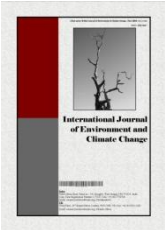

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Response on Phenological, Fruiting Behaviour and Growth Characteristics of F_1 Candidates Rootstock Seedlings of Peach [*Prunus persica* (L.) Batsch]

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aim: The aim of present study was to evaluate the flowering and fruiting behaviour of different variety of peach, plum along with growth characteristics of their F_1 hybrids and identification hybrid rootstocks for future genetic improvement.
Study Design: The experiment was designed in Randomized Block Design Factorial with three replications.
Place and Duration of Study: Rootstock hybridization programme were carried out at main fruit research station Punjab Agricultural University, Ludhiana, Punjab during 2016-17 and 2017-18.
Methodology: Rootstock hybridization programme were carried out with three varieties two peach namely Sharbati and Flordaguard and one plum Kala amritsari and study the phenological, fruiting behavior and growth performance of seedlings of parents and F_1 hybrids.
Results: Higher days from full bloom to maturity take by Sharbati × Flordaguard (129.4 Days) and minimum in Kala amritsari × Flordaguard (111.1 Days). For completion of stratification seeds of Sharbati and Sharbati × Flordaguard took maximum days for stratification (90-105 Days and 30-105 Days, respectively) and minimum in Flordaguard (30-60 Days). Seed germination % higher in Flordaguard (97.15%) and minimum in Sharbati × Kala amritsari (70.81%). Pollen viability in stored and fresh pollen was highest in Flordaguard (96.26 and 97.58%), while, minimum in Sharbati

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(90.89% and 96.60%). Leaf colour values (L, a, b, chroma and hue) maximum were in Sharbati and minimum in Flordaguard and leaf colour values of both hybrids, were as Flordaguard. Maximum chlorophyll (SPAD units) were recorded in Flordaguard × Sharbati (42.87) which was at par with the SAPD values of Sharbati × Flordaguard. Leaves of Flordaguard and both the hybrids showed dark reddish green colour on upper and light reddish green in lower side of leaves. Seedlings of Sharbati, Sharbati × Flordaguard and Flordaguard × Sharbati showed better growth characteristics as compares to seedlings of Flordaguard.

Conclusion: The advance candidate hybrid rootstocks may be useful for further exploitation for genetic improvement and development of rootstock with good nursery characters**.**

Keywords: Hybridization; flordaguard; stratification; pollen viability; tree growth.

1. INTRODUCTION

Seedling rootstocks still lead rootstock utilization in many growing regions around the world. The development of new rootstocks to solve some of existing soil and disease problems has mainly focused on interspecific hybridizations and has been mostly undertaken by public programmes because of the time, cost and risk associated with their development. However, the private industry is also emerging in the current decade as a significant contributor to the development of some of the newest rootstocks. Adaptation to hot, arid climates and to orchard replant sites are important criteria in the development of new rootstocks for peach. Rootstock has an important effect on performance of the peach, which includes growth rate, tree size, productivity, nutrient uptake, time of defoliation, bloom time, tree survival, nematode infestation and resistance to canker and Peach Tree Short Life (PTSL) [1]. The major problem in the peach industry is PTSL which cause early decline of orchards and the average life of peach is around 10-12 years or less. It is caused by multiple factor like nematode, bacterial canker, iron chlorosis and variety of non-specific secondary pathogens [2] however; nematode is the most important factor for PTLS. The use of nematicides has been banned due to environmental issues hence, peach rootstocks with durable resistant to root-knot nematodes are needed. Several rootstock breeding programmes using interspecific hybridization among *Prunus* species has been initiated in the developed nations but, most of them are in private domain. Thus, most of these new improved rootstocks are patent protected and hence, can't be commercially exploited in India.

Sharbati variety of peach is used as rootstock in sub-tropical regions of India, because of its wide adaptability to warm climatic conditions and alkaline soils, but its susceptibility to root-knot nematode leads to PTSL. Flordaguard rootstock is a sixth generation inter-specific cross of Chico 11 × *Prunus davidiana.* It has been found to be resistant against the root-knot nematodes and resistant to *M. javanica, M. incognita* and *M. floridensis* [3,4]. However, Flordaguard is showing very poor response to propagation by stooling and cutting and seed germination; and after growth under the subtropics which cause major problem in large scale multiplication of it for commercial purposes. It is also susceptible to severe iron deficiency under alkaline conditions. Most of these factors are influenced by rootstock which is the major contributor to tree performance and longevity as it determines tolerance to various biotic and abiotic stresses. No one rootstock can be rated as an ideal rootstock for all situations.

