



Scion physiology and root morphology of peach and plum cultivars grafted on local rootstock

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ABSTRACT

Influence of local peach genotype as rootstock were studied on graft success, plant survival, scion physiology and root morphology of plum cultivars viz., Kala Amritsari and Satluj Purple and peach cultivars viz., Partap; Flordaprince and Shan-e-Punjab at Horticultural Experimental Farm, ICAR Research Complex for NEH Region, Umiam, Meghalaya during 2018-19 and 2019-20. Among the varieties grafted on local RC peach-1 rootstock, cv. Kala Amritsari recorded highest graft success and plant survival (90.0 per cent and 83.60 per cent) followed by cv. Flordaprince (88.33 per cent and 83.01 per cent), while lowest graft success was recorded in cv. Shan-e-Punjab (75.00 per cent) and plant survival in cv. Satluj Purple (78.38 per cent). The plant height (1.19 m) was recorded highest in cv. Kala Amritsari, while scion and rootstock diameter were noticed maximum in cv. Flordaprince (8.43 mm and 7.24 mm). In scion physiology, individual leaf fresh weight (0.48g), leaf area (17.73 cm²) and specific leaf weight (9.75 mg/cm²) were recorded highest in cv. Kala Amritsari. Similarly, maximum relative water content was recorded in cv. Kala Amritsari (80.34 per cent) followed by cv. Flordaprince (77.47 per cent). In root morphology, total root length (257.37 cm), root surface area (225.17 cm²); root volume ((16.34 cm³) and average root diameter ((2.55 mm) was recorded maximum in cv. Kala Amritsari followed by cv. Flordaprince (205.97 cm; 160.94 cm²; 6.05cm³ and 2.48 mm), respectively. while, root to shoot ratio was recorded highest in cv. Flordaprince (0.30) followed by cv. Kala Amritsari (0.25). Results suggested the possibility of utilizing local genotype RC Peach-1 as rootstock for multiplication of plum cv. Kala Amritsari and peach cv. Flordaprince.

1. Introduction

Among the stone fruits, peach (*Prunus persica*) and plum (*Prunus salicina*) are adapted well to agro-ecology of north eastern region of India and grown are grown in an area of 2.80 thousand hectare with production of 9.91 thousand tonnes (Anonymous2018). Productivity of these fruit species is quite low (3.54 t/ha) compared with national average (6.42 t/ha) might be due to short productive trees life; absence of suitable rootstock; excessive crop load of undersized fruits (Deshmukh *et al.* 2017) and susceptibility to biotic and abiotic stresses. In India, peach, apricot, behmi and plum seedlings were used as rootstocks (Singh and Gupta 1971) but resultant union vary widely in degree of compatibility (Ahmad *et al.* 2012). Local fruit species as

cultivars or rootstocks have proved to improve the scion characteristics viz., vigour, maturity, quality, chilling requirements, yield and tolerance to different stresses in fruit crops (Milosevic *et al.* 2015 and Reig *et al.* 2016) and thrive well under adverse climatic conditions (Sharma and Rana 2005). Thus, while using local fruit species, compatibility behaviour with scion cultivar needs to be tested (Zarrouk *et al.* 2006) as rooting success was related to endogenous hormone concentrations and type of cultivars.

Graft success and survival is significantly influenced by stock-scion interactions, assimilates partitioning and movement of essential nutrients (Perez-alfonso *et al.* 2010 and Irisarri *et al.* 2021). Understanding of root morphology by using advanced imaging technologies through professional software (Nagel *et al.* 2009) is pertinent for identification of

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suitable rootstock scion combination. But the information on effect of local genotype as rootstock on scion physiology and root morphology of peach and plum varieties is scanty. Therefore, the current experiment attempted to understand the influence of local peach genotype as rootstock on scion physiology and root morphology of promising low chilling peach and plum cultivars to strengthen peach and plum production system in NEH region of India by early orchard establishment and higher economic performance from young trees.

