *et al.* (1997) recorded highest TSS (16.5⁰B) content was seen in 'Safeda' followed by 'Pishori Gola' (16⁰B) and lowest in 'Venture' (12%), maximum acidity (0.86%) in 'Flordasun' and lowest in 'Sharbati' (0.28%), highest reducing sugars (4.40%) in 'Shan-i-Punjab' closely followed by 'Matchless' (4.32%) and lowest in 'Rochan' (2.43%) and total sugars content was highest in 'Sharbati' (9.44%) closely followed by 'Pishori Gola' (8.60%), 'Matchless' (8.84%) and lowest in 'Sunred' (6.14%).

Mratinic (1998) evaluated some peach varieties for processing purpose and found that the average soluble solids content ranged between 12 per cent (Babygold-7) and 16.33 per cent (Vivian), total sugars content ranged between 8.52 per cent (Villa Ada) and 13.68 per cent (Adriatica) and titratable acidity ranged from 0.23 (Babygold 7) to 0.56 per cent (Loadal).

Ogasanovic (1998) conducted studies on medium late ripening peach cultivar 'Dora' and found that fruit total soluble solids, total sugars and total acids content were 10.4, 7.27 and 0.68 per cent, respectively.

Kher and Dorjay (2001) evaluated and characterized some peach varieties for fruit quality characteristics under Jammu conditions. They recorded maximum TSS (12.1⁰B), acid content (0.68%), total sugars (8.35%), reducing sugars (4.23%), non reducing sugars (4.12%) and pulp to stone ratio (12.94) in 'Shan-i-Punjab' as compared to 'Flordasun'. TSS/acid ratio was maximum (19.18) in 'Flordared' and minimum in 'Flordasun' (17.14)).

Kumar *et al.* (2001) recorded flesh firmness, total soluble solids, total sugars and acidity, with corresponding values of 7.51 and 7.71 kg/cm², 13.01 and 12.35⁰Brix for

'Redhaven', 9.26 per cent and 8.59 per cent and 0.64 and 0.36 per cent for 'July Elberta', respectively.

Ravi and Tshering (2001) evaluated the fruit quality characteristics of different peach varieties under Jammu conditions. Total sugars ranged from 7.64 per cent (Flordared) to 8.35 per cent (Shan-i-Punjab) and reducing sugars recorded 4.12, 4.23 and 3.66 per cent in Flordasun, Shan-i-Punjab and Flordared, respectively, Shan-i-Punjab and Flordared, respectively.

Babu and Yadav (2002) recorded (12.31%) TSS, (0.67%) acidity and (5.43%) total sugars content in cultivars Shan-i-Punjab under Meghalaya conditions.

Kanwar *et al.* (2002) reported the highest TSS (10.60⁰B) in 'Tropic Sweet' followed by 'Tropic Beauty' (10.22⁰B) with same value of acidity (0.59 %) in both the cultivars. The lowest TSS (9.63⁰B) and highest acidity (0.74%) was found in 'ValleGrande'.

Kaul (2002) recorded the total soluble solids (TSS) content varied from 13.40⁰Brix in 'Shan-i-Punjab' to 13.80⁰Brix in 'Flordasun'. The total titratable acidity was minimum (0.58%) in 'Flordasun' and maximum (0.61%) in 'Pratap'. The total TSS: acidity ratio varied from 21.26 in 'Shan-i-Punjab' to 23.44 in 'Flordasun'.

Wen and Sherman (2002) while evaluating peach cultivars at three locations (North-Central, Central and South West) in Florida, determined the soluble solid content (SSC) and titratable acidity (TA) of four peach cultivars namely 'Flordaprince', 'Flordaglo', 'UFGold' and 'Tropic Beauty'. Soluble solids content was highest (11.9±2.1 B) in Tropic Beauty and lowest (10.2±1.4 B) in Flordaprince. They found titratable acidity to be highest (0.86±0.09%) in 'Tropic Beauty' and lowest (0.31±0.26%) in 'UFGold'

Yarilgac and Balta (2003) characterized some peach cultivars for physico-chemical characteristics. Titratable acidity varied from 0.14 (Dixired) to 0.88 per cent (Hale Haven) while reducing sugars varied from 6.98 (Redhaven) to 5.27 per cent (Glohaven and Jefferson). Total sugars ranged from 13.90 (Jefferson) to 10.61 per cent (Dixired).

Tandon (2006) observed that total soluble solids were maximum (16.07⁰B) in Early Amber and minimum (11.62⁰B) in Fire Prince. Maximum titratable acidity (1.15%) was observed in Scarlet Pearl and minimum (0.53%) in Gold Prince. Total sugars were maximum

(6.95%) in Early Amber and minimum (5.92%) in Scarlet Pearl. Reducing sugars was highest (3.65%) in Scarlet Pearl and least (1.81%) in Early Amber. Sugar/acid ratio was highest (11.02) in Jewel and lowest (5.14) in Scarlet Pearl.

Singh *et al.* (2009) observed highest acidity in Flordaprince (0.94%) followed by Earligrande (0.80%) and least in Prabhat (0.31%).

Sharma and Verma (2014) conducted the experiment to study behavior, yield and fruit quality parameters of ten peach cultivars during the year 2006-07 to 2012-13 under lower Shivalik Himalayas. Acidity and total soluble solids (TSS) were observed to vary from 0.51 per cent (Prabhat) to 1.92 per cent (Redhaven) and 11.1⁰B (July Elberta) to 13.8⁰B (MayFire), respectively. 'Prabhat' was earliest maturing cultivar whereas 'July Elberta' was comparatively late in fruit maturity.

Singh *et al.* (2014) evaluated low chill peach germplasm having TSS content maximum (0.89⁰B) in Pratap and minimum (0.42⁰B) in Saharanpur Prabhat. Total sugars were maximum (12.94%) in Pratap and minimum (9.26%) in Tropic Beauty.

Jana (2015) reported variation in fruiting characters of six peach cultivars under Eastern Plateau region of India and reported that TSS and acidity exhibited variation which ranged from 13.8⁰B (Pratap) to 17.9⁰B (Prabhat) and 0.18 per cent (Prabhat) to 0.35 per cent (Shan-i-Punjab), respectively.

Kishor *et al.* (2017) recorded that the highest TSS was in Flordasun (12.17⁰B) and lowest in Fla-16-33 (9.40⁰B). Highest acidity was recorded in Asariya (1.21%), while lowest in Sharbati (0.49%). Total sugars (4.16%) and reducing sugars (3.03%) were recorded highest in Flordasun, while lowest total sugars (2.65%) and reducing sugars (1.85%) were recorded in Paradelux. The highest non-reducing sugars (1.32%) was recorded in Red June and Reliance, while lowest in Paradelux (0.76%).

Chaurasiya and Mishra (2017) studied the performance of different peach varieties under Chhattisgarh conditions. Total soluble solids was highest (18.86⁰B) in Earligrande and lowest (15.40⁰B) in Glohaven. Acidity was highest (0.30%) in Flordaprince and lowest (0.22%) in Shan-i-Punjab. Reducing sugars (7.40%) and total sugars (13.50%) was maximum in Shan-i-Punjab. While reducing sugars was minimum (4.67%) in Suncrest and total sugars was minimum (10.50%) in Flordaprince.

Chapter-3

MATERIALS AND METHODS

The present investigation entitled “**Characterization and evaluation of some peach [*Prunus persica* (L.) Batsch.] accessions**” was carried out in the field gene bank of National Bureau of Plant Genetics Resources, Regional Station Phagli, Shimla at an elevation of 1924m amsl during the year 2017-2018. The climate of location is wet temperate. The peach germplasm accessions undertaken for studies were: Ambri, Belle of Georgia, Early Amber, Kanto-5, Yum Yong, Fertilia, Flordasun, Summerglo, Hale Haven, Suncoast, Shan-i-Punjab, Early Redhaven, FloridaBelle, Fire Prince, Okubo, Nishiki.

Three plants of each of the accession were selected for various observations. These plants are 15-18 year old and are grafted on wild peach rootstock.

Standard analytical procedures and IPGRI descriptors (1984) were followed to record data on various morphological and physico-chemical characters.

3.1 TREE CHARACTERS

3.1.1 Growth habit

It was categorized on the basis of the geometry of the tree crown.

3.1.1.1 Upright

When the height of the tree was distinctly more than its spread and the branches were growing erect.

3.1.1.2 Semi upright

When the height of the tree was slightly more or equal to spread and the branches were less spreading.

3.1.1.3 Spreading

When branches growing outward from the trunk of the tree.



1. Upright



2. Semi upright



3. Spreading

3.1.2 Tree height

The height of the tree was measured with the help of calibrated staff from ground level to the tip of tallest branch of the tree and it was expressed in meters (m).

3.1.3 Tree spread

The spread of the tree was measured by a calibrated staff in two directions i.e. North-South (N-S) and East-West (E-W) and the observations were recorded in meters (m).

3.1.4 Trunk girth

The trunk girth was measured at the height of 15 cm above from the graft union with the help of measuring tape and was expressed in centimeters (cm).

3.2 FOLIAGE CHARACTERS

Thirty leaves from the middle portion of the current growth were selected during the last week of July for recording observations as suggested by Beyers (1962).

3.2.1 Time of leaf bud burst

The data on leaf bud burst was recorded in each genotype. For this, the date on which the first bud had sprouted was taken.

3.2.2 Leaf length

The length of the leaf was measured by a scale from tip of the apex to the base.

3.2.3 Leaf width

The width of the leaf was measured with a scale at its broadest expand.

3.2.4 Leaf area

It was worked out using the digital leaf area meter (LICOR - model 3100 A). Average area of ten leaves was considered as one replication and three such replications were made.

3.2.5 Leaf colour

- a) Colour of emerging leaves
- b) Colour of mature leaves

Colour charts of the Royal Horticultural Society, London were used to determine the surface colour of the leaves.

3.2.6 Leaf shape

Leaf shape was observed visually following Standard Cyclopedia of Horticulture (Bailey, 1963)

3.2.7 Leaf margin

The leaf margin was examined for the presence or absence of serration in each genotype.



Only crenate



Shallow serrate



Deep serrate

3.2.8 Leaf surface

The hairiness of the upper and lower surfaces in mature leaves of each genotype was observed. Hand lens was used for observing presence or absence of hairiness.