Hence, breeding of new peach rootstocks having root-knot nematode (RKN) resistance along with useful horticultural traits viz. easy of propagation, adaptation to the new environments and diverse soils has become very essential. Breeding of peach rootstocks for high RKN resistance with good adaptation to alkaline soils with graft compatibility and rooting ability will be crucial for sustainable stone fruit production in the subtropics of North West India. The present study was conducted to develop new hybrid rootstock seedlings for peach.

2. MATERIALS AND METHODS

This experiment was conducted at Fruit Research Farm of the Department of Fruit Science, Punjab Agricultural University, Ludhiana during the year 2016 to 2018. The experimental site is situated at 75°86' E longitude, 30°90' N latitude and an elevation is 244 m above mean sea level. The average maximum temperature ranges between 12.9 to 33.9°C and the average minimum temperature ranges between 5.7 to 26.9°C. The average annual rainfall of this area

is about 885 mm. Out of this, 75% received during monsoon period i.e. July to September. The experiment was laid out in a randomized block design with five replications.

The crosses were made within the parents Sharbati (S), Flordaguard (FG) and Kala amritsari (KA). Phenological and fruit characteristics of parent and growth parameters of the hybrid seedlings along with their parents were recorded based on Descriptors for Peach [5] for each genotype. Six plant of each parents with similar age (7 years old) and height are used in hybridization programme and we got successfully survived seedlings of two hybrids namely Sharbati × Flordaguard and Flordaguard × Sharbati. Five month old thirty seedlings of both hybrids and parents are used in the study of plant growth characteristics and data were recorded at one-month interval. The plant growth characteristics like plant height, seedlings girth, leaf blade length and width and internodal length etc. were measured with the help of scale and Digital Vernier's Calliper (Mitutoyo Inc, Japan). Days taken for stratification and germination % was recorded from the seeds when seeds are kept along with moist media containing cocopeat, vermiculite and perlite (2:1:1). Seeds were stratified in the medium inside well perforated polybag at 4±2°C temperature till >80% seeds showed radicle emergence was considered as time taken to stratification. Stratified seeds are sown in portrays at the time of sowing seed germination % was workout. After establishment of seedlings of parents and F_1 hybrids in portrays were planted under uniform field conditions and 25 uniform healthy seedlings were maintained for each genotype. The plants were raised as per the recommended package and practices for peach cultivation in lower hills or sub-tropical conditions. Each plant was tagged for recording the observations.

The viability of pollen was tested in 1% acetocarmine solution. One to two drops of acetocarmine solution was taken on the clean glass slide and then the pollen grains were dusted carefully on the slide. Just after dusting of pollen grains, a cover slip was placed carefully to avoid the formation of air bubble in acetocarmine solution and examined under the microscope. Deeply stained and normal looking pollen grains were counted viable, while shrivelled, lightly stained or colourless were considered as non-viable pollen grains. Leaf colour was measured by a Hunter Lab Colour difference meter (ColorFlex®, EZ, USA). The chromacity L, a and b values were obtained from the Hunter Lab Colour meter. L ranges from 0 (black) to 100 (white) which represents the lightness of the fruit colour. Chromacity 'a' represents redness (+a) or greenness (-a) and 'b' depicts yellow (+b) or blue (-b) colour. The chroma (C) was calculated as C= (a2 + b2)½ which shows the intensity of colour saturation from dull to vivid colour depicted by low to high values, respectively. The hue angle (h^o) was calculated by equation tan-1 b/a; represents red at 0^o or 360^o, yellow at 90^o, green at 180^o and blue at 270^o.Chlorophyll level was measured as SPAD value taken by a chlorophyll meter (SPAD 502 plus Konica Minolta Sensing, Europe B.V.). The leaf area of parents and hybrid seedlings was measured by using Leaf Area Meter (CI-203 Area Meter) and expressed in square centimetres (cm^2).

The pooled data were subjected to analysis of variation (ANOVA) using Randomized Block Design [6]. The mean separation was done using least significant difference (Fisher's LSD) at $P \leq 0.05$ following significant F test.

3. RESULTS AND DISCUSSION

In general, flowering was late in the year 2017-18 as compared to 2016-17 (Table 1). Variation was recorded in all the three genotypes with respect to phenological characteristics viz. flowering season in both the years. In both the years, the earliest bud burst was observed in Sharbati (1^{st} February and 22^{nd} January) followed by Flordaguard (6^{th} February and 24^{th} January) while the latest bud burst was observed in Kala Amritsari (9^{th} February and 30^{th} January) in 2017 and 2018, respectively. Similarly, the earliest initiation of flowering was recorded in Sharbati (6^{th} and 1^{st} February) followed by Flordaguard (14^{th} and 6^{th} February) and latest in Kala Amritsari (14^{th} and 4^{th} February) respectively, in the year 2017 and 2018. The date of full bloom was also earliest in Sharbati (14^{th} and 9^{th} February) followed by Flordaguard (18^{th} and 13^{th} February) and Kala Amritsari (22^{nd} and 10^{th} February) respectively in both years 2017 and 2018. The cultivar Sharbati was the earliest to show end of flowering (24^{th} and 20^{th} February) followed by Flordaguard (28^{th} and 20^{th} February) and Kala Amritsari (27^{th} and 17^{th} February) in 2017 and 2018, respectively. The duration of flowering did not show any significant variation over the years (Table 4). The pooled data for duration of flowering showed that longest duration of flowering in both years (19.60 days) was recorded in Sharbati, followed by

Flordaguard (15.40 days) and the shortest duration (13.00 days) was recorded in Kala Amritsari.

