

Studies on leaf traits of different stionic combinations in pear (*Pyrus communis*)

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ABSTRACT

The biochemical and physiological evaluation of pear (*Pyrus communis*) cultivars, Carmen, Concorde, Red Bartlett and Packham's Triumph was done on Quince A, BA 29, Quince C and Kainth rootstocks at Dr Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh, India during 2018-19. The highest leaf carbohydrate and starch content were reported in plants grafted on Quince C rootstock, whereas lowest on Quince A rootstock. Maximum total sugars and phenols were found in plants of Red Bartlett grafted on Quince C rootstock and minimum on Carmen grafted on Quince A. However, Carmen grafted on Quince A rootstock had highest total leaf chlorophyll content and uptake of nitrogen, phosphorus and potassium, whereas minimum on Red Bartlett grafted on Quince C rootstock. The correlation studies revealed a negative correlation among plant height, total sugars and phenols.

Key words: Stionic combinations, Traits plant height, leaf starch

Traditionally pear (*Pyrus* spp.) is grafted on *Pyrus pashia* (Kainth) rootstock that produces vigorous trees with long juvenile phase and problem of alternate bearing (Francescatto *et al.*, 2010). Presently, Quince (*Cydonia* spp.) is being adopted as a size-controlling rootstock for pear; however, it shows graft incompatibility with various pear cultivars and the mechanism by which it regulates scion vigor is not clear. The growth regulating effect might be attributed to anatomical feature like presence of small vessels which affects the hydraulic conductivity, decreased sap solute content and production of growth hormones (Dubey *et al.*, 2021). These factors result in series of physiochemical changes in carbohydrate metabolism and nutrient uptake, thereby affecting growth of stionic combinations. Auxin (IAA) plays a crucial role growth of the plants and naturally occurring substances like phenols alter the activity of IAA oxidase and transportation of IAA (Francescatto *et al.*, 2010). Therefore, evaluation of pear cultivars on *Cydonia* spp (Quince A, BA 29, Quince C) and Kainth rootstocks was done.

MATERIALS AND METHODS

The experiment was conducted at the Experimental Nursery Block at Dr Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh, India (30°51'N; 77°88'E; 1300 mamsl) during 2018-19. The region has sub-temperate climate with moderate summers and distinct winters. Raised nursery beds (3 m × 1 m) were prepared after leveling the surface and one-year-

old Quince A, BA 29, Quince C and Kainth rootstocks were planted in three individual rows per bed during the last week of December 2018. Each row contained ten plants spaced at 25 cm × 20 cm. During first week of February 2019, these rootstocks were grafted with one-year-old scions of Carmen, Concorde, Packham's Triumph and Red Bartlett pears, at a height of approximately 15 cm above the ground using tongue grafting method. The plants were subjected to standardized cultural practices. The experiment was done in a completely randomized block design. Estimation of leaf carbohydrates, sugars, starch and nutrient content were done on dry leaf samples, while chlorophyll and phenolic contents were measured from fresh leaves plucked during last week of June as per the procedure described by Sharma *et al.*, (2020). The data were analyzed using OPSTAT software.

RESULTS AND DISCUSSION

Quince C exerted the most pronounced dwarfing effect, resulting in a 22.19 and 14.94% reduction in plant height compared to Quince A and Kainth rootstocks, respectively (Table 1). Among cultivars, Carmen registered maximum plant height, followed by Packham's Triumph, while Red Bartlett attained minimum height with a reduction of 24.56% compared to Carmen. Regarding different stionic combinations, Carmen grafted on Quince A rootstock obtained maximum plant height (95.15 ± 0.87 cm), followed by Packham's Triumph on Quince A rootstock. However, lowest plant height (49.34 cm) was observed in plants of Red Bartlett on Quince C rootstock. Comparisons within stionic combinations revealed that plant height of Red Bartlett on Quince C was statistically similar to Red Bartlett on Quince A. The variations in plant