3.2.9 Petiole length

The length of fifteen petioles was measured using hand scale and average value was worked out for three replications.



3.2.10 Presence or absence of glands

Presence or absence of glands was observed visually and an average of ten leaves was considered as one replication and three such replications were made.

3.2.11 Time of leaf fall

The observations on leaf fall were recorded as the date on which there was 80-85 per cent leaf fall.

3.3. FLOWER CHARACTERS

3.3.1 Time of flowering

3.3.1.1 Time of opening of first flower

The date was recorded on which first flower opened in each genotype.

3.3.1.2 Date of full bloom

The date on which about 75 per cent flowers had opened was recorded as the date of full bloom.

3.3.1.3 Date of opening of last flower

The date was recorded on which last flower opened in each genotype.

3.3.2 Duration of flowering

The number of days from the date of opening of first flower to the date of opening of last flower in each genotype was determined.

3.4 POLLEN STUDIES

3.4.1 Pollen viability

3.4.1.1 Acetocarmine test

Pollen grains were stained in acetocarmine (2%) solution prepared by dissolving 2 g of carmine powder in 45 ml of glacial acetic acid and making a final volume of 100 ml by

adding distilled water. This solution was boiled for five minutes and filtered through Whatman No. 4 filter paper. The pollen grains were dusted on a clean glass slide and one or two drops of acetocarmine were put on these grains. After placing a cover slip over the stain it was left for five minutes for proper staining of pollen grains. Slides were observed under microscope. Deeply stained and normal looking pollen grains were considered as viable whereas shrivelled, lightly stained or colourless pollen grains were counted as non-viable. Three microscopic fields were observed and number of viable and non-viable pollen grains were counted in each field to work out the per cent pollen viability. Each microscopic field was considered as one replication.

3.4.1.2 Erythrosin B

Pollen grains were stained in 0.1 per cent erythrosin B solution. The unstained pollen grains were considered viable in this method. Stain solution (0.1 %) was prepared by dissolving 100 mg of erythrosin B in distilled water to make a final solution of 100 ml. Staining procedure was same as done in acetocarmine test (Section 3.4.1.1).

3.4.2 *In vitro* pollen germination

The freshly dehisced pollen grains were used for *in vitro* pollen germination test. The different concentration of sucrose i.e. 10 and 15 per cent sucrose solutions were prepared by dissolving 10 and 15 gm of sucrose in 100 ml of distilled water, respectively. Sucrose solution was placed in the cavity of a microscopic slide and pollen grains were dusted over it. After placing cover slip its edges were smeared by molten wax and the slide was inverted instantly, leading to the formation of a hanging drop over the cover slip. These cavity slides were then placed in petri dishes containing moist filter paper to ensure uniform and high relative humidity. Pollen tube growth was assessed for each cultivar under microscope after 24 hours. The pollen grains having pollen tubes at least two times longer than pollen size were considered to be germinated and percentage of germinated pollen grains under three microscopic fields was worked out which were treated as one replication.

3.5 FRUIT CHARACTERS

To study fruit characters, 15 representative fruit samples (five in each replication) were taken at optimum maturity. The average length, breadth and weight were measured. The surface colour of the fruits was observed by comparing it with the colour charts of the Royal Horticultural Society, London.

3.5.1 Fruit weight (g)

The weight of ten fruits under three replicates of each genotype was recorded and the average weight per fruit was calculated.

3.5.2 Fruit diameter (mm)

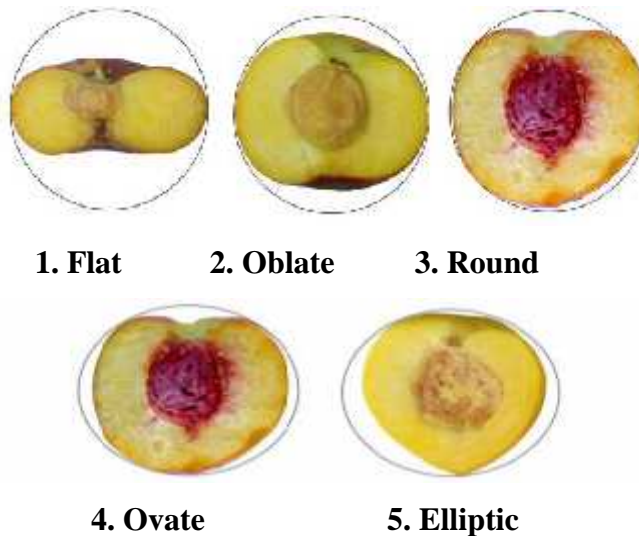
The Fruit diameter was measured with the help of a digital Vernier Callipers (Model No. CD-6"CS, Mitutoyo Corp. Japan).

3.5.3 Fruit length (mm)

The fruit length was measured with the help of a digital Vernier Callipers (Model No. CD-6"CS, Mitutoyo Corp. Japan).

3.5.4 Fruit shape

The shape of fruit was observed visually and classified as flat, oblate, round, ovate, elliptic.



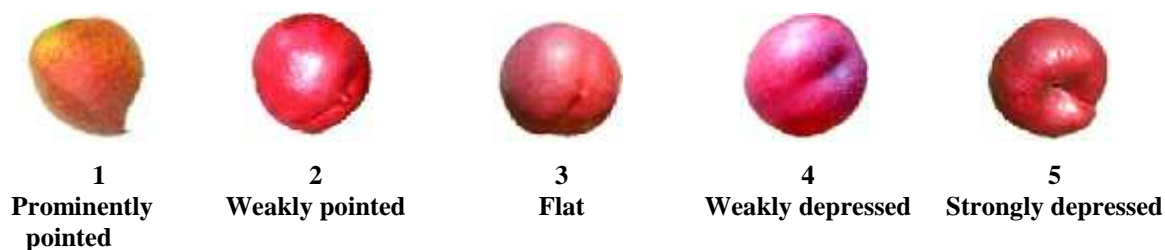
3.5.5 Mucron tip at pistil end

Mucron tip at pistil end was determined visually and classified as absent or present for each accession.



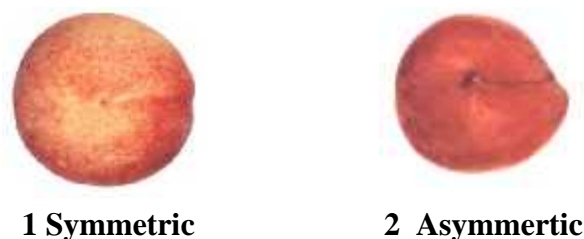
3.5.6 Shape of pistil end (excluding mucron tip)

Shape of the pistil excluding mucron tip was determined visually and classified as prominently pointed, weakly pointed, flat, weakly depressed, or strongly depressed.



3.5.7 Fruit symmetry (viewed from pistil end)

The symmetry of fruit was viewed from pistil end and classified as symmetric or asymmetric.



3.5.8 Prominence of suture

The prominence of suture was determined visually and classified weak or medium or strong.

3.5.9 Fruit skin colour

The surface colour of the fruit was observed by comparing it with the colour charts of the Royal Horticultural Society, London.

3.5.10 Fruit firmness

Fruit firmness was measured with the help of penetrometer (kg/cm^2)

3.5.11 Fruit flesh colour

The flesh colour of fruit was observed by comparing it with the colour charts of the Royal Horticultural Society, London.

3.5.12 Time of harvesting

The date on which fruit was harvested from plants.

3.5.13 Number of days from full bloom to harvest

Number of days were counted from the date of full bloom to the date of harvest.

3.5.14 Stone characters

For recording observations, stones were washed well so that no pulp remains attached to the stones.

3.5.14.1 Stone shape and size

The stone size was recorded by measuring the length, breadth and thickness with the help of digital Vernier Callipers (Model No. CD-6"CS, Mitutoyo Corp. Japan). The shape of stone was determined visually and categorized as oblate or circular or elliptic or obovate.



1. Oblate 2. Circular 3. Elliptic 4. Obovate

3.5.14.2 Stone weight

The weight of ten stones under three replicates of each genotype was recorded and the average weight per stone was calculated.

3.5.14.3 Anthocyanin coloration of stone

The anthocyanin coloration of stone was determined visually and categorized as weak or medium or strong.

3.5.14.4 Adherence of flesh to stone

It was observed visually in each genotype and classified as:

- a) Clingstone
- b) Freestone

3.5.14.5 Pulp/stone ratio

It was worked out by dividing the weight of the fruit pulp by the weight of stone.

3.5.14.6 Presence of grooves/pits

It was observed visually in each genotype.

3.5.14.7 Shape of apex

It was observed visually in each genotype.

3.5.15 Biochemical characteristics of fruit

The following biochemical characteristics of fruit will be determined as per the standard procedures given by Ranganna (1986).

3.5.15.1 Total soluble solids

The total soluble solid content of fruits was determined with digital pocket refractometer (Pal-Atago, Japan). The prism of the refractometer was washed with distilled water before taking each reading. A drop of fresh juice of fruit was taken on the prism of refractometer and the total soluble solids present in the fruit in °Brix were reflected on the screen.