The variability in flowering behaviour is a varietal characteristic. The variation in time of flowering may be due to climatic reasons (accumulation of chilling units and growing degree days) required to break bud dormancy in various genotypes. Sharma et al. [7] also observed variation in floral characteristics among the different peach varieties with Suncrest was earliest to flower while, Glohaven was the latest. Likewise, Joshi et al. [8] also recorded variation in the flowering traits in peach with earliest flowering in Tropic Beauty followed by Pratap, Saharanpur Prabhat, Redhaven and July Elberta.

The pooled result (Table 2) indicated that highest fruit set was recorded in Sharbati × Flordaguard (36.88%) followed by Flordaguard × Sharbati (26.00%), Sharbati × Kala Amritsari (23.36%) and lowest pooled value for fruit set found in Kala Amritsari × Flordaguard (17.82%). Mean pooled value for fruit drop % was higher in Sharbati × Kala Amritsari (92.98%) followed by Kala Amritsari × Flordaguard (72.74%). There was nearly same pooled value were recorded in Sharbati × Flordaguard (60.76%) and Flordaguard × Sharbati (60.60%). No significant difference was observed fruit drop % in both years in Sharbati × Flordaguard (60.76%) and Flordaguard × Sharbati. In terms of fruit retention % maximum and similar value was recorded in Flordaguard × Sharbati (39.32%) and Sharbati × Flordaguard (39.23%) followed by in Kala Amritsari × Flordaguard (27.49%) and lowest in Sharbati × Kala Amritsari (7.53%). The days taken from full bloom to maturity showed significant difference, maximum pooled value was recorded in Flordaguard × Sharbati (129.4 Days) followed by Sharbati × Kala Amritsari (120.2 Days), Sharbati × Flordaguard (118.6 Days) and minimum in Kala Amritsari × Flordaguard (111.1 Days). Fruits of Kala Amritsari × Flordaguard were mature earliest (8^{th}-12^{th} May) followed by Sharbati × Kala Amritsari (13^{th}-18^{th} June) and Sharbati × Flordaguard (12^{th}-21^{st} June) and latest in Flordaguard × Sharbati (20^{th}-28^{th} June). Full bloom and fruit maturity dates, the number of days for maturity also varied from season to season and for a given variety variation up to 3-8 days was recorded in different years. The results show that there was high fruit set and retention in crosses involving peach genotypes whereas; wide hybridization involving peach and plum resulted in poor fruit retention, similarly, in Egypt Shaltout et al. [9] also observed that highest (56.67%) fruit set in cross Okinawa × Om El-fahm followed by Okinawa × M. Dalet (31.67%). Neamtu et al. [10] also found 11% to 91% fruit set on different peach under Romania conditions. Kanwar et al. [11] were recorded mean number of days for fruit ripening were varied from 73 (Flordaprince) to 114 days (Flordaguard). Maturity comes earlier in Flordaprince (1^{st} May) and latest in Tropic Snow and Florda Grande on 3^{rd} and 4^{th} June respectively. Likewise, Johnson et al. [12] also found that the average fruit development period of La Sweet peach variety in Clinton, La conditions was 116 ±7 days.

The data on the days taken for stratification showed (Table 3) that 82.78% seeds of Flordaguard got germinated after 32 days' stratification period. After 60 days, 97.78% germination was recorded in Flordaguard. In S, 43.64% seeds have taken germination time of 90 days and after 105 days of stratification, 80% seeds were germinated. In Kala Amritsari, 73.33% seed germination was recorded after 90 days stratification period. The seeds from the cross Sharbati × Flordaguard showed staggered germination from 7.91% at 30 days to 88.38% at 105 days from the initiation of stratification. While, in Flordaguard × Sharbati the seed germination staggered between 30.88% at 60 days to 83.82% at 90 days of stratification. In Kala Amritsari × Flordaguard, 83.78% seed germination was recorded at 60 days of stratification period. Ledia et al. [13] have reported that seed germination in peach seeds after the stratification period was associated with the reduction in abscisic acid (ABA) and most of which is reduced in the very first week of stratification. They further concluded that peach genes ppa005020m, ppa004957m and ppa025943m which codes for an ABA 8′-hydroxylase-like and two ABA glucosyl transferase like genes, respectively were also induced by stratification. Many genes which were down-regulated during the period of breaking of bud dormancy in plants after the accomplishment of the chilling requirement of a variety were also subdued by stratification in embryos. This suggests a common regulatory pathway for the release of dormancy in buds as well as seeds.

