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Stionic interaction on leaf parameters and survival of grafted pear saplings

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ABSTRACT

The present study was conducted to find the effect of different rootstock-scion combinations on multiplication of Pear *(Pyrus communis)* saplings. There were four scion cultivars and five rootstocks, constituting twenty treatment combinations. Data revealed that maximum leaf length and width were recorded in cv. Chinese Sandy Pear grafted on BA-29 and Pear sucker rootstocks. However, the minimum leaf length and width were recorded in cv. Carmen grafted on Quince and cv. Abate Fetel on BA-29 rootstocks. The highest leaf area (23.46 cm^2) was recorded in cv. Chinese Sandy Pear on BA-29, while it was minimum (14.19 cm^2) in cv. Abate Fetel on BA-29. Leaf chlorophyll content was highest (3.71 mg/g) in Chinese Sandy Pear grafted on Quince. Length (27.11 µm) and width (9.96 µm) of stomata were recorded maximum in cv. Abate Fetel grafted on Kainth and cv. William Bartlett grafted on Quince, respectively. In contrast, the stomatal density was maximum (20.63/$µm^2$) in cv. Carmen grafted on Quince. Grafted saplings of cv. Abate Fetel on Quince , cv. Chinese Sandy Pear on BA 29 and cv. William Bartlett on Quince C rootstocks recorded 86.67 per cent survival compared to other grafts. More number of saleable plants was recorded when cv. William Bartlett was grafted on Quince (86.33%). The investigations concluded that pear varieties raised on Quince rootstock had higher values for all studied parameters, followed by Quince C rootstock.

Keywords: *Pyrus communis*, Scion, Rootstocks, Chlorophyll, Stomata, Survival.

INTRODUCTION

Pear is mainly grown in hills of North and North-Eastern states of India at elevations ranging from 1500 to 2500 meters which belongs to the genus *Pyrus* and family Rosaceae (Silva *et al.,*13). It is widely grown worldwide, with China, Italy, USA, USSR, Japan, Turkey, Germany and France as major producing countries. Scion cultivars of Pear are also propagated either by grafting or budding on clonal rootstocks. The rootstock is a critical component of grafted plants that governs the victory and defeat of orchards and directly affects growth, life cycle, earliness, nutrient uptake, productivity and quality of fruits of scion cultivars grafted on them. Rootstock performance is affected by many factors, viz., scion variety, rootstock material quality, management practices and the environment of that area. The choice of rootstock is of utmost importance for planning an intensive production system in Pear. Generally, pears are grafted on the seedlings of *Pyrus* and *Cydonia* species. Due to more diverse genetic characteristics within pear rootstocks, problems of graft incompatibility persist, and disparities with respect to growth, productivity and fruit quality exist. Therefore, it is essential to determine how a specific scion cultivar will perform after grafting on different rootstocks under particular conditions. Rootstocks influence the scion leaf chlorophyll content, a better indicator of photosynthesis activity (Naumann *et al.,*10). Stomata number per unit leaf area of rootstock was directly correlated with the scion varieties vigour grafted on those rootstocks, and the stomata size and stomatal density are influenced by rootstock (16). More stomatal density results in higher initial stomatal conductance, leading to more rapid photosynthetic induction with lower stomatal limitation in fluctuating light (Tanaka *et al.,* 15). As leaf is an important organ for photosynthesis, its size and stomatal density affect photosynthetic efficiency and influence overall plant growth potential, nutrient supply, resistance, and carbon partitioning to different plant organs. However, the effects of pear rootstocks on scion cultivars' performance have not been studied under Kashmir conditions. Hence the study was conducted to find a suitable rootstock-scion combination of pears under nursery conditions.

MATERIALS AND METHODS

The experiment was laid out in the Experimental field of the Division of Fruit Science of SKUAST-

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Kashmir, Shalimar Srinagar (Jammu and Kashmir) in 2020. The highest and lowest temperature during the experimental period varied from 18.1-32.0°C and 4.42-17.7°C with a mean relative humidity of 43.90 per cent. The experiment was laid out with four pear cultivars viz. two introduced (Carmen, Abate Fetel) and two commercial (William Bartlett and Chinese Sandy Pear) grafted on five rootstocks *viz.* two clonal (Quince C and BA-29) and three seedlings (Quince seedlings, Kainth seedlings and Pear suckers rootstocks) forming twenty combinations with three replications. Bench grafting (cleft grafting) was performed in the second week of March, and grafted material was transplanted in nursery beds at 30 cm × 30 cm spacing. All the cultural practices, *viz*. irrigation, weeding, hoeing and fertilization were performed uniformly.