3.5.15.2 Titratable acidity

In each sample, 25 g of fruit pulp was crushed and the volume was made to 250 ml in a volumetric flask by adding distilled water. Out of it, 50 ml extract was taken for the estimation of acidity and the rest was used for determining the total sugars and reducing sugars. 10 ml of this juice extract was titrated against N/10 NaOH solution, using phenolphthalein as an indicator, to a light pink coloured end point. The titratable acidity was calculated in terms of malic acid on the basis of 1 ml of N/10 NaOH = 0.0067 g of anhydrous malic acid. Formula used for calculation of per cent acidity was:

$$\text{Acidity (\%)} = \frac{\text{Titre} \times \text{Normality} \times \text{Volume made up} \times \text{equivalent weight}}{\text{Volume of sample} \times \text{Weight or volume of sample} \times 1000} \times 100$$

3.5.15.3 Total sugars

Lane and Eynon's volumetric method (A.O.A.C., 1980) was employed for the estimation of sugars. The 200 ml of juice extract remaining after the estimation of acid was used. To this, 10 ml of saturated lead acetate was added. The contents of the flask were shaken and filtered into flask containing 10 ml of potassium oxalate to precipitate the excess of lead. The filtrate was shaken and again filtered after keeping it for few minutes. The 50 ml of the filtrate was taken in 250 ml volumetric flask and to it 5 ml concentrated HCl was added for hydrolysis. It was kept overnight at room temperature. The excess of hydrochloric acid was neutralised with saturated NaOH solution. The total sugars were then estimated by

titrating against boiling mixture containing 5 ml each of Fehling A and Fehling B solution, using methylene blue as an indicator. The end point was indicated by the appearance of brick red colour. Total sugars content was expressed as percentage of fresh pulp weight as per the formula:

$$\text{Total sugars (\%)} = \frac{0.05 \% \times \text{Dilution}}{\text{Titre value} \times \text{Weight or volume of sample}} \times 100$$

3.5.15.4 Reducing sugars

For the estimation of reducing sugars, unhydrolysed but lead free and clarified solution was titrated against boiling solution of 5 ml each of Fehling A and Fehling B using methylene blue as an indicator (A.O.A.C., 1980). Reducing sugars content was expressed as percentage of fresh pulp weight as per the formula given below:

$$\text{Reducing sugars (\%)} = \frac{0.05 \% \times \text{Dilution}}{\text{Titre value} \times \text{Weight or volume of sample}} \times 100$$

3.5.15.5 Non-reducing sugars

The content of non-reducing sugars was calculated by subtracting reducing sugars from total sugars and multiplying the difference by 0.95 which is standard factor. Non-reducing sugars content was also expressed as percentage of fresh pulp weight. The formula used was:

$$\text{Non-reducing sugars} = (\text{Total sugars} - \text{Reducing sugars}) \times 0.95$$

3.5.15.6 Sugar/acid ratio

It was worked out by dividing per cent total sugars with per cent Titratable acidity.

$$\text{Sugar/acid ratio} = \frac{\text{Total Sugars (\%)}}{\text{Acidity (\%)}}$$

3.5.16 Yield (kg/tree)

Yield was recorded by direct weighing the total number of fruits at the time of harvesting and was expressed as kg per tree.

3.5.17 Yield efficiency

The usual method of obtaining yield efficiency is to calculate kilograms of fruits per square centimeter of cross-sectional area of the trunk. This estimates the efficiency of bearing

surface. Yield per hectare (ha) estimates the efficiency of both bearing surface and land surface as given by Westwood (1993):

$$\text{Yield efficiency (tree unit)} = \text{kg yield} / \text{cm}^2 \text{ trunk area}$$

3.6 STATISTICAL ANALYSIS

The statistical analysis for each character was carried out on mean values. The data were subjected to the analysis of various traits as described by Gomez and Gomez (1984) for Randomized complete Block Design. The following procedures were adopted for estimation of different statistical parameters.

3.6.1 ANALYSIS OF VARIANCE

Source of variation	Degree of freedom	Sum of squares	Mean sum of squares	F _{cal}
Treatments	(t-1)	S _t	M _t = S _t / (t-1)	M _t / M _e
Replications	(r-1)	S _r	M _r = S _r / (r-1)	M _r / M _e
Error	(r-1)(t-1)	S _e	M _e = S _e / (r-1)(t-1)	
Total	(rt-1)	S _T		

Where,

- r = Number of replications
- t = Number of treatments
- S_r = Sum of squares due to replications
- S_t = Sum of squares due to treatments
- S_e = Sum of squares due to error
- S_T = Total sum of squares
- M_r = Mean sum of squares due to replications
- M_t = Mean sum of squares due to treatments
- M_e = Mean sum of squares due to error

The replication and treatment mean sum of square were tested against error mean squares by 'F' test at (r-1), (r-1) (t-1) and (t-1), (r-1) (t-1) degree of freedom for RCBD at 5% level of significance.

The calculated F-values were compared with tabulated F- value. When F- test was found significant, critical difference was calculated to find out the superiority of one treatment over the others.

The standard error and critical difference shall be calculated as follow:

$$CD_{0.05} = S.E. (d) \times t_{(0.05) (r-1) (t-1) df}$$

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

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

Where,

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

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

$$CD_{0.05} = \text{Critical difference at 5 per cent level of significance}$$

Chapter-4

RESULTS AND DISCUSSION

The experimental results obtained in the present study entitled, “**Characterization and evaluation of some peach [*Prunus persica* (L.) Batsch.] accessions**” are presented under suitable heads as follows:

4.1 TREE CHARACTERS

4.1.1 Growth habit

Out of sixteen peach genotypes, as many as eight genotypes namely, Shan-i-Punjab, Kanto-5, Flordasun, Suncoast, Early Redhaven, Early Amber, Fire Prince, Nishiki were found to have spreading type of growth habit (Table 1), whereas, Fertilia, Yum Yong, Summerglo, Ambri, Okubo, Belle of Georgia and Hale Haven had semi upright growth habit. Only one genotype FlordaBelle had upright type of growth habit.

4.1.2 Tree height

Tree height in all the sixteen peach genotypes studied ranged between 2.07 m (Nishiki) and 6.13 m (Flordasun). Flordasun was found to be statistically at par with Shan-i-Punjab. The overall mean for the tree height was recorded as 3.89 m.

4.1.3 Tree spread

Maximum value of tree spread in N-S direction was recorded as 5.23 m in Shan-i-Punjab and corresponding minimum value was 1.30 m in FlordaBelle. Maximum tree spread in E-W direction was 5.30 m in Shan-i-Punjab whereas, Nishiki recorded a minimum value of only 1.74 m. Mean value for this growth characteristic was 2.63 m in N-S direction and 3.19 m in E-W direction. It was found that the tree spread of all the genotype was statistically different.

4.1.4 Trunk girth

Maximum trunk girth (73.67 cm) was recorded in Shan-i-Punjab followed by Ambri (64.33cm) and minimum (15.00 cm) in Nishiki. Mean value of trunk was determined as 38.34 cm. The trunk girth of all the genotype was significantly different.

Table.1 Tree characters of some peach accessions

Accession	Growth habit	Height (m)	Girth (cm)	Spread (m)		Fruit Yield (Kg/plant)	Yield efficiency (Kg/cm ²)
				N-S	E-W		
Shan-i-Punjab	Spreading	6.09	73.67	5.23	5.30	24.66	0.06
Kanto-5	Spreading	3.33	60.67	2.83	4.07	23.00	0.08
Fertilia	Semi upright	4.32	41.67	2.87	3.50	23.00	0.17
Yum Yong	Semi upright	3.95	35.00	3.13	3.03	15.00	0.15
Flordasun	Spreading	6.13	60.87	3.83	3.60	11.00	0.04
Summerglo	Semi upright	4.03	35.00	2.97	2.93	19.00	0.19
Suncoast	Spreading	2.20	22.67	2.06	2.20	21.00	0.52
FlordaBelle	Upright	2.43	32.50	1.30	2.09	15.00	0.18
Ambri	Semi upright	5.57	64.33	1.83	2.33	15.33	0.05
Early Redhaven	Spreading	4.06	18.33	2.22	2.55	23.00	0.87
Okubo	Semi upright	2.53	22.67	2.00	2.53	20.00	0.50
Early Amber	Spreading	3.63	44.00	2.33	3.51	22.00	0.14
Fire Prince	Spreading	3.50	31.67	2.67	2.10	23.00	0.29
Belle of Georgia	Semi upright	4.07	19.33	1.39	7.03	11.00	0.38
Hale Haven	Semi upright	4.40	36.00	3.16	2.51	14.00	0.14
Nishiki	Spreading	2.07	15.00	2.27	1.74	18.00	1.01
Mean		3.89	38.34	2.63	3.19	18.63	0.30
CD _{0.05}		0.51	2.69	0.42	0.43	1.13	0.10

Among the sixteen peach genotypes studied, Shan-i-Punjab recorded maximum tree height and girth while Nishiki recorded the least values (Table 1) suggesting considerable variation in tree vigour. Such variation in growth characters has also been reported by previous workers (Badiyal and Lakhanpal, 1994; Singh, 2005; Yephthomi, 2011; Jana, 2015; Chauhan, 2016). Maximum value of tree spread in N-S and E-W direction was recorded in Shan-i-Punjab and minimum tree spread in N-S direction in FlordaBelle whereas minimum tree spread in E-W direction in Nishiki. Shan-i-Punjab, Kanto-5, Flordasun, Suncoast, Early Redhaven, Early Amber, Fire Prince, Nishiki were found to have spreading type of growth habit (Table 1), whereas, Fertilia, Yum Yong, Summerglo, Ambri. Okubo, Belle of Georgia and Hale Haven had semi upright growth habit. Only one genotype FlordaBelle had upright type of growth habit. Upright growth habit recorded here in FlordaBelle suggests its suitability under high density planting system, it otherwise good or use as a gene source to develop short statured peach scion varieties. Fruit yield was maximum in Shan-i-Punjab followed by in Kanto-5, Fertilia and Fire Prince. The fruit yield was minimum in Flordasun and Belle of Georgia. Such variation in fruit yield in different set of varieties under different geographical conditions have been reported by several previous workers (Badiyala and

Lakhanpal, 1995; Chahill *et al.* 1997; Tandon, 2006; Dumitru *et al.* 2007). The yield efficiency was maximum in Nishiki followed by Suncoast whereas, minimum in Flordasun (Table 1).

4.2 FOLIAGE CHARACTERS

Data (Table 2) recorded on various foliage characteristics of peach genotypes are presented as under:

4.2.1 Time of bud burst

The time of bud burst was earliest in FloridaBelle on 18th January and last in Fertilia on 11th March.

4.2.2 Leaf length

Leaf length was recorded highest in Okubo (19.23 cm) followed by Suncoast (18.50 cm), Kanto-5 (18.46 cm), Nishiki (17.46 cm) and the least in Fertilia (11.03 cm). The mean value for leaf length was 15.33 cm. It was found that Okubo was statistically at par with Kanto-5, Suncoast and Nishiki.

4.2.3 Leaf width

Leaf width was recorded maximum both in Okubo and Nishiki with 5.03 cm followed by Kanto-5 (4.46 cm) and minimum in Fertilia with 2.86 cm (Table 2). The mean value for leaf width was 3.97 cm. Okubo was statistically at par with Kanto-5, Flordasun, Early Amber and Nishiki.