Table 1. Phenological characteristic of low chill peach cultivars during 2017 and 2018

Varieties	Date of bud swell		1st opening of flower		Date of full bloom		End date of flowering		Date of fruit harvest	
	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
Sharbati	1st Feb	22nd Jan	6th Feb	1st Feb	14th Feb	9th Feb	24th Feb	20th Feb	12th -21st June	8th – 19th June
Flordaguard	6th Feb	24th Jan	14th Feb	6th Feb	18th Feb	13th Feb	28th Feb	21st Feb	20th -28th June	16th -26th June
Kala Amritsari	9th Feb	30th Jan	14th Feb	4th Feb	22nd Feb	10th Feb	27th Feb	17th Feb	8th -12th May	6th -11th May

Table 2. Fruit set, fruit drop, fruit retention, days from full bloom to maturity and date of harvest during 2017 and 2018

Genotypes	Fruit set %			Fruit Drop %			Fruit retention %			Days from full bloom to maturity		
	2017	2018	Mean	2017	2018	Mean	2017	2018	Mean	2017	2018	Mean
Sharbati × Flordaguard	36.41	37.35	36.88	61.68	59.84	60.76	38.31	40.15	39.23	118.8	118.4	118.6
Sharbati × Kala Amritsari	22.96	23.76	23.36	94.62	91.33	92.98	6.37	8.68	7.53	120.4	120	120.2
Flordaguard × Sharbati	25.67	26.32	26.00	59.45	61.74	60.60	40.38	38.27	39.32	128.4	130.4	129.4
Kala Amritsari × Flordaguard	17.28	18.35	17.82	70.09	75.38	72.74	30.91	24.08	27.49	111.4	110.8	111.1
SE	**1.08**	**0.90**	**0.70**	**1.24**	**1.23**	**0.87**	**0.85**	**1.16**	**0.72**	**2.51**	**1.62**	**1.49**
Mean	**25.58**	**26.45**	**26.01**	**71.46**	**72.07**	**71.77**	**28.99**	**27.79**	**28.39**	**119.75**	**119.9**	**119.83**
CV	**6.71**	**5.36**	**6.05**	**2.75**	**2.70**	**2.72**	**4.65**	**6.58**	**5.66**	**3.31**	**2.13**	**2.78**
CD(P=<0.01)	**2.36**	**1.95**	**1.45**	**2.70**	**2.68**	**1.80**	**1.86**	**2.52**	**1.48**	**5.46**	**3.52**	**3.08**

Table 3. % of seed stratified at different interval in hybrid seeds of different crosses

Variety and Genotypes	30 days	45 days	60 days	75 days	90 days	105 days
Sharbati	-	-	-	-	43.64	80.00
Flordaguard	82.78	-	97.78	-	-	-
Kala Amritsari	-	-	-	-	73.33	-
Sharbati × Flordaguard	7.91	33.67	41.58	52.69	75.93	88.38
Sharbati × Kala Amritsari	-	-	47.83	69.57	-	-
Flordaguard × Sharbati	-	-	30.88	57.35	83.82	-
Kala Amritsari × Flordaguard	-	-	83.78	-	-	-

The variation in germination time may a genotypic effect. Cultivar Halford took longer stratification time to germinate as compare to Nemaguard a low chill cultivar [14]. Malcolm et al. [15] also found that stratification period of seed at 5°C varied from 1344 hour for Flordaguard and Okinawa and up to 2352 hours in Golden Queen. Guerriero and Scalabrelli [16] recorded variation in the seed germination of several peach line rootstocks from 60 to 103 days. At 6±2°C stratification temperature, the seeds of Okinawa, Nemaguard, Elberta and Lovell germinated after completion of 425, 775, 900, and 1,075 hours chilling, respectively.

The highest pooled value for seed germination (Table 4) was recorded in Flordaguard (97.15%) which did not differ significantly with the seed germination in Sharbati × Flordaguard (88.97%). It was followed by seed germination in Flordaguard × Sharbati (86.48%), Kala Amritsari × Flordaguard (82.37%) and Sharbati (80.69%). The minimum pooled seed germination % value was observed in Kala Amritsari (73.07%) and in Sharbati × Kala Amritsari (70.81%). The seeds of early maturing low chill peach and nectarine are physiologically immature at fruit maturity and show very poor seed germination. An efficient protocol for seed germination is needed for peach breeding programme for recovery of new hybrids [17]. Shaltout et al. [9] recorded high seed germination % (68 to 74%) in peach rootstock hybrids from Om El-Fahm × Okinawa and M. Dalet × Okinawa; and also in parents following self-pollination. Similarly, Singh et al. [18] also recorded high germination % in hybrid seeds from Florda Glo × Tropic Sweet (81.5%), Tropic Beauty × Florda Grand (80.3%) and Florda Grand × Tropic Beauty (68.0 %). Minimum in Sun Coast × Punjab Nectarine (37.7%) and Punjab Nectarine × Suncoast (43.1%).