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Table 1: Effect of stionic combinations on plant height, total carbohydrates and total sugars in the leaves of pear nursery plant

| Rootstock/ scion | Plant height (cm) | | | | Total carbohydrate content (%) | | | | Total sugar content (%) | | | |
|-------------------------|-------------------|----------|-----------------|----------------------|--------------------------------|----------|-----------------|----------------------|-------------------------|----------|-----------------|----------------------|
| | Carmen | Concorde | Red Bartlett | Packham's Triumph | Carmen | Concorde | Red Bartlett | Packham's Triumph | Carmen | Concorde | Red Bartlett | Packham's Triumph |
| Quince A | 95.15 | 69.51 | 52.81 | 89.53 | 12.43 | 12.23 | 11.70 | 11.80 | 1.18 | 2.30 | 2.51 | 1.18 |
| BA 29 | 75.52 | 65.03 | 69.15 | 77.58 | 12.87 | 13.17 | 13.03 | 12.57 | 2.44 | 1.65 | 2.57 | 1.60 |
| Quince C | 68.41 | 56.03 | 49.34 | 65.10 | 13.95 | 14.54 | 14.46 | 13.43 | 2.22 | 2.95 | 2.85 | 2.76 |
| Kainth | 76.82 | 65.93 | 67.02 | 71.05 | 13.08 | 13.45 | 13.99 | 12.13 | 1.54 | 1.75 | 2.14 | 1.62 |
| CD _(0.05) | | | | | CD _(0.05) | | | | CD _(0.05) | | | |
| Rootstock: 1.77 | | | | | Rootstock: 0.73 | | | | Rootstock: 0.09 | | | |
| Scion: 1.77 | | | | | Scion: NS | | | | Scion: 0.09 | | | |
| Rootstock × Scion: 3.54 | | | | | Rootstock × Scion: NS | | | | Rootstock × Scion: 0.17 | | | |

height could be attributed to vigor potential of different rootstocks, scions and varying levels and proportions of auxin and cytokinin in apical meristem of pear varieties (Rahman *et al.*, 2017).

Rootstocks exhibited a significant effect on total carbohydrate content in leaves. Maximum leaf carbohydrate content (14.10%) was recorded in plants grafted on Quince C rootstock, followed by Kainth (13.16%), which was statistically lower than plants on Quince A rootstock but at par with plants on BA 29. While, minimum carbohydrates were found in plants grafted on Quince A (12.04%). Individually, the scion cultivar and interaction between rootstock and scion did not have significant effect on total leaf carbohydrate content (Table 1). Correlation estimation revealed a positive correlation between plant height and carbohydrate content (Table 4). Leaf carbohydrate status is significantly affected by grafting due to modifications in sugar transport. The results are in conformity with the those of Li *et al.* (2015). However, contradictory to those of Whiting and Lang (2004) who observed negative effect of smaller canopies on storage carbohydrates.

The sugar levels in leaf tissue of grafted nursery plants were significantly influenced by different rootstocks, scions and interaction between them (Table 1). Mean effect of rootstocks revealed the presence of high sugars in leaves of plants grafted on dwarf rootstock Quince C (2.70%) and minimum on Kainth (1.76%), followed by Quince A (1.79%). Among cultivars, Red Bartlett accumulated maximum sugars (2.52%), while Packham's Triumph (1.79%) had minimum value for total sugars. Rootstock/scion combinations significantly affected leaf sugar contents, Concorde grafted on Quince C had 58.60% higher leaf sugar content in comparison to Carmen and Packham's Triumph grafted on Quince A. Plant height was negatively correlated with total leaf sugar content (Table 4). Gonclaves *et al.* (2006) also reported that total soluble sugars were highest in cherry plants grafted on dwarfing rootstocks.