4.2.4 Leaf area

The maximum leaf area (193.43 cm²) was recorded in Okubo followed by Nishiki (165.40cm²), Kanto-5 (154.63 cm²) and the minimum (54.83 cm²) was observed in Shan-i-Punjab. The overall mean for leaf area was 124.51 cm².

4.2.5 Leaf colour

Leaf colour of the emerging leaves in all the genotypes was in Yellow- Green Group (152) however slight variation was observed in the shade of the colour. These were 152 A in Shan-i-Punjab, Kanto-5, Fertilia, Flordasun, Summerglo, Fire Prince, Belle of Georgia, Okubo and 152 B in Yum Yong, Suncoast, FloridaBelle, Ambri, Early Redhaven, Early

Amber, Hale Haven and Nishiki, whereas, colour of mature leaves was under Green Group and Yellow-Green Group. These were Green Group 136 A in Kanto-5, 137 A in Shan-i-Punjab, 139 A Fertilia and Yellow-Green Group 133 A in Okubo, 135 A in Hale Haven and Nishiki, 136 A in Early Amber, 137 A in Early Redhaven and Belle of Georgia, 139 A in Fire Prince, 146 A in Yum Yong and Ambri.

4.2.6 Leaf shape

In all the sixteen peach genotypes, lanceolate leaf shape was observed.

4.2.7 Leaf margin

Leaf margin was shallow serrate in all the sixteen peach genotypes studied.

4.2.8 Leaf surface

Leaf surface of all the sixteen genotypes under study was found to be pubescent.

4.2.9 Petiole length

Petiole length was found to be maximum (1.20 cm) in Ambri which was followed by Kanto-5 (1.13 cm) and minimum (0.40 cm) was in Hale Haven. The mean for petiole length was 0.80 cm. Ambri was found to be statistically at par with Kanto-5 and Suncoast.

4.2.10 Presence and absence of glands

Glands were found to be present in all the sixteen genotypes.

4.2.11 Time of leaf fall

Shedding of leaves was recorded as early as on 12th November in Suncoast and as late as on 11th December in FlordaBelle (Table 2). The dates of leaf fall in other genotypes were 16th November in Summerglo, 18th November in Yum Yong, 19th November in Okubo, 20th November in Kanto-5, 23rd November Early Amber, 25th November in Ambri and Nishiki, 30th November in Early Redhaven, 2nd December Shan-i-Punjab, 3rd December in Flordasun and Fire Prince, 4th December in Fertilia, 5th December in Belle of Georgia, 10th December in Hale haven.

Table 2. Foliage characters of some peach accessions

Accession	Time of leaf bud burst	Leaf length (cm)	Leaf width (cm)	Leaf area (cm ²)	Leaf colour		Leaf shape	Leaf margin	Petiole length (cm)	Leaf surface	Presence/absence of glands	Time of leaf fall
					Emerging leaves	Mature leaves						
Shan-i-Punjab	25 th January	12.33	3.36	54.83	Yellow Green Group 152 A	Green Group 137 A	Lanceolate	Shallow Serrate	0.80	Pubescent	Present	2 nd December
Kanto-5	4 th March	18.46	4.46	154.63	Yellow Green Group 152 A	Green Group 136 A	Lanceolate	Shallow Serrate	1.13	Pubescent	Present	20 th November
Fertilia	11 th March	11.03	2.86	104.40	Yellow Green Group 152 A	Green Group 139 A	Lanceolate	Shallow Serrate	0.70	Pubescent	Present	4 th December
Yum Yong	3 rd March	16.66	3.95	144.40	Yellow Green Group 152 B	Yellow Green Group 146 A	Lanceolate	Shallow Serrate	0.77	Pubescent	Present	18 th November
Flordasun	27 th January	13.10	4.25	109.26	Yellow Green Group 152 A	Green Group 133 A	Lanceolate	Shallow Serrate	0.77	Pubescent	Present	3 rd December
Summerglo	10 th March	12.70	3.56	102.03	Yellow Green Group 152 A	Green Group 137 A	Lanceolate	Shallow Serrate	0.53	Pubescent	Present	16 th November
Suncoast	2 nd March	18.50	4.03	145.56	Yellow Green Group 152 B	Green Group 137 A	Lanceolate	Shallow Serrate	1.10	Pubescent	Present	12 th November
FlordaBelle	18 th January	15.63	3.56	106.16	Yellow Green Group 152 B	Green Group 133 A	Lanceolate	Shallow Serrate	0.60	Pubescent	Present	11 th December
Ambri	4 th March	14.90	3.70	124.70	Yellow Green Group 152 B	Yellow Green Group 146 A	Lanceolate	Shallow Serrate	1.20	Pubescent	Present	25 th November
Early Redhaven	3 rd March	15.03	3.33	104.58	Yellow Green Group 152 B	Yellow Green Group 137 A	Lanceolate	Shallow Serrate	0.83	Pubescent	Present	30 th November
Okubo	8 th March	19.23	5.03	193.43	Yellow Green Group 152 A	Yellow Green Group 133 A	Lanceolate	Shallow Serrate	0.73	Pubescent	Present	19 th November
Early Amber	24 th February	15.16	4.16	90.66	Yellow Green Group 152 B	Yellow Green Group 136 A	Lanceolate	Shallow Serrate	0.90	Pubescent	Present	23 rd November
Fire Prince	5 th March	16.33	3.66	149.20	Yellow Green Group 152 A	Yellow Green Group 139 A	Lanceolate	Shallow Serrate	0.80	Pubescent	Present	3 rd December
Belle of Georgia	3 rd March	14.00	3.76	131.67	Yellow Green Group 152 A	Yellow Green Group 137 A	Lanceolate	Shallow Serrate	0.70	Pubescent	Present	5 th December
Hale Haven	6 th March	14.75	3.43	111.23	Yellow Green Group 152 B	Yellow Green Group 135 A	Lanceolate	Shallow Serrate	0.40	Pubescent	Present	10 th December
Nishiki	4 th March	17.46	5.03	165.40	Yellow Green Group 152 B	Yellow Green Group 135 A	Lanceolate	Shallow Serrate	0.83	Pubescent	Present	25 th November
Mean		15.33	3.97	124.51					0.80			
CD _{0.05}		2.17	0.63	1.84					0.29			

Leaf characters are commonly used to distinguish and identify various fruit crop species and varieties. However, in the present study no marked variation was observed in leaf shape, surface, margin, presence and absence of glands as well as colour (Table 2) except for some in leaf length, width, area and petiole length. The leaf area varied from 54.83 cm² to 193.43 cm². The colour of mature leaves was green and yellow green in all the genotypes except for slight variation in the shade. Such variation in foliage characters has also been reported by various workers (Wolfe and Strang, 2010; Byrne and Anderson, 2012; Chauhan, 2016) in the past. Leaf shape was recorded to be lanceolate and margin shallow serrate in all the genotypes. This has also been reported by Byrne and Anderson (2012). The leaf length, width and area was maximum in Okubo and length and width minimum in Fertilia whereas, leaf area was minimum in Shan-i-Punjab. The time of bud burst was earliest in FlordaBelle and latest in Fertilia. The late leafing genotype holds promise for avoiding possible damage due to spring frost. Whereas, time of leaf fall was earliest in Suncoast and latest in FlordaBelle. The leaf fall occurred between 12th November in Suncoast and 11th December in FlordaBelle (Table 2). However, Yephthomi (2011) has reported earlier that leaf fall occurred between last week of October and 3rd week of November in different set of genotypes at Nauni, Solan conditions. The difference in time of leaf emergence and leaf fall in various studies might be due to genetic constitution of the cultivars and prevailing climatic conditions in the corresponding seasons.

4.3 TIME AND DURATION OF FLOWERING

4.3.1 Flowering time

4.3.1.1 Time of opening of first flower

The flower initiation was earliest in FlordaBelle on 20th January followed by Shan-i-Punjab on 27th January, Flordasun on 29th January whereas, Fertilia was the last to initiate flowering on 14th March (Table 3).

4.3.1.2 Date of full bloom

The period of full bloom (Plate 1) varied among all the genotypes. The full bloom was observed in FlordaBelle as early as on 29th January, whereas, Shan-i-Punjab and Flordasun recorded full bloom on 5th February. Fertilia and Hale Haven was last to do so on 20th March.



Kanto-5



Fire Prince



Flordasun



Ambri

Plate 1 Peach accessions in full bloom

4.3.1.3 Date of opening of last flower

The data in Table 3 indicate that FlordaBelle was earliest (10th February) in terms of date of opening of last flower followed by Shan-i-Punjab (20th February), Flordasun (25th February) and Fertilia was the last to do so on 5th April.

Table 3. Time and duration of flowering in some peach accessions

Accession	Time of opening of first flower	Date of full bloom	Date of opening of last flower	Duration of Flowering (Days)
Shan-i-Punjab	27 th January	5 th February	20 th February	24
Kanto-5	6 th March	11 th March	26 th March	20
Fertilia	14 th March	20 th March	5 th April	21
Yum Yong	4 th March	10 th March	24 th March	20
Flordasun	29 th January	5 th February	25 th February	27
Summerglo	11 th March	17 th March	29 th March	18
Suncoast	3 rd March	10 th March	22 th March	20
FlordaBelle	20 th January	29 th January	10 th February	21
Ambri	6 th March	15 th March	26 th March	20
Early Redhaven	5 th March	12 th March	27 th March	22
Okubo	10 th March	16 th March	31 th March	21
Early Amber	25 th February	4 th March	20 th March	23
Fire Prince	7 th March	18 th March	26 th March	19
Belle of Georgia	5 th March	11 th March	26 th March	21
Hale Haven	8 th March	20 th March	29 th March	22
Nishiki	2 nd March	11 th March	22 nd March	21

4.3.2 Duration of flowering

The longest duration (27 days) of flowering was recorded in Flordasun and shortest (18 days) was in Summerglo. The duration of flowering in other genotypes were 24 days in Shan-i-Punjab, 23 days in Early Amber, 22 days in Hale Haven and Early Redhaven, 21 days in Fertilia, FlordaBelle, Okubo, Belle of Georgia and Nishiki, 20 days in Kanto-5, Yum Yong, Suncoast and Ambri, 19 days in Fire Prince (Table 3).