Five plants were randomly selected for recording observations. Five fully matured leaves were taken from marked plants in August; leaf length and width were measured using Vernier Caliper and expressed in cm. Leaf area was measured with Licor 3100 leaf area meter and expressed in cm^2. Specific leaf area was calculated by dividing the leaf area by its dry mass and expressed in cm^2/g. Chlorophyll content was measured with the procedure given by Halfacre *et al.* (Halfacre *et al.,* 8). Stomatal density was measured as per the method described by Beakbane and Majumdar (2) and expressed in numbers per μm^2. Stomata size (length and width) was measured using stage and ocular micrometres. The survival of plants was recorded after the cessation of the growth of plants. Time of leaf fall was recorded when more than 75 per cent of the leaf fall was completed. Data recorded in the present study were statistically analyzed (Snedecor and Cochran,14) with a two-way analysis of variance (ANOVA) using SPSS software (SPSS PSW 18.0).

RESULTS AND DISCUSSION

Data in Table 1 reveal that scion cultivars had significantly influenced the leaf length and width. Chinese Sandy Pear had significantly higher leaf length (6.26 cm) and leaf width (4.41 cm) than other scion cultivars studied. In contrast, the lowest leaf length and width were measured in William Bartlett (5.48 cm) and Abate Fetel (3.41 cm). Concerning rootstocks, maximum and minimum leaf length and width were registered by pear suckers (6.07 cm) and Quince C (3.80 cm). Scion cultivars had a significant influence on leaf area and maximum leaf area was observed in Chinese Sandy Pear (21.69 cm^2), which was statistically higher than other studied cultivars, followed by William Bartlett (17.01 cm^2). Among rootstocks, Pear suckers (18.78 cm^2)

Table 1. Rootstock-scion influence on foliage parameters.

Scion \ Rootstock	Leaf length (cm)						Leaf width (cm)						Leaf area (cm^2)					
	Quince C	BA-29	Quince	Kainth	Pear suckers	Scion mean	Quince C	BA-29	Quince	Kainth	Pear suckers	Scion mean	Quince C	BA-29	Quince	Kainth	Pear suckers	Scion mean
Chinese Sandy Pear	5.65	5.96	6.10	6.77	6.81	6.26	4.32	4.34	4.51	4.19	4.67	4.41	19.28	21.98	21.24	22.48	23.46	21.69
William Bartlett	5.59	5.41	5.40	5.28	5.74	5.48	3.81	3.92	3.99	4.11	3.82	3.93	16.82	16.32	17.01	17.14	17.77	17.01
Abate Fetel	5.64	5.71	5.99	5.63	5.83	5.76	3.36	3.15	3.42	3.62	3.50	3.41	14.99	14.19	16.47	16.13	16.13	15.58
Carmen	5.42	5.19	5.08	5.97	5.91	5.51	3.69	3.82	3.49	3.75	3.90	3.73	15.81	16.07	14.01	17.79	17.79	16.30
Rootstock mean	5.58	5.57	5.64	5.91	6.07		3.80	3.81	3.85	3.92	3.97		16.73	17.14	17.18	18.38	18.78	
$CD_{0.05}$																		
Scion			0.36						0.07						1.24			
Rootstock			NS						NS						NS			
S × R			NS						NS						NS			

and Quince C (16.73 cm^2) registered maximum and minimum leaf area, respectively. However, the differences were non-significant. The interaction effect of rootstock-scion combinations showed non-significant differences. Leaves are the most important organ for transpiration and photosynthesis in plants, and their arrangement, size and anatomy differ in different environments (Serdar and Kurt, 11). As per Warrington *et al.* (16) leaf area of the Starkspur Supreme Delicious apple decreased linearly with the plant densities and reported that vigorous rootstocks (M7 and MAC24) had more leaf area than dwarf rootstocks (M9 and M27).