The higher germination %ages in the hybrids and the parents in the present studies might be due to higher fruit development period (>100 days) of the seed parent. Fruit development period is a common index for embryo maturity used by peach breeders. The peach varieties which have a fruit developmental period of <80 days need embryo rescue for successful seed germination while, the varieties having a fruit development period of more than >100 days can be germinated after stratification before the drying of the seeds [19].

The highest pollen viability in case of stored as well as fresh pollen was observed in pollen grains of Flordaguard (96.26 and 97.58%) (Fig. 1) followed by Kala Amritsari (95.14% and

Table 4. Seed germination % and duration of flowering

Variety and Genotype	Seed Germination %			Duration of Flowering		
	2017	2018	Mean	2017	2018	Mean
Sharbati	80.07	81.31	80.69	19.8	19.4	19.60
Flordaguard	97.78	96.52	97.15	14.6	16.2	15.40
Kala Amritsari	73.12	73.03	73.07	13.2	12.8	13.00
Sharbati × Flordaguard	89.69	88.24	88.97	-	-	-
Sharbati × Kala Amritsari	69.37	72.24	70.81	-	-	-
Flordaguard × Sharbati	85.44	87.52	86.48	-	-	-
Kala Amritsari × Flordaguard	83.45	81.28	82.37	-	-	-
SE	**1.79**	**1.58**	**1.19**	**0.67**	**0.81**	**0.53**
Mean	**82.70**	**82.88**	**82.79**	**15.87**	**16.13**	**16.00**
CV	**3.42**	**3.02**	**3.22**	**6.71**	**7.92**	**7.35**
CD (P=<0.01)	**3.69**	**3.27**	**2.40**	**1.55**	**1.86**	**1.12**

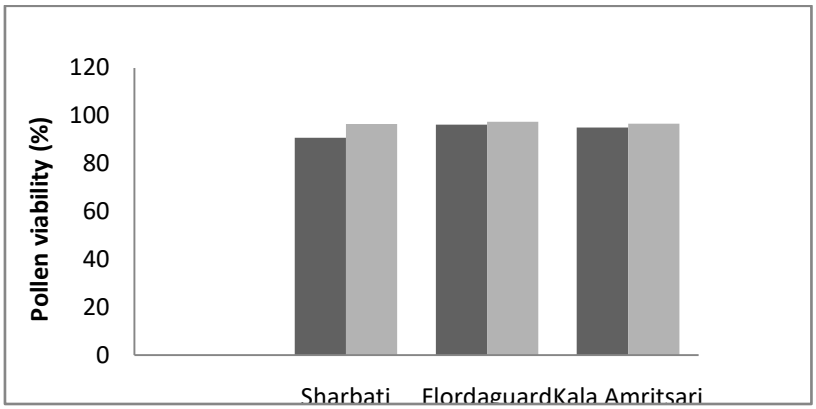

Fig. 1. Pollen Viability % of stored (13month) and fresh pollens of parents

96.73%) and minimum in Sharbati (90.89% and 96.60%). Similarly, Joshi et al. [8] recorded maximum pollen viability in fresh pollen during 2013 and 2014 in Saharanpur Prabhat (97.34% and 94.33%), but minimum in Pratap (93.99% in 2013) and in Tropic Beauty (90.99% in 2014). While, in stored pollen highest in Saharanpur Prabhat and Pratap (93.40% and 92.67%) and minimum in Tropic Beauty (90.93%) respectably during both years. Meena et al. [20] reported highest pollen viability in Shan-i-Punjab (94.28%) followed by Flordasun (92.65%) and Partap (91.44%).

The data pertaining to the plant growth parameters of the hybrids and the parents were presented in Figs. 2 and 3. As discussed earlier, out of the four crosses attempted the crosses Sharbati × Flordaguard and Flordaguard × Sharbati showed high fruit retention and survival of the seedlings. However, the fruit retention was very poor in Sharbati × Kala Amritsari. In Kala Amritsari × Flordaguard also there was poor fruit retention and survival of the hybrid seedlings. Hence, the crosses Sharbati × Kala Amritsari and Kala Amritsari × Flordaguard were not taken for further studies due to availability of very limited number of hybrid seedlings.

