Research Article

Impact of Different Scion-Rootstock Combinations on Vegetative growth of Peach Cultivars under Pothohar Conditions

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Abstract | The recent approaches in peach orchard management are focused towards climate resilient varieties having high yield and growth attributes. This scenario demands the evaluation of different scion cultivars for their compatibility and growth behavior. The current research trial was conducted to evaluate ten promising scion cultivars of peach on local root-stock for their growth and development. The experiment was laid out in randomized complete block design (RCBD) with three replication and 10 plants per replication. Data were recorded on plant survival rate (PSR %), bud sprouting rate (BSR %), shoot length (SL cm), shoot diameter (SD cm) and number of leaves per plant (NLP). The outcomes exhibited that peach scion cvs., "*Coronet*" and *Early Maria Delizia* exhibited the maximum plant survival rate (97.67 and 97.33%) and maximum bud sprouting rate (96.0 and 97.0), respectively. On the contrary, the highest shoot length (23.33 and 20.55 cm), shoot diameter (4.11 and 3.64 cm) and number of leaves per plants (19.77 and 23.22) were recorded in cultivars *Early grand* and *Spring Belle* respectively. It is concluded from the current experimental results that the local root-stock is an appropriate stock and could be used as a promising root-stock for peach cultivation in Pakistan.

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Introduction

Peach (*Prunus persica* L.) is among one the most liked stone fruit species around the globe (Seker et al., 2017; Santana et al., 2020). They are esteemed for their exceptional nutritional and medicinal attributes, owing to their abundant content of vitamin A, potassium, carbohydrates, organic acids, minerals, and dietary fiber. Consequently, peaches are of substantial economic and nutritional importance (Singh *et al.*, 2018). The presence of these valuable nutrients in peaches contributes significantly to their potential health benefits. Consumption of peaches can effectively reduce the presence of reactive oxygen

species (ROS) in human blood plasma, offering protection against various chronic diseases (Bento *et al.*, 2022). Additionally, peaches are recognized for their natural laxative properties, making them a suitable choice for preventing constipation and managing duodenal ulcers. Notably, the phenolic acids, flavonoids, and anthocyanin compounds found in peaches are considered primary sources of potential antioxidants, which may play a role in their medicinal applications (Zhong *et al.*, 2021).

It is one of majorly grown temperate fruits in Pakistan and covers an area of 15,424 ha with an annual production of 1,33,915 tonnes. Among provinces, KPK shares about 55% of total production followed by Baluchistan contributing 43% of total production (MNFSR, 2022). As comparable to world production, Pakistan is far below from average yield and currently ranks at 25th position with respect to peaches and nectarine production, thereby contributing only about 0.3% share in the world production (FAO, 2022). In Pakistan, various peach cultivars thrive across the diverse growing regions of Khyber Pakhtunkhwa (KPK) and Baluchistan. Growers in KPK predominantly favor early grand, Florida king 6-A, and numbers 7, 8, 9 for cultivation. Conversely, in Baluchistan, the preferred cultivars include Golden Early, Shah Pasand, and Shireen (Zeb and Khan, 2008).

Certain factors, i.e., genotype, rootstock, cultural practices and prevailing climatic conditions are of extreme importance for growth, development and ultimate yield of peaches. Among these factors, root-scion combination is the crucial one as peaches are mostly asexually propagated and modifies training systems, yield and fruit quality (Shivran *et al.*, 2022). It has been also documented that rootstock species affect the vitality and viability of the grafted scion cultivar (Font-i-Forcada, 2020). The rootstock alters stomatal opening, transpiration capability and water use efficiency thus controls plant growth and fruit quality (Edwards *et al.*, 2022) sugar profile (Yahmed *et al.*, 2016), yield, vigor and plant blooming (Shahkoomahally *et al.*, 2021). On the contrary, rootstocks also provides a firm anchorage, provision of nutrients through soil and confer tolerance to different biotic and abiotic stresses in the soil (Santhi *et al.*, 2020).