2. Materials and methods

Experiment was conducted at Horticultural Experimental Farm, ICAR Research Complex for NEH Region, Umiam, Meghalaya during 2018-19 and 2019-20. Experimental site is situated at an elevation of 910 meters and lies between 25° 40' to 25° 21' N altitude and 90° 55' 15 to 91° 55' 16 E longitude. The RC Peach-1(IC-0632364) genotype selected as rootstock for the study is heavy bearer (fruit yield: 50-70 kg plant⁻¹); high seed germination (85 per cent); spreading growth habit; early in fruit maturity (i.e. 90-95 days) with better adoptability to agro-ecology of region (Annual Report 2019). Two low chilling plum (*Prunus salicina*) cultivars viz., Kala Amritsari and Satluj Purple and three peach (*Prunus persica*) cultivars viz., Partap; Flordaprince and Shan-e-Punjab were tongue grafted on one-year old seedlings of RC Peach-1 during November and grafts were kept in polybags inside the polyhouse during both the season of experiment following uniform package of practices. Experiment was laid out in randomized block design comprising of five treatments replicated thrice with 20 grafts in each replication. The mean average minimum and maximum temperature inside polyhouse during experimental period were also recorded to be 11.8 °C & 35.2 °C.

The observation on days to sprouting (days), graft success (%) was measured using formula i.e. {(No. of sprouted graft/Total plant grafted) x 100}. The plant survival (%) was measured after 120 days using the formula i.e. {(Survived plant/Graft success plant) x 100}. Morphological traits viz., plant height (m), rootstock diameter (mm), scion diameter (mm) and number of leaves per plant (nos.) were also recorded at 120 days after grafting. Physiological traits viz., leaf fresh weight (g), leaf dry weight (g), leaf area (cm²), specific leaf weight (mg/cm²) were recorded as per standard protocols. The relative water content (RWC) of fresh leaves was measured using the formula: $RWC = \frac{FW - DW}{TW - DW} \times 100$ where FW= Fresh weight which was measured with the help of electronic balance; DW= Dry weight which was measured by drying turgid weighted leaves in oven at 60°C for 24 hr. and TW=Turgid weight of leaves, which was measured with the help of electronic balance by dipping leaves selected for fresh weight in distilled water for 24 hr.

For root morphology, fresh root systems (120 days after grafting) were removed carefully and washed in tap water placed and spread on the Regent's water-proof fabric trays. Image of the root system was acquired using an extra optimized Epson perfection V-700 Photo scanner at 200 dots per inch (dpi) and analysed with the *WinRHIZO* professional software (Regent Instruments Inc., Quebec, QC, Canada). It is an automatic and interactive image analysis system specifically designed for root morphological traits viz., total root length (cm), root surface area (cm²), root volume (cm³) and average root diameter (mm). Roots of six plants were scanned for each treatment and average data was work out. The root to shoot ratio was also computed by using formula (root dry weight/shoot dry weight). The average data of two years were subjected to analysis of variance (ANOVA) using statistical software SPSS version 17.0 and difference were considered statistically significant at $P=0.05$.

3. Results and discussion

Graft success and Plant survival:

All the stone fruit varieties grafted on local RC Peach-1 genotype showed significant ($P=0.05$) variation for days to sprouting; graft success and plant survival (Table 1). Among the varieties plum cv. Kala Amritsaritook minimum days to sprouting (25.67 days) followed by peach cv. Flordaprince (28.67 days) while delayed sprouting was recorded in cv. Partap (32.67 days). Highest graft success was recorded in cv. Kala Amritsari (90.0 per cent) followed by Flordaprince (88.33 per cent), while lowest graft success was recorded in cv. Shan-e-Punjab (75.00 per cent). It may be due to rapid completion of union of xylem and cambium tissue of the scion and rootstock favoured early sprout (Hartmann *et al.* 1997). The significantly ($P=0.05$) higher graft success was recorded in plum cv. Kala Amritsari and peach cv. Flordaprince compared with other varieties on local RC Peach-1 rootstock may be due to better rootstock scion compatibility coupled with higher sugars and moderate C: N ratio may be contributed to the higher percentage of graft success. These results are in line with Ahmad *et al.* (2012) and Zarrouk (2006) who observed graft compatibility/incompatibility due to differential response of cultivars and rootstock in prunus spp.