Significant differences in chlorophyll content were observed for scion, rootstock and rootstock-scion interaction (Table 2). Among scions, Chinese Sandy Pear (3.71 mg/g) registered the highest chlorophyll content in leaves. It was statistically higher among all scion cultivars, whereas minimum chlorophyll content was observed in cv.Carmen (3.21 mg/g). Among the rootstocks, Quince (3.81 mg/g) had the highest chlorophyll content in leaves, and it was statistically at par with Quince C (3.49 mg/g) and BA-29 (3.47 mg/g), whereas minimum chlorophyll content was observed in Pear suckers rootstock (2.91 mg/g). Interaction studies of scion-rootstock combination reveal that maximum chlorophyll content was recorded in the combination of Chinese Sandy Pear with Quince (3.97 mg/g) and was statistically at par with combinations of William Bartlett on Quince (3.93 mg/g), Abate Fetel on BA 29 (3.91 mg/g), Chinese Sandy Pear on Quince (3.83 mg/g), Abate Fetel on Quince (3.79 mg/g), Chinese Sandy Pear on Pear sucker (3.78 mg/g), Carmen on Quince (3.72 mg/g), William Bartlett on Quince C (3.63 mg/g) and Chinese Sandy Pear on Kainth (3.54 mg/g) whereas minimum chlorophyll content recorded in combination of Abate Fetel/Pear sucker (2.43 mg/g). The higher chlorophyll content is beneficial and preferred for better plant growth and development. This increase in leaf chlorophyll content may be due to the compact behaviour of scion/rootstock. Present results comply with Akbari et al. (1), who also observed that leaf chlorophyll content was directly correlated with the compactness of the scion compared to non-compact plants. Data in Table 2 also revealed that scion, rootstock and rootstock-scion interaction significantly influenced specific leaf areas. Chinese Sandy Pear (37.99 cm^2/g) recorded a maximum specific leaf area that was statistically at par with William Bartlett (35.28 cm^2/g), followed by Carmen (33.18 cm^2/g) whereas minimum specific leaf area was observed in Abate Fetel (30.99 cm^2/g). Among rootstocks, Kainth (37.89 cm^2/g) scored maximum value for specific leaf area, which was statistically

Table 2. Rootstock-scion influence on chlorophyll content, leaf shape and specific leaf area parameters.

Scion \ Rootstock	Chlorophyll content (mg/g)					Leaf shape					Specific leaf area (cm^2/g)				
	Quince C	BA-29	Quince	Kainth	Pear suckers	Scion mean	Quince C	BA-29	Quince	Kainth	Pear suckers	Quince C	BA-29	Quince	Kainth	Pear suckers	Scion mean
Chinese Sandy Pear	3.97	3.46	3.83	3.54	3.78	3.71	Elliptical	Elliptical	Elliptical	Elliptical	Elliptical	44.80	28.21	40.51	32.49	43.99	37.99
William Bartlett	3.63	3.22	3.93	3.45	2.67	3.38	Ovate	Ovate	Ovate	Ovate	Ovate	35.02	27.83	34.67	44.93	31.34	30.99
Abate Fetel	3.16	3.91	3.79	3.21	2.43	3.31	Lanceolate	Lanceolate	Lanceolate	Lanceolate	Lanceolate	30.12	21.02	27.70	44.81	31.34	30.99
Carmen	3.20	3.32	3.72	3.02	2.78	3.21	Lanceolate	Lanceolate	Lanceolate	Lanceolate	Lanceolate	40.70	24.69	29.25	29.34	41.90	33.18
Rootstock mean	3.49	3.47	3.81	3.30	2.91							37.66	25.44	33.03	37.89	37.80	
$CD_{0.05}$																	
Scion			0.22											3.29			
Rootstock			0.34											5.72			
S × R			0.36											8.79			