All the genotypes under study did not show any significant differences in plant height at 60 and 90 days after germination. However, the highest plant height at 120 days after germination was recorded in hybrid seedlings of Sharbati × Flordaguard (30.48 cm) followed by Flordaguard × Sharbati (29.30 cm), Flordaguard (25.55 cm) and Sharbati (24.51 cm). The leaf numbers also showed no significant difference at 60 days after germination. At 120 days after germination, maximum leaf number was recorded in seedlings in the seedlings of Flordaguard × Sharbati (35.50) which did not differ significantly with the leaf number in seedlings of Sharbati × Flordaguard (32.35). It was closely in Flordaguard (31.13). The minimum leaf number was recorded in the seedlings of Sharbati at all the three stages. The maximum internodal length at 60 days after germination was recorded in Sharbati × Flordaguard (1.14 cm) followed by Flordaguard (1.09 cm) and Flordaguard × Sharbati (0.98 cm). While, at 120 days maximum internodal length was recorded in the seedlings of Flordaguard × Sharbati (1.70 cm) which did not differ significantly from internodal length in Sharbati × Flordaguard. However, minimum internodal length recorded in seedling of Sharbati (0.96, 1.02 and 1.39 cm) respectively at all the three growth stages. The highest petiole length was recorded in Sharbati × Flordaguard (5.44, 5.65 and 6.13mm) followed by Flordaguard (4.64, 4.93 and 5.20 mm), Flordaguard × Sharbati (4.48, 4.80 and 5.20 mm) and minimum in Sharbati (4.18, 4.69, and 5.00 mm) at 60, 90 and 120 days after germination, respectively.

Highest leaf blade length at all three stages were recorded in Sharbati (6.97, 7.35 and 8.57 cm) and minimum in Flordaguard (5.5, 5.07 and 6.03 cm) respectively. In case of hybrids, the seedlings of Sharbati × Flordaguard (5.49, 5.73 and 7.02 cm) shows higher leaf blade length than Flordaguard × Sharbati (5.41, 5.83 and 6.39 cm). Similarly, maximum leaf blade width was recorded in Sharbati (1.56, 1.59 and 1.84 cm) followed by Sharbati × Flordaguard (1.43, 1.38 and 1.69 cm), Flordaguard × Sharbati (1.31, 1.37 and 1.53 cm) and minimum in Flordaguard (1.28, 1.30 and 1.60 cm) respectably at all the three stages. Leaf blade ratio showed significant difference only at 60 days after germination. The maximum leaf size was recorded at all the three

stages in Sharbati (11.12, 11.99, and 16.06 cm^2) followed by seedlings of Sharbati × Flordaguard (8.23, 8.22, and 11.99 cm^2) and Flordaguard × Sharbati (7.23, 8.04, and 10.36 cm^2), while, minimum was recorded in Flordaguard (6.11, 6.73 and 8.40 cm^2) respectively at 60, 90 and 120 days after germination. The differences in growth parameters may be due to the genotypic variations growth habit of parents and their progeny. Similarly, Singh et al. [18] also recorded variation in the plant growth parameters of hybrid seedlings. The seedlings of Florda Glo × Tropic Sweet showed highest plant height (160.0 cm) and number of branches (13) after 11 months of transplanting. Higher seedling growth was recorded in crosses whose seed parent had lower chilling requirement and higher fruit development period. Likewise, in almond and peach hybrid seedlings, Shaltout et al. [9] recorded variation in seedling height; stem girth and number of leaves.

No significant variation was observed in the leaf characteristics of the parents and hybrids (Table 5). The common alternate leaf arrangement and lanceolate shape with acute at base and more acute at apex was observed in all the peach genotypes, while in Kala Amritsari broadly ovate leaf shape observed. Leaves of Flordaguard and both hybrids showed dark reddish green colour on upper side and light reddish green in lower side of leaves.