The plant survival (Table 1) recorded at 120 days after grafting indicated that the cv. Kala Amritsari (83.60 per cent) grafted on local RC Peach-1 genotype recorded highest plant survival followed by cv. Flordaprince (83.01 per cent), while lowest plant survival was recorded in cv. Satluj Purple (78.38 per cent) followed by cv. Partap (81.20 per cent). This may be due to variation in varietal behaviour and stock-scion interactions between source leaves and roots, which are desirable for assimilates partitioning and free movement of water and essential nutrients (Perez-alfocca *et al.* 2010 and Mestre *et al.* 2017).

Morphological traits:

The perusal of data (Table 1) showed significant ($P=0.05$) effect of local peach genotype on morphological traits of plum and peach varieties. Highest plant height was recorded in cv. Kala Amritsari (1.19 m) followed by cv. Satluj Purple (1.13 m) and cv. Flordaprince (1.10 m) while, lowest in cv. Shan-e-Punjab (0.81 m). The rootstock diameter was recorded maximum in cv. Flordaprince (8.43 mm) while, lowest in cv. Shan-e-Punjab (7.90 mm). Further, scion diameter was noticed highest in cv. Flordaprince (7.24 mm) followed by cv. Kala Amritsari (7.17 mm). The number of functional leaves per plant was recorded highest in cv. Kala Amritsari (232.0 nos.) followed by cv. Satluj Purple (215.0 nos.) while lowest in cv. Shan-e-Punjab (170.0 nos.). Our results showed higher value for above traits in peach cv. Flordaprince and plum cv. Kala Amritsari possibly due to rapid and strong formation of union between the rootstock and scion (Skene *et al.* 1983), successively influencing absorption of nutrients by sprouted shoots. These results are in line with Kumar *et al.* (2020) reported that the plant height and trunk girth differ in different prunus cultivars grafted on wild apricot rootstock.

Scion Physiology:

The peach and plum varieties grafted on RC Peach-1 genotype showed significant ($P=0.05$) relationship with observed physiological traits (Table 2). Leaf fresh weight and leaf dry weight was recorded highest cv. Kala Amritsari (0.48 g and 0.17 g) followed by cv. Satluj Purple (0.40 g and 0.13 g) while lowest in cv. Shan-e-Punjab (0.32 g and 0.09 g). Leaf area was recorded highest in cv. Kala Amritsari (17.73 cm²) while lowest in cv. Satluj Purple (15.00 cm²). The specific leaf weight was recorded highest in cv. Kala Amritsari (9.75 mg/cm²) followed by cv. Flordaprince (8.41 mg/cm²). The maximum fresh weight, dry weight and leaf area expansion was recorded in plum cv. Kala Amritsari and peach cv. Flordaprince may be due to higher uptake of water and essential nutrients, favourable stock-scion interaction achieved through better root shoot signalling mechanism and good source (scion) physiology and thereby higher shoot biomass accumulation (Ali *et al.* 1996). While reduced values of leaf growth parameters in other peach and plum cultivars grafted on same rootstock may be due to metabolic inhibition and reduced growth capacity affected by impaired root scion interaction (Irisarri *et al.* 2021).

The relative water content was recorded highest in cv. Kala Amritsari (80.34 per cent) followed by cv. Flordaprince (77.47 per cent), while lowest was recorded in cv. Satluj Purple (72.86 per cent). Higher water retention in the plant may be due to increased water use efficiency which has direct relation with overall health and biomass

accumulation (Passioura 1986). Higher relative water content of the leaves was observed plum cv. Kala Amritsari and peach cv. Flordaprince may be attributed to higher water uptake and retention which is directly related to better root growth and proliferation (Schroeder *et al.* 2001).

Root morphology:

The results showed that the total root length, root surface area, root volume, root diameter and root to shoot ratio were significantly ($P=0.05$) influenced by local peach genotype as rootstock and different stone fruit varieties (Table 3). The total root length was recorded highest in cv. Kala Amritsari (257.37 cm). However lowest root length was recorded in cv. Shan-e-Punjab (121.54 cm). The root surface area was recorded maximum in cv. Kala Amritsari (225.17 cm²) followed by cv. Flordaprince (160.94 cm²) while, lowest root surface area was recorded in cv. Shan-e-Punjab (68.54 cm²). Root volume was also recorded maximum in cv. Kala Amritsari (16.34 cm³) while, lowest root volume was recorded in cv. Partap (4.18 cm³) followed by cv. Shan-e-Punjab (4.20 cm³). The root diameter was recorded highest in cv. Kala Amritsari (2.55 mm) followed by cv. Flordaprince (2.48 mm) while lowest in cv. Shan-e-Punjab (1.71 mm). The root to shoot ratio was recorded highest in cv. Flordaprince (0.30) while lowest was observed in cv. Partap (0.17). The appropriate compatible rootstock greatly influenced the growth of scion and imaging technologies (Nagel *et al.* 2009) helped us to understand the root morphological traits as influenced by established root-scion union after successful grafting. The maximum total root length, root surface area and root to shoot ratio was recorded plum cv. Kala Amritsari and peach cv. Flordaprince might be due to compatible rootstock leads to synthesis of required quantities of secondary metabolites like phenolic and alkaloid compounds required for better root growth (Perez-alfocea *et al.* 2010 and Mestre *et al.* 2017).

4. Conclusion

Considering the graft success, plant survival, scion physiology and root morphology, our results pointed out the possibility of utilizing local RC Peach-1 as rootstock for multiplication of plum cv. Kala Amritsari and peach cv. Flordaprince. This could prove useful in early orchard establishment with higher economic performance of young tree.

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6. References

- Ahmad I, Cheng Z, Liu T, Nan WC, Ejaz M, Khan MA and Wasila H (2012). Effect of different time of budding on the bud take success of peach on peach rootstock. *Advances in Environmental Biology* 6(5): 1848-1852
- Ali IA, Kafkafi U, Yamaguchi I, Sugimoto Y and Inanaga S (1996). Effects of low root temperature on sap flow rate, soluble carbohydrates, nitrate contents and on cytokinin and gibberlin levels in root xylem exudate of sand grown tomato. *Journal of Plant Nutrition* 19:619-634
- Annual Report (2019). ICAR Research Complex for NEH Region, Umiam, Meghalaya-793103 INDIA Pp:28
- Anonymous (2018). *Horticultural Statistics at a Glance*, Ministry of Agriculture, Govt. of India., pp. 458
- Deshmukh NA, Rymbai H, Jha AK, Lyngdoh P and Malhotra SK (2017). Effect of thinning time x fruit spacing on fruit maturity, yield, fruit size, skin colour and quality attributes of Peach cv. Flordasun. *Indian Journal of Horticulture* 74 (1):45-50
- Hartmann HT, Kester DE, Davies FT and Geneve RL (1997). *Plant Propagation: Principal and Practices*, 8th edition, pp 770. Prentice Hall of India Pvt. Ltd, New Delhi, India.
- Irisarri P, Errea P and Pina A (2021). Physiological and molecular characterization of new apricot cultivars grafted on different prunus rootstocks. *Agronomy* 11(8): 1464. <https://doi.org/10.3390/agronomy11081464>
- Kumar A, Shahnaz E, Iqbal U and Mir MM (2020). Effect of wild apricot root stock on graft success, growth and foliage characters of different varieties of prunus spp. *International Journal of Current Microbiology and Applied Sciences* 9(12): 3276-3286
- Mestre L, Reig G, Betrán JA and Moreno MA (2017). Influence of plum rootstocks on agronomic performance, leaf mineral nutrition and fruit quality of 'Catherina' peach cultivar in heavy-calcareous soil conditions. *Spanish Journal of Agricultural Research* 15, (1): e0901
- Milosevic T, Milosevic N and Glisic I (2015). Apricot vegetative growth, tree mortality, productivity, fruit quality and leaf nutrient composition as affected by Myrobalan rootstock and Blackthorn Inter-Stem. *Erwerbs-Obstbau* 57:77-91
- Nagel KA, Kastenholz B, Jahke S, Van-Dusschoten D, Aach T, Muhlich M, Truhn D, Scharr H, Terjung S, Walter A and Schurr U (2009). Temperature responses of roots: impact on growth, root system architecture and implications of phenotyping. *Functional Plant Biology* 36: 947-959
- Passioura I B (1986). Resistance to drought and salinity: Avenues for crop improvement. *Australian Journal of Plant Physiology* 13:191-201
- Perez-alfocea F, Albacete A, Ghanem ME and Dodd IA (2010). Hormonal regulation of source and sink relations to maintain crop productivity under salinity: a case study of root to shoot signaling in tomato. *Functional Plant Biology* 37:592-603
- Reig G, Mestre L, Betran JA, Pinochet J and Moreno MA (2016). Agronomic and physicochemical fruit properties of 'Big Top' nectarine budded on peach and plum based rootstocks in Mediterranean conditions. *Scientia Horticulturae* 210:85-92
- Schroeder JI, Kwak JM, and Allen GJ (2001). Guard cell abscisic acid signalling and engineering drought hardiness in plants. *Nature* 410: 327-330
- Sharma BD and Rana JC (2005). Plant genetic resources of Western Himalaya- status and prospects. Bishen Singh Mahendra Pal Singh, Dehradun, India Pp 457
- Singh RN and Gupta PN (1971). Rootstock problem in stone fruits and potentialities of wild species found in India. *Punjab Horticultural Journal* 11: 157-175
- Skene DS, Shepherd HR and Howard BH (1983). Characteristic anatomy of union formation in budded fruit and ornamental tree. *Journal of Horticultural Sciences* 58:295-99.
- Zarrouk O, Gogorcena Y and Moreno MA (2006). Graft compatibility between peach cultivars and prunus rootstocks. *Hort Science* 41(6):1389-1394