Although rootstock significance cannot be neglected in the scion-stock combination but the consumers demand for diverse taste, texture and fruit quality primarily relies on introducing cultivars having desired characteristics (Jimenez *et al.*, 2011). This study was planned to evaluate growth performance and success ratio of scion-stock combination of different peach cultivars on local rootstock.

Materials and Methods

Experimental trial

The experiment was carried out at Fruit Program Nursery, Horticultural Research Institute (HRI), NARC, Islamabad (33.6701° N, 73.1261° E). The area designated for experimental trial was flat having 01% slope (to allow excess water drainage) while the sandy loam, weakly acidic soil was used as growing medium. All the recommended cultural practices were followed i.e., mulching was done to suppress weeds germination and irrigation at regular intervals. The physico-chemical characters of soil and water from the experimental area is presented in Table 1.

Table 1: *Pre-experiment soil and water characteristics.*

Soil	Units	Value	Water	Units	Value
Texture		Loam	pH		7.18
pH		7.5	Conductivity	µS cm^{-1}	902
EC		2.05	Carbonates	meq·L^{-1}	0.0
Organic matter	%	0.70	Bicarbonates	meq·L^{-1}	0.81
Organic N	%	0.045	Chlorides	meq·L^{-1}	1.48
Available P	mg Kg^{-1}	6.33	Ca + Mg	meq·L^{-1}	8.74
Available K	mg Kg^{-1}	142	SAR		1.27

Plant materials

In the study, 01-year-old clonal rootstocks of peach (Swat local) having 2.5 feet height and 10 mm stem thickness was used. The P × P and R × R distance was kept at 01 foot and 04 feet in nursery respectively. Ten promising peach genotypes i.e., Early grand, Spring Crest, Spring Belle, Coronet, Early Maria Delicia, NJC-84, Maria Bianca, Golden, Late Maria Bianca and Indian Blood were used as scion-stock. The bud-wood of these cultivars were taken from five year old stock.

Grafting process

The experiment followed a similar sized scions and rootstocks combination for grafting via T-budding method (Hartmann *et al.*, 2011; Lewis and Alexander, 2008). The inter-stock (graft union) was established

at a height of 20 cm above the ground following the protocol of Hartmann *et al.* (2011) and subsequently covered with the silicone grafting tape.

Data collection

Bud sprouting rate (BSR %): The BSR % was recorded 20 days after budding and was measured using the following formula.

$$\text{BSR (\%)} = \frac{\text{Number of buds sprouted}}{\text{Total buds inserted}} \times 100$$

Plant survival rate (PSR %): The plant survival rate (PSR%) in grafted peach plants was recorded 50 days after budding according to the procedure of Ozturk *et al.* (2011).

$$\text{PSR (\%)} = \frac{\text{Total buds surived}}{\text{Total buds inserted}} \times 100$$

Shoot length (cm): The shoot length above inter-stock was recorded 50 days after budding and expressed in cm (Rahman *et al.*, 2017).

Shoot diameter (SD mm): Similar to shoot length, diameter of shoot was also recorded 50 days after budding with a digital vernier caliper and expressed in mm (Zenginbal *et al.*, 2017).

Number of leaves plant^{-1} (NLP): The NLP of newly inducted fresh leaves above inter-stock in grafted peach plants was also recorded 50 days after budding.

Experimental layout and statistical analysis

The experiment was laid out following Randomized Complete Block Design (RCBD), having ten treatments with three replications and 10 plants per replication. The Statistix 8.1 software was used to evaluate ANOVA and LSD test with 5% probability (Steel *et al.*, 1997).

Results and Discussion

Bud sprouting rate (BSR %)

The means of the data regarding BSR% have been presented in Figure 1. Analysis of the data revealed statistically significant differences for BSR % among different peach cultivars (Table 2). The data exhibited that the maximum BSR of 97 and 96 % was recorded in Early Maria Delizia Coronet, respectively as against the minimum BSR of 42.27 % recorded Late Maria Delizia (Figure 2).