Maximum starch content was reported on Quince C rootstock to the tune of 52.11 mg/100g DW which was

statistically at par with BA 29 and Kainth while, Quince C had the minimum starch content (Table 2). The results are in accordance with the findings of Foster *et al.* (2017). However, Gonclaves *et al.* (2006) observed highest starch content in plants grafted on invigorating rootstocks. Leaf phenolic content was significantly affected rootstock, scion and their interactions (Table 2). Considering rootstocks, Quince C had highest leaf phenolic content (25.82 mg/g FW), while among scion cultivars Red Bartlett obtained maximum value (24.79 mg/g FW). Interaction among various stionic combinations revealed that most dwarf combination (Red Bartlett grafted on Quince C) had 29.80% higher accumulation of phenolics in leaves in comparison to the most vigorous combination (Carmen grafted on Quince A) that had lowest values for leaf phenolic content.

Phenols regulates plant growth and its content which may vary depending upon rootstock, cultivar, organ, developmental stage and cultural practices (Garcia *et al.* 2004). In present study higher content of phenolics have been reported in dwarf combinations (Table 4) as previously reported by Andreotti *et al.* (2006). Polyphenols determine the function of IAA oxidase, affects the IAA synthesis and thereby plays important role in growth reduction (Yildirim *et al.*, 2016). In contrast, Gonclaves *et al.* (2006) observed higher phenolic concentrations in plants grafted on vigorous rootstocks.

Individually, Quince A rootstock and Carmen cultivar and interaction between this stionic combination registered maximum value for total chlorophyll content (2.58 mg/g FW, 2.51 mg/g FW, 3.072.51 mg/g FW, respectively) (Table 2). Fallah *et al.*, (2019) reported higher chlorophyll content was on invigorating rootstocks due to higher nitrogen. All the factors *i.e.*, rootstock, scion and their interaction influenced the leaf nitrogen, phosphorus and potassium levels (Table 3). These nutrients were found highest in Quince A rootstock (2.04% N, 0.225% P, 1.20% K), while lowest value was recorded in plants grafted on Quince C (1.79% N, 0.132% P, 1.08% K). In scion cultivars, Carmen accumulated maximum (2.09% N, 0.188% P and

Table 2: Effect of stionic combinations on leaf starch, phenolic and total chlorophyll in pear nursery plants

| Rootstock/ scion | Leaf starch content (mg/g DW) | | | | Total phenolic content (mg/g DW) | | | | Total chlorophyll (mg/g FW) | | | |
|-----------------------|-------------------------------|----------|-----------------|----------------------|----------------------------------|----------|-----------------|----------------------|-----------------------------|----------|-----------------|----------------------|
| | Carmen | Concorde | Red Bartlett | Packham's Triumph | Carmen | Concorde | Red Bartlett | Packham's Triumph | Carmen | Concorde | Red Bartlett | Packham's Triumph |
| Quince A | 45.91 | 47.75 | 46.47 | 50.32 | 19.52 | 23.92 | 21.97 | 20.71 | 3.07 | 1.84 | 2.51 | 2.88 |
| BA 29 | 50.58 | 49.35 | 50.76 | 50.86 | 22.66 | 20.96 | 26.81 | 22.82 | 2.58 | 2.28 | 1.97 | 2.58 |
| Quince C | 51.66 | 52.36 | 51.10 | 53.33 | 26.20 | 24.17 | 27.81 | 25.10 | 2.36 | 1.89 | 1.69 | 2.23 |
| Kainth | 51.34 | 49.75 | 50.34 | 49.85 | 21.89 | 23.07 | 22.56 | 22.39 | 2.58 | 2.48 | 2.00 | 2.99 |
| CD _(0.05) | | | | | CD _(0.05) | | | | CD _(0.05) | | | |
| Rootstock: 1.48 | | | | | Rootstock: 1.6 | | | | Rootstock: 0.19 | | | |
| Scion: NS | | | | | Scion: 1.6 | | | | Scion: 0.19 | | | |
| Rootstock × Scion: NS | | | | | Rootstock × Scion: 3.2 | | | | Rootstock × Scion: 0.37 | | | |