at par with Pear sucker (37.80 cm^2/g), Quince C (37.66 cm^2/g) and Quince (33.03cm^2/g). However, the minimum specific leaf area was recorded in BA-29 (25.44 cm^2/g). Rootstock-scion combinations of William Bartlett/Kainth (44.93 cm^2/g) registered with maximum specific leaf area, which was statistically at par with combinations viz. Abate Fetel on Kainth (48.81 cm^2/g), Chinese Sandy Pear on Quince C (44.80 cm^2/g), Chinese Sandy Pear on Pear sucker (43.99 cm^2/g), Carmen on Pear sucker (41.90 cm^2/g), Carmen on Quince C (40.70 cm^2/g) and Chinese Sandy Pear on Quince (40.51 cm^2/g). In comparison, the minimum specific leaf area was recorded with Abate Fetel on BA-29 (21.02 cm^2/g). Specific leaf area indicates the thickness of the leaf and is defined as the leaf area over one gram of dry matter of the leaf. Specific leaf area also increases as leaf thickness decreases. In the present study, specific leaf area was significantly and statistically influenced by both scion, rootstock and interaction. Minimum values of specific leaf areas predict the thickness of leaves, which is important in leaf and plant functioning. Thick leaves may have greater photosynthetic pigments per unit of their area, resulting in higher photosynthetic rates and dry matter production. However, it has been reported that thick leaves with low specific leaf area had a lower rate of photosynthesis (Gulias *et al*.,7), probably with limited diffusion and CO_2 at the site of carboxylation.

Non-significant results were observed for stomatal length (Fig. 1) and stomatal width (Fig 2). Scion-rootstock interaction of Abate Fetel/Kainth (27.11 µm) recorded higher stomatal length followed by William Bartlett/Quince C (26.84 µm), William Bartlett/BA-29 (26.62 µm) and William Bartlett/Quince (26.56 µm). However, minimum stomatal length was obtained in the combination of Carmen on Pear sucker (24.90 µm). Rootstock-scion combination of William Bartlett on Quince (9.96 µm) recorded maximum stomatal width followed by Abate Fetel on Kainth (9.67 µm), Chinese Sandy Pear on Quince (9.68 µm) and William Bartlett/BA-29 (9.62 µm), however, minimum stomatal width was registered in the rootstock-scion combination of Abate Fetel on Quince (8.30

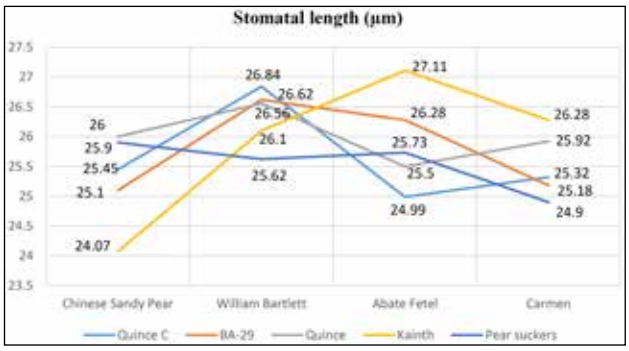

Fig. 1. Rootstock-scion influence on stomatal length.

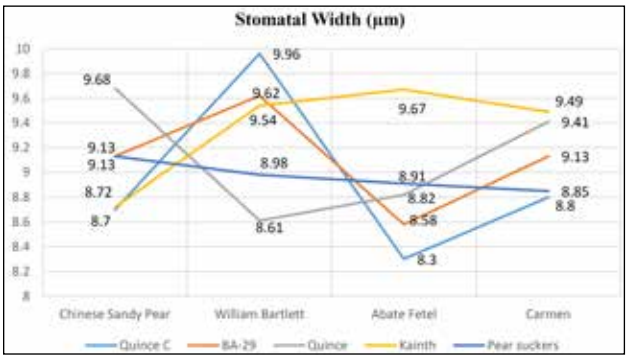

Fig. 2. Rootstock-scion influence on stomatal width.

Table 3. Rootstock-scion influence on survival plant and stomatal density parameters.