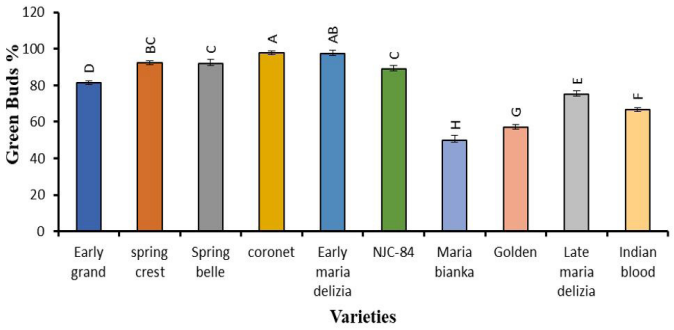

Figure 1: *The effect of "Peach Local" root-stock on Green Buds % of different scion cultivars.*

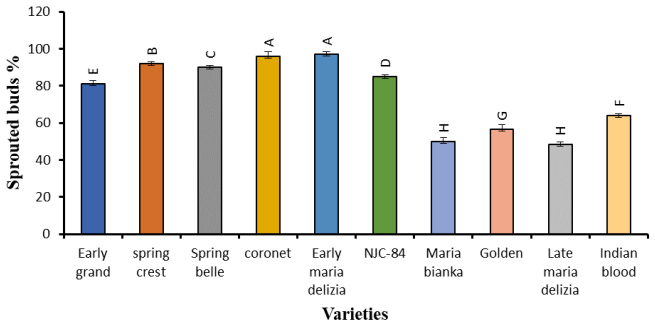

Figure 2: *The effect of "Peach Local" root-stock on Sprouted Buds % of different scion cultivars.*

Table 2: *Analysis of variance for different growth parameters.*

	DF	SS	MS	F	P	Remarks
Green buds %						
Replication	2	64.08	32.038			
Treatment	9	7840.21	871.134	132.22	0	***
Error	18	118.6	6.589			
Total	29	8022.88				
Sprouting buds %						
Replication	2	4.7	2.36			
Treatment	9	10288.3	1143.15	492.01	0	***
Error	18	41.8	2.32			
Total	29	10334.9				
Shoot length						
Replication	2	0.626	0.3129			
Treatment	9	882.509	98.0566	84.87	0	***
Error	18	20.796	1.1553			
Total	29	903.931				
Shoot diameter						
Replication	2	1.832	0.916			
Treatment	9	329.269	36.5855	27.46	0	***
Error	18	23.981	1.3323			
Total	29	355.082				
Number of leaves						
Replication	2	1.832	0.916			
Treatment	9	329.269	36.5855	27.46	0	***
Error	18	23.981	1.3323			
Total	29	355.082				

Plant survival rate (PSR %)

The means of the data recording PSR % have been presented in Figure 2. Analysis of variance revealed statistically significant differences in PSR% among different peach cultivars (Table 2) different peach varieties (Table 2). The maximum PSR (97.67 and 97.33%) was observed in Coronet and Early Maria Delizia followed by Spring crest peach cultivar (92.3%), Spring Belle (92%) and the minimum PSR of 50% was observed on *Maria bianca* (Figure 2). The outcomes exhibited that different cultivars had significant impact on survival rate capability (%).

Shoot length (SL cm)

The data pertaining to the means of shoot length (SL cm) have been given in Figure 3. Analysis of variance (Table 2) indicated statistically significant differences in SL among different peach cultivars. The average shoot length varied among 10-15 cm. While the maximum shoot length (23.33 cm) was recorded in Early Grand followed by Spring Belle (20.55cm), Spring Crest (18.67 cm). On the contrary, the minimum shoot length (7.22 cm) was observed on NJC-84.