The flowering (full bloom) was earliest in the last week of January in FlordaBelle and the last was Okubo, Summerglo, Fertilia and Hale Haven in third week of March. The variation in time of flowering may be due to the differences in chilling hour requirement to break bud dormancy in various genotypes. This find support from the findings of Kanwar, 2002; Meena, 2011; Tandon, 2016. The longest duration of flowering was recorded in

Flordasun (27 days) and the shortest in Summerglo (18 days). The similar type of variation in duration of flowering was reported by Sharma (2014), Kumar (2015) and Joshi *et al.*(2017).

4.4 POLLEN STUDIES

4.4.1 Pollen viability

Pollen viability recorded in different peach genotypes are presented in Table 4 and Plate 2.

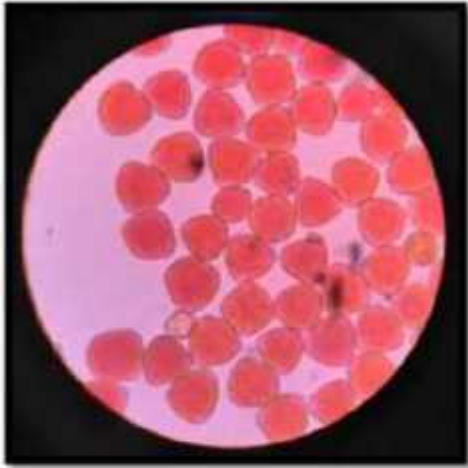
The highest pollen viability was recorded in Belle of Georgia (98.47%) and minimum in Suncoast (91.35%) when tested by 2 per cent acetocarmine. The overall mean value for this was recorded as 95.12 per cent. The pollen viability of Belle of Georgia was statistically at par with Fertilia, FlordaBelle, Ambri, Okubo, Early Amber and Fire Prince.

Pollen viability was found to be highest in FlordaBelle (93.90%) followed by Flordasun (87.99%) and least in Kanto-5 (58.68%) when tested with 0.1 per cent erythrosin B. The mean value for this was 73.48 per cent. FlordaBelle was statistically at par with Hale Haven, Flordasun and Belle of Georgia.

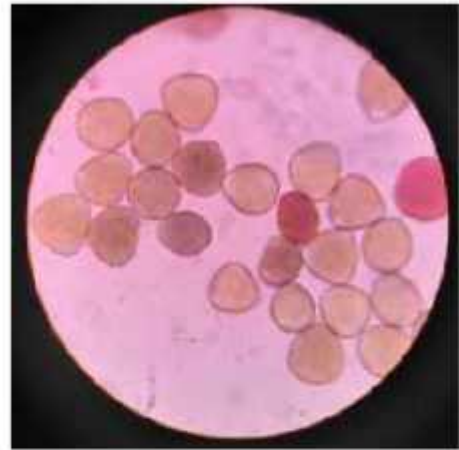
4.4.2 *In vitro* pollen germination

Pollen germination under *in vitro* was maximum (84.33%) in Flordasun and minimum (11.54%) in Yum Yong (10% sucrose solution). While with 15 per cent sucrose solution it was maximum (74.22%) in FlordaBelle and minimum (11.56%) in Ambri (Table 4). The overall mean for pollen germination under (10%) sucrose solution was 39.29 per cent and under (15%) sucrose solution was 41.16 per cent. Pollen germination of FlordaBelle was statistically at par with Kanto-5 and Flordasun.

Pollen viability ranged from 91.35 per cent in Suncoast to 98.47 per cent in Belle of Georgia when tested by 2 per cent acetocarmine and 58.68 per cent in Kanto-5 to 93.90 per cent in FlordaBelle by 0.1 per cent erythrosin B (Table 4). The *in vitro* pollen germination in all the peach genotypes under study varied from 11.54 per cent in Yum Yong to 84.33 per cent in Flordasun under 10 per cent sucrose solution and 11.56 per cent in Ambri to 74.22 per cent in FlordaBelle under 15 per cent sucrose solution. No definite relationship however, could be established among the staining tests (acetocarmine and erythrosin B) and the pollen germination test. Similar results were observed in different sets of varieties by Josan and

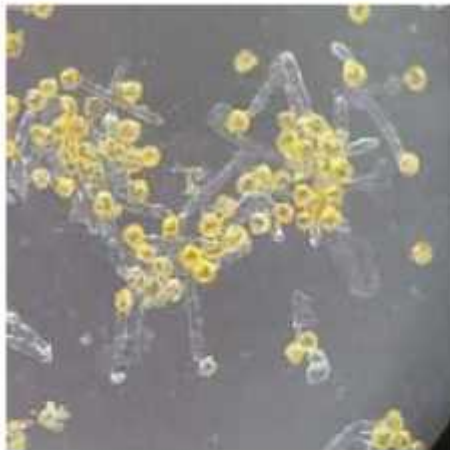


Acetocarmine test



Erythrosin B test

Staining test for pollen viability



***In vitro* pollen germination**

Plate 2 Pollen viability and *in vitro* pollen germination in peach accessions

Chohan (1980), Kumar *et al.* (2004), Tandon (2006), Fakim *et al.* (2011), Yephthomi (2011) and Joshi *et al.* (2017). The variation in pollen germination percentage so observed may be attributed to the genotypic constitution of the pollen in different genotypes.

Table 4. Pollen viability and germination of some peach accessions

Accession	Pollen viability (%)		Pollen germination (%)	
	Acetocarmine (2%)*	Erythrosin B (0.1%)**	Sucrose (10%)**	Sucrose (15%)**
Shan-i-Punjab	92.80 (9.68)	82.26 (65.07)	31.80 (34.24)	63.60 (52.94)
Kanto-5	93.33 (9.71)	58.68 (50.07)	67.31 (55.32)	57.34 (49.28)
Fertilia	98.00 (9.95)	62.97 (52.58)	20.26 (26.18)	15.59 (23.11)
Yum Yong	92.33 (9.66)	70.15 (57.01)	11.54 (19.85)	42.93 (40.91)
Flordasun	92.81 (9.68)	87.99 (69.73)	84.33 (66.71)	66.24 (55.67)
Summerglo	94.48 (9.77)	69.70 (56.77)	60.46 (51.01)	38.84 (38.49)
Suncoast	91.35 (9.60)	61.41 (51.63)	19.82 (26.41)	46.37 (42.88)
FlordaBelle	96.39 (9.86)	93.90 (76.14)	64.98 (53.71)	74.22 (60.17)
Ambri	96.17 (9.85)	75.61 (60.39)	18.53 (25.09)	11.56 (19.83)
Early Redhaven	93.77 (9.73)	76.33 (60.86)	57.20 (49.12)	47.54 (43.57)
Okubo	97.18 (9.90)	61.29 (51.67)	55.60 (48.23)	15.00 (22.58)
Early Amber	97.94 (9.94)	68.87 (56.11)	26.78 (31.12)	34.09 (35.45)
Fire Prince	97.89 (9.94)	69.11 (56.75)	27.68 (31.73)	26.45 (30.93)
Belle of Georgia	98.47 (9.97)	86.32 (68.28)	25.19 (29.92)	22.64 (28.21)
Hale Haven	93.75 (9.73)	75.08 (68.03)	17.23 (24.50)	41.52 (39.44)
Nishiki	95.16 (9.80)	76.00 (60.66)	39.83 (39.09)	54.52 (47.64)
Mean	95.12	73.48	39.29	41.16
CD _{0.05}	0.13	8.36	6.73	11.70

Figure in parenthesis are square root () and arc sign (**) transformed

4.5 FRUIT CHARACTERS

Data pertaining to morpho-physical characteristics of fruits of peach genotypes are presented in Table 5 and Plate 3 a, b, c and d.

4.5.1 Fruit weight

Heaviest fruits were found in Suncoast having 203.83 g average fruit weight and lightest fruits were observed in Ambri having 72.33 g average fruit weight. The mean value of fruit weight was determined as 132.74 g. The genotype Suncoast were found to have statistically at par with Summerglo, Kanto-5 and Okubo.

4.5.2 Fruit length

Maximum fruit length (96.95 mm) was recorded in Summerglo whereas, minimum fruit length (53.36 mm) in Shan-i-Punjab. The mean value for fruit length was 73.93 mm. Fruit length of Summerglo was statistically at par with Suncoast and Okubo.

4.5.3 Fruit diameter

Maximum fruit diameter (88.45 mm) was recorded in Summerglo whereas, minimum (56.00 mm) in Nishiki. The mean value for fruit diameter was 73.12 mm. The fruit diameter of Summerglo was statistically at par with Kanto-5.

4.5.4 Fruit shape

The shape of fruit was oblate in Flordasun and FlordaBelle, round in Shan-i-Punjab, Suncoast, Fire Prince and Belle of Georgia, ovate in Yum Yong, Summerglo, Okubo, Early Amber, Hale Haven, Nishiki, Elliptic in Kanto-5, Fertilia, Ambri and Early Redhaven.

4.5.5 Mucron tip at pistil end

Mucron tip at pistil end was present in all the genotypes, except FlordaBelle, Early Redhaven, Early Amber, Fire Prince and Hale Haven.

4.5.6 Shape of pistil end (excluding mucron tip)

Shape of the pistil end (excluding mucron tip) was weakly pointed in most of the genotypes, except Kanto-5 and Nishiki (Prominently pointed); Flordasun and FlordaBelle (Weakly depressed); Early Amber, Fire Prince and Hale Haven (Flat) .

4.5.7 Fruit symmetry (viewed from pistil end)

The fruits from pistil end was symmetric in Shan-i-Punjab, Yum Yong, Summerglo, Suncoast, Ambri, Early Amber, Okubo, Early Redhaven and Nishiki. The genotypes Kanto-5, Fertilia, Flordasun, FlordaBelle, Fire Prince, Belle of Georgia and Hale Haven had asymmetric fruits, while viewed from pistil end.

4.5.8 Prominence of suture

The prominence of suture were medium in most of the genotypes, except Summerglo, Early Redhaven, Okubo and Hale Haven (Strong); Suncoast and Fire Prince (Weak).