Table 1. Days to sprouting; graft success; plant survival and morphological traits of plum and peach cultivars grafted on local peach genotype

Varieties	Days to sprouting (days)	Graft/bud success (%)	Plant survival (%)	Plant height (m)	Rootstock diameter (mm)	Scion diameter (mm)	Leaves per plant (nos.)
Plum (<i>Prunus salicina</i>)							
Kala Amritsari	25.67	90.00 (71.99)*	83.60 (66.57)*	1.19	8.06	7.17	232.00
Satluj Purple	31.00	85.00 (67.44)*	78.38 (62.38)*	1.13	7.97	7.02	215.00
Peach (<i>Prunus persica</i>)							
Shan-e-Punjab	30.33	75.00 (60.11)*	80.10 (63.71)*	0.81	7.90	6.73	170.00
Flordaprince	28.67	88.33 (70.15)*	83.01 (65.69)*	1.10	8.43	7.24	195.67
Partap	32.67	80.00 (63.58)*	81.20 (64.34)*	0.92	8.09	7.04	208.00
SEM (±)	0.95	1.19	1.48	0.06	0.21	0.19	8.15
CD (<i>P</i> =0.05%)	3.11	3.89	4.81	0.18	0.69	0.62	26.59

*Figure in parentheses indicate Arcsine transform value

Table 2. Scion physiology of plum and peach cultivars grafted on local peach genotype

Varieties	Leaf fresh weight (g)	Leaf dry weight (g)	Leaf area (cm ²)	Specific leaf weight (mg/cm ²)	Relative water content (%)
Plum (<i>Prunus salicina</i>)					
Kala Amritsari	0.48	0.17	17.73	9.75	80.34
Satluj Purple	0.40	0.13	15.00	8.19	72.86
Peach (<i>Prunus persica</i>)					
Shan-e-Punjab	0.32	0.09	15.33	6.01	74.99
Flordaprince	0.39	0.12	15.50	8.41	77.47
Partap	0.36	0.11	14.83	7.06	75.53
SEM (±)	0.02	0.01	0.74	0.45	1.43
CD (<i>P</i> =0.05%)	0.05	0.04	2.41	1.46	4.66

Table 3. Root morphology of plum and peach cultivars grafted on local peach genotype

Varieties	Total root length (cm)	Root SA (cm ²)	Root Vol. (cm ³)	Avg. root diameter (mm)	Root: Shoot ratio
Plum (<i>Prunus salicina</i>)					
Kala Amritsari	257.37	225.17	16.34	2.55	0.25
Satluj Purple	185.53	118.60	6.05	2.02	0.19
Peach (<i>Prunus persica</i>)					
Shan-e-Punjab	121.54	68.54	4.20	1.71	0.22
Flordaprince	205.97	160.94	10.04	2.48	0.30
Partap	129.33	77.37	4.18	1.89	0.17
SEM (±)	3.87	3.33	0.41	0.09	0.03
CD (<i>P</i> =0.05%)	12.63	10.87	1.33	0.28	0.10