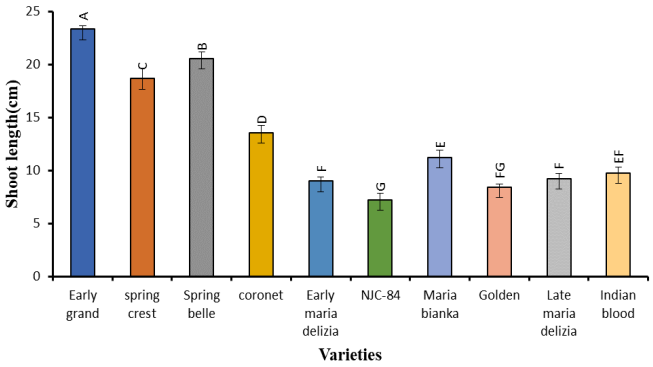

Figure 3: *The effect of "Peach Local" root-stock on Shoot Length (cm) % of different scion cultivars.*

Shoot diameter (SD mm)

The means of the data for SD have been presented in Figure 4. Analysis of variance (Table 2) showed statistically significant differences in SD among different peach cultivars. The data revealed that the highest shoot diameter (4.11 mm) was recorded in *Early Grand* followed by Spring Belle (3.64mm), Spring Crest (3.03mm) and the lowest diameter (2.03 mm) was observed in *Golden* peach cultivar.

Number of leaves per plant (NLP)

The means of the data concerning to NLP have been presented in Figure 5. Analysis of variance expressed statistically significant variation in NLP among different peach cultivars grafted on a similar root-stock (Table 2). The average leaves number varied among 15-20 with the highest (23.22) observed in Spring Belle followed by Early Grand (19.78), Spring Crest (18.34), Coronet (18.11) and lowest 11.78 leaves recorded in NJC-84 (Figure 5).

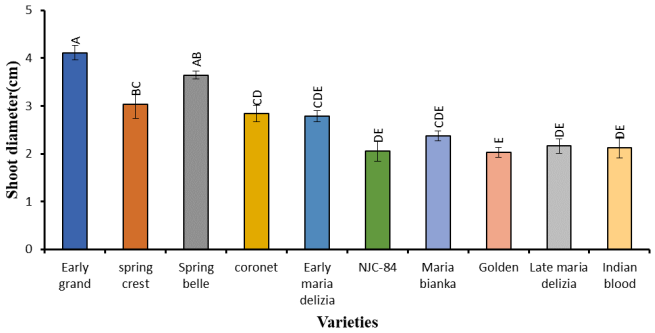

Figure 4: *The effect of "Peach Local" root-stock on Shoot Diameter (mm) % of different scion cultivars.*

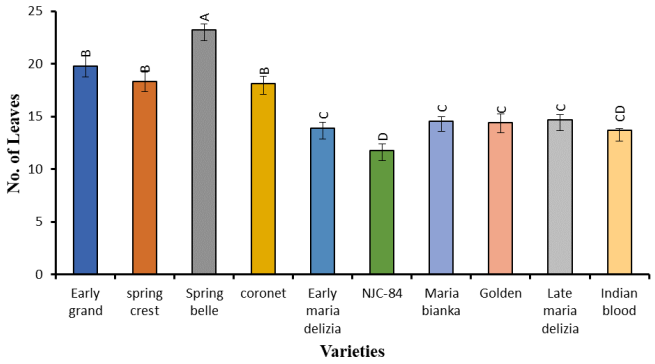

Figure 5: *The effect of "Peach Local" root-stock on Number of leaves of different scion cultivars.*

Grafting serves as a pivotal technique in modern fruit cultivation to propagate various fruit species and their diverse varieties. The method of grafting is applicable not only within the same variety, cultivar, species, or genus but also across different cultivars, species, or genera (Darikova et al., 2011; Dogra and Kumar, 2018). For instance, peaches can be grafted onto their own seedlings or cloned rootstocks. However, it's important to note that the success of grafting can significantly differ when attempting grafts across genera (Pio et al., 2018). This variation in graft success across different genera may be attributed to underlying genetic distinctions, as suggested (Francescatto et al., 2010; Hartmann *et al.*, 2011).