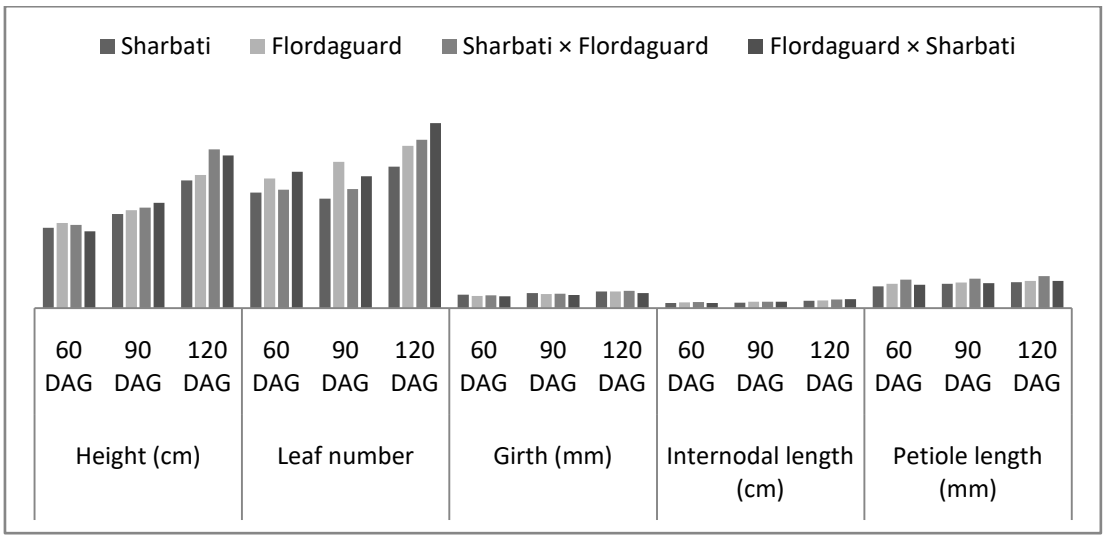

Fig. 2. Seedling height, leaf number, girth, internodal length and petiole length of and hybrid seedlings

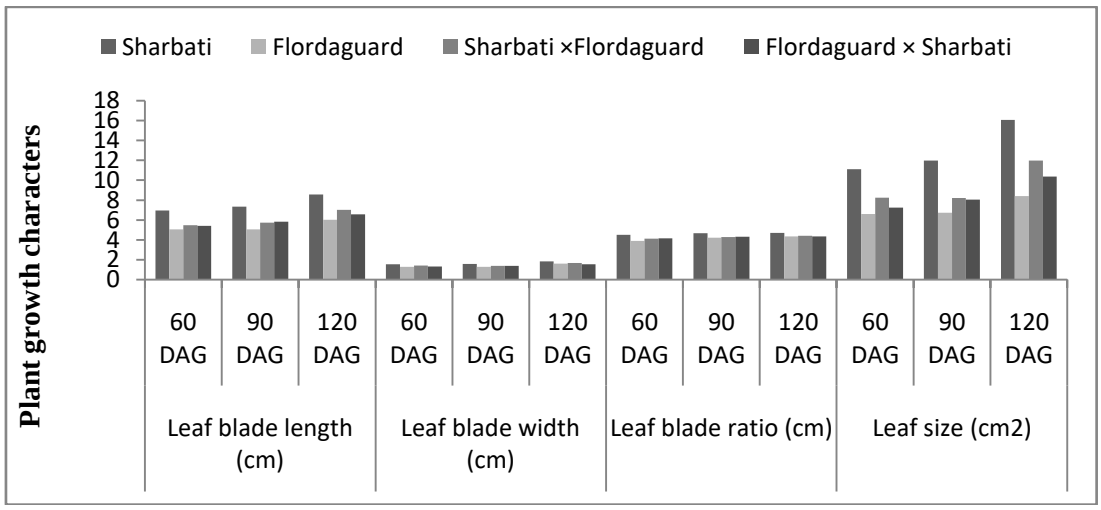

Fig. 3. Leaf blade length, Leaf blade width, Leaf blade ratio and leaf size of parents and hybrid seedlings

Table 5. Leaf characteristics of different genotype of peach

Variety and Genotypes	Leaf shape	Leaf Surface	Leaf bladed margin	Arrangement of leaves on shoot	Petiole gland	Shape of petiole gland	Leaf blade shape in cross section	Leaf blade angle at base	Leaf blade angle at apex	Leaf blade- red mid vine
Sharbati	Lanceolate	Smooth	Crenate	Alternate	Present	Reniform	Flat	Acute	Small	Absent
Flordaguard	Lanceolate	Smooth	Crenate	Alternate	Present	Reniform	Flat	Acute	Small	Present
Kala Amritsari	Broadly ovate	Smooth	Shallow Serrate	Alternate	Absent	NA	Flat	Right	Small	Present
Sharbati × Flordaguard	Lanceolate	Smooth	Crenate	Alternate	Present	Reniform	Flat	Acute	Small	Present
Flordaguard × Sharbati	Lanceolate	Smooth	Crenate	Alternate	Present	Reniform	Flat	Acute	Small	Present

Crenate leaf blade margin with smooth leaf surface was observed in peach genotypes, but shallow serrated in Kala Amritsari with upper side smooth and presence of pubescent in lower surface of leaf. The leaf blade-red mid-vein on the lower surface of newly leaves was present in Flordaguard, Kala Amritsari and in both the hybrids (Sharbati × Flordaguard and Flordaguard × Sharbati), but it was not observed in the leaves of Sharbati. Results of leaf characteristics are in accordance with findings of [21] who observed lanceolate leaf shape with crenate leaf margin and reniform petiole gland shape in 19 out of 27 accessions and circular shape in the rest eight accessions of peach. Similarly, Byrne and Bacon [19] found that the leaves of variety Tex Prince were medium to large, lanceolate with acute base and sharply acute at the apex. Ogasanovic [22] noted that the leaves of cultivar Dora peach were dark green on the upper side and light green on lower side.