Table 3: Effect of stionic combinations on leaf nitrogen, phosphorus and leaf potassium content in pear nursery plants

| Rootstock/ scion | Nitrogen content (%) | | | | Phosphorus content (%) | | | | Potassium content (%) | | | |
|-------------------------|----------------------|----------|-----------------|----------------------|--------------------------|----------|-----------------|----------------------|-------------------------|----------|-----------------|----------------------|
| | Carmen | Concorde | Red Bartlett | Packham's Triumph | Carmen | Concorde | Red Bartlett | Packham's Triumph | Carmen | Concorde | Red Bartlett | Packham's Triumph |
| Quince A | 2.25 | 1.98 | 1.73 | 2.18 | 0.253 | 0.209 | 0.199 | 0.236 | 1.25 | 1.20 | 1.10 | 1.24 |
| BA 29 | 2.05 | 1.68 | 1.67 | 2.09 | 0.160 | 0.160 | 0.119 | 0.169 | 1.22 | 1.12 | 0.98 | 1.24 |
| Quince C | 1.96 | 1.70 | 1.62 | 1.87 | 0.150 | 0.130 | 0.120 | 0.129 | 1.17 | 1.10 | 0.92 | 1.14 |
| Kainth | 2.09 | 1.88 | 1.93 | 2.02 | 0.189 | 0.180 | 0.160 | 0.189 | 1.23 | 1.15 | 1.17 | 1.21 |
| CD _(0.05) | | | | | CD _(0.05) | | | | CD _(0.05) | | | |
| Rootstock: 0.05 | | | | | Rootstock: 0.004 | | | | Rootstock: 0.02 | | | |
| Scion: 0.05 | | | | | Scion: 0.004 | | | | Scion: 0.02 | | | |
| Rootstock × Scion: 0.09 | | | | | Rootstock × Scion: 0.009 | | | | Rootstock × Scion: 0.04 | | | |

Table 4: Correlation analysis of different leaf physiological and biochemical parameters

| Parameter | Plant height | Total CHO | Starch | Total Sugars | Total Phenols | Total Chl content | N | P | K |
|---------------|-----------------|--------------|---------|-----------------|---------------|----------------------|--------|--------|---|
| Plant height | 1 | | | | | | | | |
| Total CHO | .202 | 1 | | | | | | | |
| Starch | -.177 | -.323* | 1 | | | | | | |
| Total Sugars | -.775** | -.232 | .299* | 1 | | | | | |
| Total Phenols | -.492** | -.450** | .338* | .597** | 1 | | | | |
| Total Chl | .630** | .043 | -.299* | -.708** | -.479** | 1 | | | |
| N | .855** | .138 | -.162 | -.709** | -.462** | .634** | 1 | | |
| P | .674** | .499** | -.568** | -.749** | -.654** | .631** | .713** | 1 | |
| K | .722** | .237 | -.155 | -.676** | -.592** | .647** | .833** | .676** | 1 |

*Correlation is significant at the 0.05 level (2-tailed), **Correlation is significant at the 0.01 level (2-tailed)

1.22% K) and minimum in Red Bartlett (1.74% N, 0.150% P and 1.04% K). Carmen grafted on Quince A had highest levels of these leaf nutrients. North and Cook (2008) found that leaf mineral status is influenced by rootstock/scion interaction rather than the rootstock or scion alone.

The genetic constitution of rootstock and variety affects the nutrient uptake and accumulation (Kucukyumuk and Erdal, 2011). Each rootstock exhibits a range of size-controlling potential and may have a different potential of transport rate of raw sap (amount of minerals) from root to leaf (Tombesi *et al.*, 2011; Tworkoski and Fazio, 2016). Correlation studies reveal a positive correlation between

plant height, leaf chlorophyll content and N, P, K (Table 4). Higher nutrient contents in plants grafted on vigorous rootstocks (Quince A and Kainth) might be due to well developed and efficient root system.

CONCLUSION

The Quince C rootstock and Red Bartlett pear cultivar exhibited significant dwarfing effects, indicating their suitability for high-density plantation. Observed biochemical and mineral variations shows interactions among different rootstocks and scions.

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