Our findings align with the observations made by Rahman *et al.* (2017) and Zenginbal and Bostan (2019), highlighting the profound impact of rootstocks and varieties on parameters such as the percentage of green buds or survival rate. The study also demonstrated

the significant influence of rootstocks and cultivars/genotypes on the graft sprout percentage (Figure 2). Rahman *et al.* (2017) emphasized the pivotal role of varieties and rootstocks in affecting bud sprouting percentages. Furthermore, immediate post-grafting temperatures play a crucial role in determining the success of grafting. To promote the formation of callus tissue and successful graft fusion, it is essential to provide suitable environmental conditions, particularly with regard to temperature and humidity (Baron *et al.*, 2019). Maintaining temperatures within the range of 12.8˚C to 32˚C during and after grafting expedites callus formation and supports the continued success of the graft. Typically, the formation of callus and the union of cambium between the rootstock and scion occur within 07 to 14 days following by grafting (Hartmann *et al.*, 2011; Lewis and Alexander, 2008). Hence, the air temperature during the initial 15 days post-grafting significantly influences the graft's overall success. While certain cultivar/rootstock combinations yielded satisfactory sprout ratios, it's worth noting that some genotypes exhibited high sprouting percentages, while others experienced low sprout percentages, often associated with graft incompatibility. In fact, grafting closely related plants tends to enhance sprouting capabilities (Hartmann *et al.*, 2011). The variations observed in the graft sprout ratios between rootstocks and varieties can be attributed to underlying genetic differences between these components.

Graft success is influenced by a multitude of factors, encompassing ecological, physiological, morphological, and genetic elements. Additionally, variables like temperature, humidity, the growth stage of the rootstock, the timing of scion collection, grafting techniques, the expertise of the grafter, and the botanical relatedness between scion and stock play a crucial role in determining the success of grafting. It's important to emphasize that graft incompatibility can lead to unsuccessful grafting attempts or low graft take rates, as mentioned by Hartmann *et al.* (2011) and Lewis and Alexander (2008). In case of graft incompatibility, even when all other factors are favorable, a complete union of tissues cannot form between the grafted plant parts, leading to their limited long-term survival (Ermel *et al.*, 1999). Hudina *et al.* (2014) observed a survival percentage of 25% to 100% in pear grafted on various rootstocks. Graft incompatibility is a complex phenomenon influenced by physiological, anatomical, and biochemical factors, often resulting in lower survival rates (Pina and Errea, 2005).

Furthermore, the research determined that both rootstocks and cultivars significantly impact the diameter of the shoots in peach (Table 2). Zenginbal and Bostan (2019) noted that the diameter of graft shoots varies depending upon the rootstock and the specific varieties of pear used for grafting on stock seedlings and hybrid rootstocks. Variations in shoot diameter are influenced by genetic distinctions between cultivars and rootstocks, and factors such as growing potential, cultural practices and prevailing climatic conditions, as suggested by Cetinbas *et al.* (2018) and Zenginbal and Bostan (2019). Statistical analysis also revealed significant differences in graft shoot length between rootstocks and cultivars, with cultivars grafted onto robust rootstocks typically displaying vigorous shoot growth, in accordance with Rahman *et al.* (2017). The variation in graft shoot length may be attributed to ecological conditions, cultivation practices, and genetic distinctions between the cultivar and rootstock, and factors related to ecology and growing conditions (Pektas *et al.*, 2009).

Novelty Statement

This is the first time to carryout budding experiment on low chilling peach varieties under Pothar agro climatic condition and the finding will benefit local nursery growers.

Author's Contribution

Noorullah Khan, Shahid Ali, Azher Zeb, M. Noman, M Imran and Rashid Iqbal Khan: Conceived and designed the experiment.
Noorullah Khan, Shahid Ali, Azher Zeb: Collected and analyzed the data and wrote the paper.
M Muneer: Carried out soil analysis.
Saima Mumtaz, Shamaila Rasheed and M. Qamar-Uz-Zaman: Provided technical assistance at every stage of the experiment.
Noorullah Khan, Shahid Ali, Azher Zeb, M. Noman, M Imran, Rashid Iqbal Khan, Saima Mumtaz, Shamaila Rasheed, M. Muneer and M. Qamar-Uz-Zaman: Critically reviewed and revised the article.

Conflict of interest
The authors have declared no conflict of interest.

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