A significant variation in leaf colour (L, a, b, chroma and hue) was observed among the different genotypes (Fig. 4). The maximum lightness (L value 37.06), greenness (a value -9.40), yellowness (b value 18.39), chroma (21.23) and hue angle (115.72) was recorded in Sharbati. The minimum lightness (L value 25.31), greenness (a value -0.52), yellowness (b value 10.84), chroma (10.76) and hue angle (92.78) was recorded in Flordaguard. The leaf colour values of both the hybrids, Sharbati × Flordaguard and Flordaguard × Sharbati were similar to Flordaguard. The presence of red leaves in the seedlings from the crosses Sharbati × Flordaguard and Flordaguard × Sharbati may be due to the dominance of red leaf colour over green in Flordaguard [23].

Chlorophyll level (Fig. 4) in terms of SPAD units were highest in seedlings of Flordaguard × Sharbati (42.87) which was at par with the SAPD values recorded in the Sharbati × Flordaguard. The SPAD value in Sharbati × Flordaguard (37.40) did not differ significantly from the SPAD values in Sharbati and Flordaguard seedlings. The higher SPAD units in Flordaguard × Sharbati may be due to the presence of darker green colour leaves. The lower SPAD unit's seedlings of Sharbati may be due to the lighter green colour. Guler and Buyuk [24] found high correlation among leaf chlorophyll (SPAD values), leaf N and yield of cucumber. Shaaban and El-Bendary [25] also found that adequate leaf nitrogen concentration range was proportional to SPAD meter reading in cucumber.

There was significant difference in leaf area in six month old seedlings of peach hybrids (Fig. 4). Maximum leaf area was recorded in Sharbati (14.53 cm²) followed by hybrid seedlings of Sharbati × Flordaguard and Flordaguard × Sharbati (13.59 cm^2 and 12.16 cm^2, respectably). However, minimum leaf area was recorded in Flordaguard (7.40 cm^2).

The higher leaf area value in S and Sharbati × Flordaguard in comparison to Flordaguard might be due to its genotypic behaviour. Sharma et al. [7] found variation among cultivars for leaf area

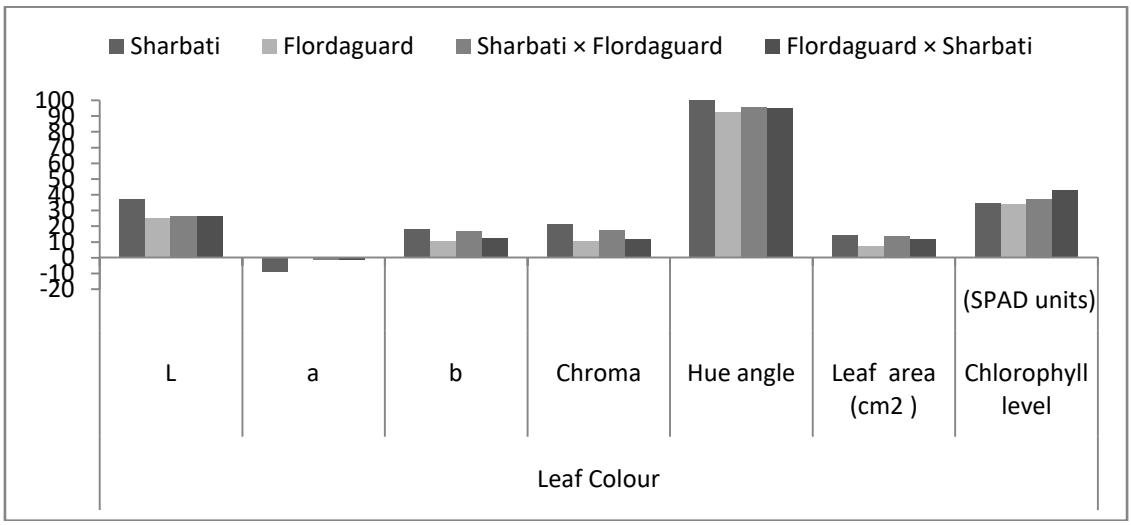

Fig. 4. Leaf colour (L, a, b value), leaf area and Chlorophyll level at 150 days after germination of parents and F1 seedlings of peach

with maximum leaf area in Early Elberta. Singh et al. [26] found variation among peach varieties for leaf area with maximum leaf area in Shan-i-Punjab peach followed by Early Grand, Florda Prince and Sharbati.

4. CONCLUSION

Hybrid seedlings obtained from the crosses Sharbati × Flordaguard and Flordaguard × Sharbati showed good nursery characters than the seedlings of Sharbati and Flordaguard. The leaves of Flordaguard and both the hybrids showed dark red to purplish colour on upper side and light reddish green in lower side of leaves. The hybrid seedlings from both the crosses showed the dominant red leaf colour of Flordaguard. Hence, these seedlings can be put for a long term evaluation to identify some better candidate rootstock(s) for peach.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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