Table 5. Morpho-physical characteristics of some peach accessions

Accession	Fruit length (mm)	Fruit diameter (mm)	Fruit weight (g)	Fruit Shape	Mucron tip at pistil end	Shape of pistil end	Fruit symmetry	Prominence of suture	Fruit skin colour	Fruit flesh colour	Fruit firmness (Kg/cm ²)
Shan-i-Punjab	53.36	56.20	125.83	Round	Present	Weakly pointed	Symmetric	Medium	Orange Group 28 A	Yellow Orange Group 28 A	2.05
Kanto-5	62.20	87.60	199.53	Elliptic	Present	Prominently pointed	Asymmetric	Medium	Orange Red Group 33 A	Yellow Group 9 A	6.50
Fertilia	75.64	76.58	121.50	Elliptic	Present	Weakly pointed	Asymmetric	Medium	Yellow Green Group 145 A	Yellow Group 12 A	4.06
Yum Yong	71.70	64.73	108.00	Ovate	Present	Weakly pointed	Symmetric	Medium	Yellow Green Group 145 B	Yellow Green Group 145 D	2.84
Flordasun	58.13	60.39	87.66	Oblate	Present	Weakly depressed	Asymmetric	Medium	Orange Red Group 34 A	Yellow Orange Group 14 A	2.79
Summerglo	96.95	88.45	202.83	Ovate	Present	Weakly pointed	Symmetric	Strong	Yellow Orange Group 17 A	Yellow Orange Group 13 A	2.93
Suncoast	90.17	84.49	203.83	Round	Present	Weakly pointed	Symmetric	Weak	Yellow Orange Group 20 A	Yellow Orange Group 19 A	4.65
FlordaBelle	77.13	80.45	134.16	Oblate	Absent	Weakly depressed	Asymmetric	Medium	Yellow Green Group 145 A	Yellow Group 9A	5.90
Ambri	66.67	68.25	72.33	Elleptic	Present	Weakly pointed	Symmetric	Medium	Orange Red Group 33 A	Yellow Group 12 A	6.11
Early Redhaven	77.94	72.45	124.33	Elleptic	Absent	Weakly pointed	Symmetric	strong	Orange Red Group 34 A	Yellow Group 9 A	6.43
Okubo	90.95	82.65	198.65	Ovate	Present	Weakly pointed	Symmetric	Strong	Yellow Group 11 A	Yellow Group 11 D	4.64
Early Amber	69.27	70.04	100.33	Ovate	Absent	Flat	Symmetric	Medium	Yellow Green Group 145 B	Yellow Group 4 D	3.73
Fire Prince	77.42	72.80	132.16	Round	Absent	Flat	Asymmetric	Weak	Red Group 147 A	Yellow Green Group 145 B	4.84
Belle of Georgia	75.74	79.85	138.50	Round	Present	Weakly Pointed	Asymmetric	Medium	Red Group 142 A	Yellow Orange Group 16 A	6.45
Hale Haven	73.99	69.06	88.16	Ovate	Absent	Flat	Asymmetric	Strong	Yellow Green Group 145 B	Yellow Orange Group 15 A	6.56
Nishiki	65.66	56.00	85.93	Ovate	Present	Prominently pointed	Symmetric	Medium	Yellow Green Group 150 A	Yellow Group 4 A	4.13
Mean	73.93	73.12	132.74								4.67
CD _{0.05}	12.97	1.92	50.88								1.34

4.5.9 Fruit skin colour

The fruit skin colour was observed to be in Yellow Green Group (145 A) in Fertilia and FlordaBelle, (145 B) in Yum Yong, Hale Haven and Early Amber, (150 A) in Nishiki; Yellow Orange Group (17 A) in Summerglo, (20 A) Suncoast; Yellow Group (11 A) in Okubo; Orange Group (28 A) in Shan-i-Punjab; Orang Red Group (33 A) in Kanto-5 and Ambri, (34 A) in Flordasun and Early Redhaven; Red Group (142 A) in Belle of Georgia, (147 A) in Fire Prince.

4.5.10 Fruit flesh colour

The fruit flesh colour was observed to be in Yellow Group (4 A) in Nishiki and (4 D) in Early Amber, (9 A) in Early Redhaven, FloradBelle and Kanto-5, (11 D) Okubo, (12 A) in Fertilia and Ambri; Yellow Green Group (145 B) in Fire Prince, (145 D) in Yum Yong; Yellow Orange Group (13 A) in Summerglo, (14 A) in Flordasun, (15 A) in Hale Haven, (16 A) in Belle of Georgia, (19 A) Suncoast and (28 A) in Shan-i-Punjab.

4.5.11 Fruit firmness

Fruit firmness varied from 2.05 kg/cm² in Shan-i-Punjab to 6.56 kg/cm² in Hale Haven. The overall mean for fruit firmness was 4.67 kg/cm². Hale Haven was statistically at par with Kanto-5, FlordaBelle, Ambri, Early Redhaven and Belle of Georgia.

4.5.12 Time of harvesting

Time of maturity ranged from 31th May in Shan-i-Punjab and Flordasun to 10th July in Kanto-5. The dates of maturity in other genotypes were 14th June in FlordaBelle, 23rd June in Nishiki, 25th June in Yum Yong and Early Redhaven, 27th June in Ambri and 30th June (Summerglo, Suncoast, Okubo, Early Amber, Fire Prince and Belle of Georgia), 3rd July in Hale Haven and 8th July in Fertilia (Table 6).

4.5.13 Number of days from full bloom to harvest

Number of days from full bloom to harvest ranged from 103 days in Ambri, Fire Prince and Nishiki to 135 days in FlordaBelle (Table 6).



Shan-i-Punjab



Kanto-5



Fertilia



Yum Yong

Plate 3a. Fruits of some peach accessions



Flordasun



Summerglo



Suncoast



FlordaBelle

Plate 3b. Fruits of some peach accessions



Ambri



Early Redhaven



Okubo



Early Amber

Plate 3c. Fruits of some peach accessions



Fire Prince



Belle of Georgia



Hale Haven



Nishiki

Plate 3d. Fruits of some peach accessions

Table 6. Days from full bloom to harvesting and time of harvesting of some peach accessions

Accession	Time of Harvesting	No. of days from full bloom to harvest
Shan-i-Punjab	31 th May	114
Kanto-5	10 th July	120
Fertilia	8 th July	109
Yum Yong	25 th June	106
Flordasun	31 th May	115
Summerglo	30 th June	124
Suncoast	30 th June	111
FlordaBelle	14 th June	135
Ambri	27 th June	103
Early Redhaven	25 th June	104
Okubo	30 th June	105
Early Amber	30 th June	117
Fire Prince	30 th June	103
Belle of Georgia	30 th June	110
Hale Haven	3 rd July	105
Nishiki	23 rd June	103

4.5.14 Stone characters

Data pertaining to stone characteristics in different peach genotypes are presented in Table 7.

4.5.14.1 Stone shape and size

Most of the genotypes had elliptic stone shape, except Early Amber (Circular); Kanto-5, Flordasun, Suncoast, FlordaBelle, and Nishiki (Obovate).

Average stone length ranged from 40.72 mm in Flordasun to 56.13 mm in Okubo. The average breadth of stone was maximum (39.50 mm) in Kanto-5 and minimum (31.34 mm) in Flordasun. The mean value for stone length and breadth was 50.64 mm and 36.26 mm respectively. The length of stone of genotype Okubo was statistically at par with Suncoast, Early Redhaven and Fire Prince. The breadth of stone of genotype Kanto-5 was statistically at par with FlordaBelle, Early Redhaven and Okubo.

4.5.14.2 Stone weight

Stone weight was maximum (11.00 g) in Kanto-5 and Early Redhaven and minimum (2.00 g) in Flordasun. Mean value for stone weight was 6.79 g. All the genotypes were statistically different.

4.5.14.3 Anthocyanin colouration of stone

Anthocyanin colouration in most of the accessions were weak, except Kanto-5, Summerglo, Suncoast, Okubo and Fire Prince (Medium); Belle of Georgia and Hale Haven (Strong).

4.5.14.4 Adherence of flesh to stone

Most of the genotype were freestone except Kanto-5, Fertilia, Ambri, Early Redhaven, Hale Haven and Nishiki which were of clingstone type.

4.5.14.5 Pulp/stone ratio

Maximum pulp/stone ratio (43.39) was found in Flordasun followed by Suncoast (39.86) and minimum (8.87) in Hale Haven. The mean value for pulp/stone ratio was 20.50. Flordasun was statistically at par with Suncoast (Table 7).

4.5.14.6 Presence of grooves/ pits

All the sixteen genotypes were found to have both grooves and pits on the stone surface.

4.5.14.7 Shape of apex

The shape of the apex was found to be rounded in half of the genotypes, whereas, pointed in others.

The maximum fruit length and diameter was observed in Summerglo and minimum fruit length in Shan-i-Punjab and fruit diameter in Nishiki. The fruit weight was maximum in Suncoast and minimum in Nishiki. Considerable variation was observed in fruit firmness of different genotypes. The fruit firmness was observed maximum in Hale Haven and minimum in Shan-i-Punjab. This is an important factor taken into consideration where the fruit has to be transported over distances and local markets are not available. The stone length was observed maximum in Okubo and minimum in Flordasun. The stone diameter was maximum

in Kanto-5 and minimum in Flordasun. Pulp/stone ratio is an important criterion to judge the quality of peach fruits. It is evident from Table 7 that pulp to stone ratio was maximum in Flordasun and minimum in Hale Haven. The similar type of variation was observed by Singh *et al.* (2014), Chaurasiya and Mishra (2017) in the different sets of varieties. Variability in fruit shape, mucron tip fruit symmetry, prominence of suture, anthocyanin coloration of stone in all the genotype was observed (Table 5 and 7). The colour of fruit (flesh and skin) as well as the adherence of stone to pulp are also important indices to differentiation between various peach cultivars and to some extent are considered as indices of maturity. Time of maturity of fruit ranged from fourth week of May in Shan-i-Punjab and Flordasun to second week of July in Kanto-5. Number of days from full bloom to harvest ranged from 103 days in Nishiki and Fire Prince to 135 days in FlordaBelle (Table 6). Peach genotypes maturing in May holds promise due to non-availability of fruits in the market in the mid hill areas, further so the fruit quality is considerably better than those are in the markets during the same time.