Scion \ Rootstock	Survival plant (%)						Stomatal density (no/µm²)					
	Quince C	BA-29	Quince	Kainth	Pear suckers	Scion mean	Quince C	BA-29	Quince	Kainth	Pear suckers	Scion mean
Chinese Sandy Pear	83.33	86.67	83.33	73.33	70.00	79.33	15.58	17.27	13.70	12.40	9.30	13.65
William Bartlett	83.33	83.33	86.67	76.67	70.00	80.00	14.18	15.37	15.48	14.42	15.08	14.91
Abate Fetel	86.67	80.00	83.33	70.00	60.00	76.00	15.47	17.48	18.05	10.62	15.02	15.33
Carmen	83.33	83.33	80.00	76.67	70.67	78.80	15.05	15.35	20.63	11.45	14.40	15.38
Rootstock mean	84.17	83.33	83.33	74.17	67.67		15.07	16.37	16.97	12.22	13.45	
$CD_{0.05}$												
Scion			0.89						0.89			
Rootstock			0.99						1.59			
S × R			1.98						3.19			

µm). Similar stomatal length and width results were also reported earlier in Pear (Chen and Poland, 4). Significant results were observed for stomatal density for scion, rootstocks and interaction rootstock-scion and are presented in Table 3. Maximum stomatal density was counted in Carmen (15.38/µm^2), which was statistically at par with Abate Fetel (15.33/ µm^2) and William Bartlett (14.91/µm^2), whereas the minimum was recorded in Chinese Sandy Pear (13.65 /µm^2). Among rootstock, Quince (16.97/µm^2) registered maximum values for stomatal density, which was statistically at par with BA-29 (16.37/ µm^2), whereas minimum stomatal density was observed in Kainth (12.22 /µm^2). Interaction of the scion-rootstock combination showed that maximum stomatal density in Carmen on Quince (20.63/µm^2), which was statistically at par with scion-rootstock interaction of Abate Fetel/Quince (18.05/µm^2) and Abate Fetel/BA-29 (17.48/µm^2) however, minimum stomatal density was recorded in the scion-rootstock interaction of Chinese Sandy Pear/Pear sucker (9.30/ µm^2). Stomata play a significant role in regulating plant water relations, and almost 85-90 per cent of water loss occurs through stomata. The present study obtained maximum stomatal size with dwarfing rootstock (Chauhan, 3). The increase in the number and size of stomata may be an expression of scion or rootstock more clearly rootstock effect in the present investigation as the dwarfing rootstocks reflected it more clearly than vigorous rootstock accordance in Pear (Dhillon *et al.*, 5).

Significant results were obtained for survival percentage for scion, rootstock and scion-rootstock interaction (Table 3). The maximum survival percentage among scion cultivars was recorded in William Bartlett (80.00%), which was statistically at par with Chinese Sandy Pear (79.33%). In contrast, the minimum survival percentage was registered in Abate Fetel (76.00%). Concerning rootstock, the maximum survival percentage was observed in Quince C (84.17%), which was statistically at par with BA-29 (83.33%) and Quince (83.33%), whereas the minimum survival percentage was registered in Pear suckers (67.67%). The interaction of the scion-rootstock combination showed that maximum plant survival was observed in cv. Abate Fetel grafted on Quince C (86.67%), Chinese Sandy Pear grafted on BA-29 (86.67%), and William Bartlett grafted on Quince (86.67%), which was statistically more among all the other scion-rootstock combinations. The minimum survival percentage was recorded in the combination of Abate Fetel on Pear sucker (60.00%). The survival per cent indicates the sustained vigour of the graft due to good growth. It is an important

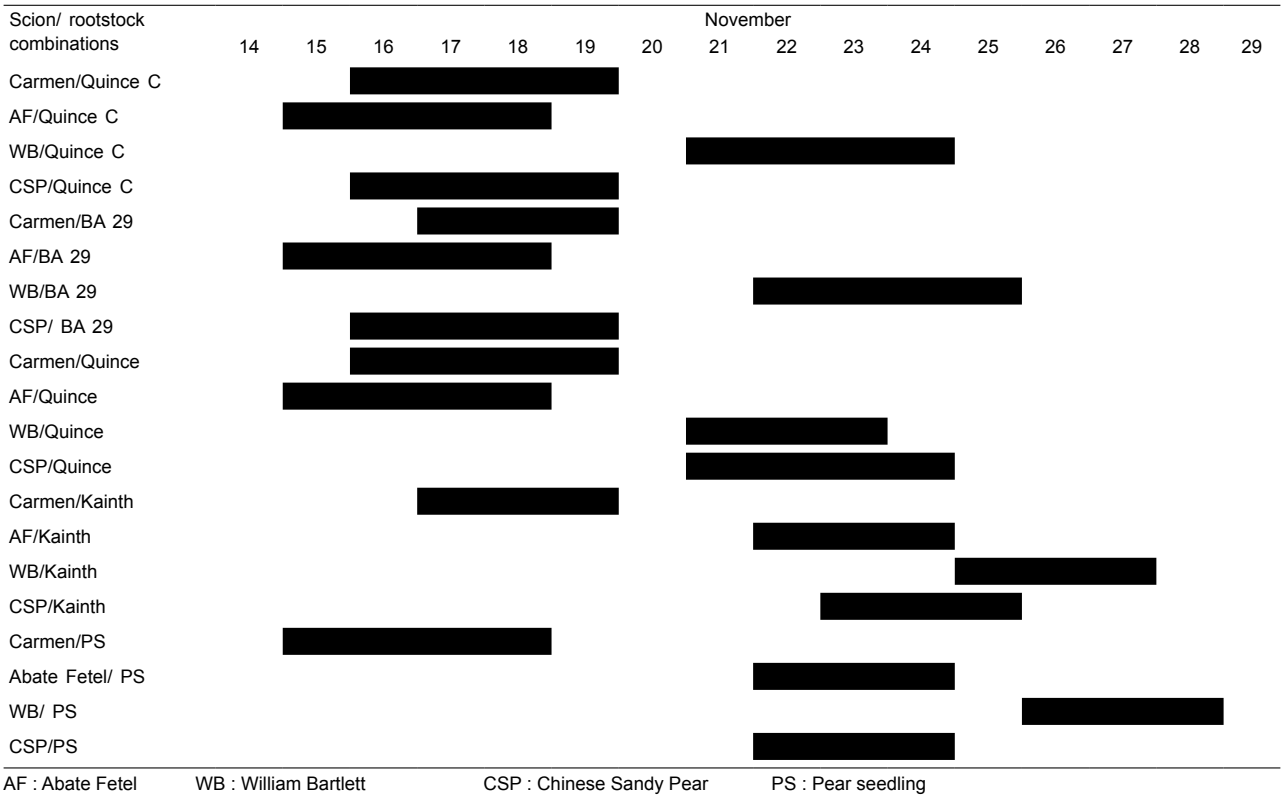

Fig. 3. Rootstock-scion influence on time of leaf fall

parameter through which we can evaluate the best combination. Similar results for survival percentage in different fruit crops revealed influence of rootstocks on graft survival rate was statistically significant (Chen, and Poland, 4 and Malasi, 9).

Leaf fall started from the third week (15th-18th) of November in the scion-rootstock combination of Abate Fetel on Quince C, Abate Fetel on BA-29 and Abate Fetel on Quince followed by Carmen on Quince C, Chinese Sandy Pear on Quince C, Chinese Sandy Pear on BA-29, Carmen on Quince and Carmen on Quince (from 16th-19th November) (Fig 3). Delayed leaf fall was observed in the scion/rootstock combination of William Bartlett on Pear seedlings (26th-28th November). All the graft combinations of William Bartlett with different rootstocks had leaf fall in the fourth week of November. Leaf fall of all the graft combinations in Kainth and Pear suckers rootstocks was in the fourth week of November except Carmen. Late leaf fall is beneficial as plant dormancy is delayed, and the green pigment (chlorophyll) allows the plant to absorb more sunlight, which turns it into more food stored as reserves before winter dormancy for better growth and survival in the subsequent seasons. Sharma and Kumar (12) in *Prunus* spp. also reported leaf fall in the third and fourth week of November after the cessation of the plant growth.

The present study infers that the foliage, stomatal density and chlorophyll parameters were positively influenced by Quince seedlings rootstock followed by Quince C however, among scion cultivars, Chinese Sandy Pear followed by William Bartlett performed better for the studied parameters.

AUTHORS' CONTRIBUTIONS

Conceptualization of research (JPP, AK); Designing of experiment (AK, MKS and AA); Contribution of experimental materials (AK, AS and ASS); Field/lab experiments and data collection (JPP and AS); data interpretation (AK and MKS); Preparation of the manuscript (AK, MKS and AA).

DECLARATION

The authors declare that they do not have any conflict of interest.

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