Table 7. Stone characters of some peach accessions

Accession	Stone size (mm)		Stone weight	Pulp/Stone ratio	Stone shape	Anthocyanin colouration of stone	Adherence of flesh to stone	Presence of grooves/Pits	Shape of Apex
	Length	Breadth							
Shan-i-Punjab	41.10	34.66	6.00	19.89	Elliptic	Weak	Freestone	Present	Pointed
Kanto-5	52.27	39.50	11.00	17.21	Obovate	Medium	Clingstone	Present	Round
Fertilia	49.22	35.07	4.50	26.02	Elliptic	Weak	Clingstone	Present	Round
Yum Yong	50.60	35.31	6.53	15.50	Elliptic	Weak	Freestone	Present	Round
Flordasun	40.72	31.34	2.00	43.39	Obovate	Weak	Freestone	Present	Pointed
Summerglo	53.50	36.07	6.53	30.24	Elliptic	Medium	Freestone	Present	Round
Suncoast	55.50	37.00	4.96	39.86	Obovate	Medium	Freestone	Present	Pointed
FlordaBelle	47.09	39.03	9.00	13.88	Obovate	Weak	Freestone	Present	Pointed
Ambri	47.63	34.87	4.00	17.05	Elliptic	Weak	Clingstone	Present	Pointed
Early Redhaven	55.80	39.17	11.00	10.44	Elliptic	Weak	Clingstone	Present	Pointed
Okubo	56.13	39.13	9.50	19.97	Elliptic	Medium	Freestone	Present	Pointed
Early Amber	46.17	32.07	4.56	21.26	Circular	Weak	Freestone	Present	Round
Fire Prince	55.43	36.83	7.00	17.84	Elliptic	Medium	Freestone	Present	Round
Belle of Georgia	50.35	35.55	7.50	17.45	Elliptic	Strong	Freestone	Present	Round
Hale Haven	51.30	36.20	9.00	8.87	Elliptic	Strong	Clingstone	Present	Round
Nishiki	48.37	34.67	8.56	9.03	Obovate	Weak	Clingstone	Present	Pointed
Mean	50.64	36.26	6.79	20.50					
CD _{0.05}	1.09	1.23	0.93	9.93					

Morettini (1962) reported the use of pulp colour in the identification of peach cultivars. However, in the present study the peach accessions exhibited no significant variation in fruit skin and flesh colour, except the slight variation was observed in the shade of colour. Significant differences in various fruit characters such as size, weight, colour of skin and flesh were observed in peach genotypes studied (Table 5). These characters are determinantal in making any variety acceptable to the end user i.e. the consumer. In general the domestic market has a likeness towards peach fruit which are large in size, sweet in taste, less acidic, juicy and flesh is easily separable from the stone. Several workers have worked on the physical aspect of peach fruits (Chahill *et al.*, 1997; Dumitru *et al.*, 2007; Tandon, 2016; Taheri and Hajnajari, 2010 and Topp *et al.*, 2012) in the past and have reported considerable variation fruits of different peach varieties.

4.5.15 Biochemical characteristics

Data (Table 8) recorded on various biochemical characteristics of peach genotypes are presented as under:

4.5.15.1 Total soluble solids

It was revealed from Table 7 that highest TSS content (13.43°B) was in FlordaBelle which was followed by Fertilia (13.13°B) and the lowest (8.10°B) in Ambri. The mean value for TSS was 10.48°B. FlordaBelle was statistically at par with Shan-i-Punjab, Fertilia, and Early Redhaven.

4.5.15.2 Titratable acidity

Highest acidity (1.64%) was in Summerglo followed by Suncoast (1.47%) and lowest in Belle of Georgia (0.20%). The mean value for titratable acidity was 0.79 per cent. It was found that titratable acidity of all the genotypes were statistically different.

4.5.15.3 Total sugars

The total sugars content was maximum 10.53 per cent in Fertilia followed by 9.23 per cent in FlordaBelle and 9.20 per cent in Shan-i-Punjab. The total sugars content was minimum 6.25 per cent in Belle of Georgia. The mean value for total sugars was 7.63 per cent. It was found that total sugars of all the genotype were statistically different.

4.5.15.4 Reducing sugars

Reducing sugars varied from 4.26 per cent in Yum Yong to 1.06 per cent in Hale Haven. The mean value for reducing sugars was 2.77 per cent. Yum Yong was statistically at par with FlordaBelle.

Table 8. Biochemical characteristics of some peach accessions

Accession	Total soluble solids (°B)	Titrateable Acidity (%)	Total Sugars (%)	Reducing Sugars (%)	Non-reducing sugars (%)	Sugar/acid ratio
Shan-i-Punjab	12.00	0.87	9.20	2.60	6.27	10.64
Kanto-5	8.73	0.69	6.34	2.90	3.28	9.37
Fertilia	13.13	0.67	10.53	2.70	7.44	15.72
Yum Yong	12.43	0.33	9.06	4.26	4.56	27.89
Flordasun	10.23	0.80	7.36	3.30	3.85	9.15
Summerglo	9.76	1.64	7.16	3.00	3.95	3.93
Suncoast	10.40	1.47	7.36	1.48	5.59	5.48
FlordaBelle	13.43	1.05	9.23	4.24	4.75	9.23
Ambri	8.10	0.44	7.06	3.07	3.79	16.17
EarlyRedhaven	11.70	0.43	8.53	3.63	4.66	20.68
Okubo	9.93	0.60	7.06	3.20	3.67	11.74
Early Amber	9.70	1.00	6.56	1.77	4.56	6.56
Fire Prince	10.46	0.60	6.90	2.58	4.11	11.85
Belle of Georgia	9.00	0.20	6.25	2.06	3.98	37.91
Hale Haven	9.70	0.91	6.78	1.06	5.44	7.46
Nishiki	8.96	0.94	6.61	2.12	4.27	7.08
Mean	10.48	0.79	7.63	2.77	4.62	13.21
CD _{0.05}	1.91	0.29	0.89	0.43	0.91	10.54

4.5.15.5 Non-reducing sugars

Maximum content of non-reducing sugars was 7.44 per cent in Fertilia followed by Shan-i-Punjab (6.27%), Suncoast (5.59%) and the lowest was 3.28 per cent in Kanto-5. The mean value for non-reducing sugars was 4.62 per cent. It was found that Non-reducing sugars of all the genotype were statistically different.

4.5.15.6 Sugar/acid ratio

The highest sugar/acid ratio was recorded as 37.91 in Belle of Georgia followed by Yum Yong (27.89), Early Redhaven (20.68), Fertilia (15.72) and the lowest was 3.93 in

Summerglo. The overall value of mean for sugar/acid ratio was 13.21. Belle of Georgia was statistically at par with Yum Yong.

4.5.16 Yield

Fruit yield was maximum (24.66 kg/tree) in Shan-i-Punjab followed by (23 kg/tree) in Kanto-5, Fertilia and Fire Prince. Whereas, minimum (11 kg/tree) in Flordasun and Belle of Georgia. The mean value for yield was 18.63 kg/tree. It was found that yield of all the genotype were statistically different (Table 1).

4.5.17 Yield efficiency

The yield efficiency was maximum (1.01 kg/cm²) in Nishiki followed by (0.52 kg/cm²) in Suncoast whereas, minimum (0.04 kg/cm²) in Flordasun. The mean value for yield efficiency was 0.30 kg/cm². All the genotypes were statistically different (Table 1).

The TSS content in fruits was found to be ranging between 8.10°B in Ambri and 13.43°B in FlordaBelle. It was revealed from the Table 8 that highest titratable acidity (1.64%) was in Summerglo followed by Suncoast (1.47%) and lowest (0.20%) in Belle of Georgia. Whereas, according to Kaul (2002) TSS content varied from 13.40°B in Shan-i-Punjab to 13.80°B in Flordasun. The titratable acidity was maximum in Pratap and minimum Shan-i-Punjab. Total sugars was highest in Fertilia (10.53%) and lowest (6.25%) in Belle of Georgia (Table 8). Reducing sugars was varied from (1.06%) in Hale Haven to (4.26%) in Yum Yong. Non-reducing sugars was highest (7.44%) in Fertilia and lowest (3.28%) in Kanto-5. The Sugar acid ratio was maximum (37.91) in Belle of Georgia and minimum (3.93) in Summerglo. These types of variability in peach genotypes were recorded by Sharma and Verma, 2014; Jana, 2015; Kishor *et al.* 2017; Chaurasiya and Mishra, 2017. Such variations may be due to the different agroclimatic conditions influencing synthesis of biochemical constituents in the developing fruits and the duration of fruit development period.

The variation observed in the TSS, sugars and acidity of the fruits in the present study as compared to others, can be due to the differences in the maturity levels of the fruits at the time of harvest besides the edaphic (nutritional status of soil) and climatic factors.

Chapter-5

SUMMARY AND CONCLUSION

The salient results of the studies on “**Characterization and evaluation of some peach [*Prunus persica* (L.) Batsch.] accessions**” is summarized as under:

- 5.1** Flordasun recorded maximum plant height (6.13 m) and girth (73.67 cm), tree spread in N-S (5.23 m) and in E-W direction (5.30 m) was maximum in Shan-i-Punjab. While, Minimum tree height (2.07 m) and trunk girth (15.00 cm) was recorded in Nishiki. The tree spread was minimum in N-S (1.30 m) and E-W (1.74 m) in FlordaBelle and Nishiki respectively. The fruit yield was maximum (24.66 kg/plant) in Shan-i-Punjab and minimum (11.00 kg/plant) in Flordsaun and Belle of Georgia. The yield efficiency was maximum (1.01 kg/cm²) in Nishiki and minimum (0.04 kg/cm²) in Flordasun.
- 5.2** Maximum leaf length (19.23 cm) was observed in Okubo and leaf width (5.03 cm) was found in Okubo and Nishiki whereas Fertilia was recorded to have minimum values of leaf length (11.03 cm) and width (2.86 cm). Leaf area was maximum (193.43 cm²) in Okubo and minimum (54.83 cm²) in Shan-i-Punjab. The petiole length was maximum (1.20 cm) in Ambri and minimum (0.40 cm) in Hale Haven. Time of leaf emergence was earliest (18th January) in FlordaBelle and last (11th March) in Fertilia. Shedding of leaves started from 12th November (Suncoast) to 11th December (FlordaBelle).
- 5.3** The time of opening of First flower was earliest (20th January) in FlordaBelle and was last (14th March) in Fertilia. Time of full bloom extended from as early as (29th January) in FlordaBelle to (20th March) in Fertilia and Hale Haven. The date of opening of last flower was earliest on 10th February in FlordaBelle, whereas Fertilia was the last on 5th April.
- 5.4** Pollen viability as tested in acetocarmine and in erythrosin B ranged from 91.35 per cent in Suncoast to 98.47 per cent in Belle of Georgia and 58.68 per cent in Kanto-5 to 93.90 per cent in FlordaBelle, respectively. *In vitro* pollen germination was maximum (84.33%) in Flordasun and minimum (11.54%) in Yum Yong under 10 per cent

sucrose solution. Pollen germination under 15 per cent sucrose solution was maximum (74.22%) in FlordaBelle and minimum (11.56%) in Ambri.

- 5.5** Maximum fruit length (96.95 mm) and fruit diameter (88.45 mm) was recorded in Summerglo, whereas minimum fruit length (53.36 mm) and fruit diameter (56.00 mm) was recorded in Shan-i-Punjab and Nishiki respectively. Heaviest fruits were found in Suncoast (203.83 g) and lightest fruits were observed in Ambri (72.33 g). Fruit firmness varied from 2.05 kg/cm² in Shan-i-Punjab to 6.56 kg/cm² in Hale Haven.
- 5.6** Average stone length ranged from 40.72 mm in Flordasun to 56.13 mm in Okubo. The average diameter of stone was maximum (39.50 mm) in Kanto-5 and minimum (31.34 mm) in Flordasun. Maximum pulp/stone ratio (43.39) was found in Flordasun and minimum (8.87) in Hale Haven.
- 5.7** TSS content of fruit was maximum (13.43°B) in FlordaBelle and minimum (8.10°B) in Ambri. Titratable acidity was maximum (1.64%) in Summerglo and minimum (0.20%) in Belle of Georgia. Total sugars were maximum (10.53%) in Fertilia and minimum (6.25%) in Belle of Georgia. Reducing sugars was ranged from (1.06%) in Hale Haven to (4.26%) in Yum Yong whereas, non reducing sugars was ranged from (3.28%) in Kanto-5 to (7.44%) in Fertilia. The sugar/acid ratio was maximum (37.91) in Belle of Georgia and minimum (3.93) in Summerglo.

CONCLUSION

From the foregoing discussion, it is concluded that the results obtained are preliminary and there is further need to evaluate these peach genotypes in the subsequent years. However, the present studies does indicate that some of these genotypes do possess one or more horticulturally desirable characteristics (enlisted below) and thus can be future commercial varieties provided they yield quality fruits consistently and sufficiently.

Peach accessions	Distinguishing character(s)
i) Summerglo	Large fruit, free stone
ii) FlordaBelle	High TSS, free stone
iii) Shan-i-Punjab	Early maturing, higher yield, high TSS, free stone
iv) Flordasun	Early maturing, high pulp/stone ratio, free stone
v) Hale Haven	Firm fleshed
vi) Yum Yong	Free stone, high TSS, high sugar/acid ratio

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Title of Thesis	: Characterization and evaluation of some peach [<i>Prunus persica</i> (L.) Batsch.] accessions
Name of the Student	: Suman Bodh
Admission Number	: H-2016-54-M
Major Advisor	: Dr Dinesh Singh Thakur
Major Field	: Fruit Science
Minor Field(s)	: Genetics and Plant Breeding
Degree Awarded	: M Sc (Fruit Science)
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ABSTRACT

The present investigation entitled “Characterization and evaluation of some peach [*Prunus persica* (L.) Batsch.] accessions” was carried out in the field gene bank of National Bureau of Plant Genetics Resources, Regional Station Phagli, Shimla. Sixteen peach genotypes namely Shan-i-Punjab, Kanto-5, Fertilia, Yum Yong, Flordasun, Summerglo, Suncoast, FlordaBelle, Ambri, Early Redhaven, Okubo, Early Amber, Fire Prince, Belle of Georgia, Hale Haven, Nishiki were evaluated for their tree, foliage, floral and fruit characters. Flordasun recorded maximum plant height (6.13 m) and Minimum (2.07 m) in Nishiki. The fruit yield was maximum (24.66 kg/plant) in Shan-i-Punjab and minimum (11.00 kg/plant) in Flordasun and Belle of Georgia. Shedding of leaves started from 12th November (Suncoast) to 11th December (FlordaBelle). Time of full bloom extended from as early as (29th January) in FlordaBelle to (20th March) in Fertilia and Hale Haven. Pollen viability as tested in acetocarmine and in erythrosin B ranged from 91.35 per cent in Suncoast to 98.47 per cent in Belle of Georgia and 58.68 per cent in Kanto-5 to 93.90 per cent in FlordaBelle, respectively. *In vitro* pollen germination was maximum (84.33%) in Flordasun and minimum (11.54%) in Yum Yong under 10 per cent sucrose solution. Pollen germination under 15 per cent sucrose solution was maximum (74.22%) in FlordaBelle and minimum (11.56%) in Ambri. Heaviest fruits were found in Suncoast (203.83 g) and lightest fruits were observed in Ambri (72.33 g). Fruit firmness varied from 2.05 kg/cm² in Shan-i-Punjab to 6.56 kg/cm² in Hale Haven. Maximum pulp/stone ratio (43.39) was found in Flordasun and minimum (8.87) in Hale Haven. TSS content of fruit was maximum (13.43°B) in FlordaBelle and minimum (8.10°B) in Ambri. Titratable acidity was maximum (1.64%) in Summerglo and minimum (0.20%) in Belle of Georgia. Total sugars were maximum (10.53%) in Fertilia and minimum (6.25%) in Belle of Georgia. From the present investigations it may be concluded that Summerglo, Shan-i-Punjab, FlordaBelle, Flordasun, Yum Yong and Hale Haven may be suggested for cultivation in conditions of Himachal Pradesh for their better quality.

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APPENDIX-I

ANOVA for tree characters of peach accessions

Source of variation	df	Tree height (m)			Tree spread (cm)						Trunk girth (cm)			Yield (kg/plant)			Yield efficiency (kg/cm ²)		
					N-S			E-W											
		SS	MS	F	SS	MS	F	SS	MS	F	SS	MS	F	SS	MS	F	SS	MS	F
Treatment (T)	2	0.34			0.07			0.68			5.76			19.62			0.01		
Replication(R)	15	71.63	4.77	50.89	42.05	2.80	44.11	83.89	5.59	83.90	14,630.00	975.33	376.85	921.91	61.46	134.50	3.84	0.25	71.17
T x R	30	2.81	0.09		1.90	0.06		2.00	0.06		77.64	2.58		13.70	0.45		0.10	0.004	
Total	47																		

ANOVA for foliage characters of peach accessions

Source of variation	df	Leaf length (cm)			Leaf width (cm)			Leaf area (cm ²)			Petiole length (cm)		
		SS	MS	F	SS	MS	F	SS	MS	F	SS	MS	F
Treatment (T)	2	4.24			0.27			1.40			0.11		
Replication(R)	15	252.92	16.86	10.03	15.03	1.00	7.03	50,645.53	3,376.36	2,792.31	2.01	0.13	4.318
T x R	30	50.38	1.68		4.27	0.14		36.27	1.20		0.93	0.03	
Total	47												

ANOVA for pollen viability and in vitro pollen germination of peach accessions

Source of variation	df	Pollen viability (%)						<i>In vitro</i> pollen germination (%)					
		Acetocarmine (2%)			Erythrosin B (0.1%)			Sucrose (10%)			Sucrose (15%)		
		SS	MS	F	SS	MS	F	SS	MS	F	SS	MS	F
Treatment(T)	2	2.61			16.15			81.53			583.64		
Replication(R)	15	246.27	16.41	6.39	4,741.07	316.07	5.07	22,450.08	1,496.67	40.44	16,698.71	1,113.24	9.29
T x R	30	76.96	2.56		1,869.63	62.32		1,110.03	37.001		3,593.31	119.77	
Total	47												

ANOVA for morpho-physical characteristics of fruits of peach accessions

Source of variation	df	Fruit length (mm)			Fruit breadth (mm)			Fruit weight (g)			Fruit firmness (kg/cm ²)		
		SS	MS	F	SS	MS	F	SS	MS	F	SS	MS	F
Treatment (T)	2	280.11			4.46			778.55			1.29		
Replication (R)	15	11,795.32	786.35	13.11	17,156.78	1,143.78	1,435.46	107,419.59	7,161.30	7.77	105.33	7.02	10.97
T x R	30	1,799.24	59.97		23.91	0.79		27,639.98	921.33		19.19	0.64	
Total	47												

ANOVA for stone characters of peach accessions

Source of variation	df	Stone length (mm)			Stone breadth (mm)			Pulp/stone ratio		
		SS	MS	F	SS	MS	F	SS	MS	F
Treatment (T)	2	3.14			2.03			76.43		
Replication (R)	15	26,168.16	1,744.54	4,231.62	20,627.38	1,375.15	2,635.75	4,504.30	300.28	8.53
T x R	30	12.36	0.41		15.65	0.52		1,055.47	35.18	
Total	47									

ANOVA for bio-chemical characters of fruits of peach accessions

Source of variation	df	Titratable acidity (%)			Total soluble solids (°B)			Total sugars (%)			Reducing sugars (%)			Non-reducing sugars (%)			Sugar/acid ratio		
		SS	MS	F	SS	MS	F	SS	MS	F	SS	MS	F	SS	MS	F	SS	MS	F
Treatment(T)	2	0.5			0.18			0.07			0.25			0.21			67.74		
Replication(R)	15	12.13	0.450	14.328	115.99	7.73	5.91	72.93	4.86	17.24	45.45	3.03	30.86	56.31	3.75	10.85	3,645.45	243.03	6.13
T x R	30	0.002	0.031		39.21	1.30		8.46	0.28		2.94	0.09		10.37	0.34		1,188.44	39.61	
Total	47																		

BRIEF BIO-DATA

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Other financial assistance received during
the study period

(Suman Bodh)