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Influence of Clonal Rootstocks on Major Morphological Characteristics of Some Exotic Apple Cultivars in Northern Himalayas of Kashmir Valley

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ABSTRACT: The present research was conducted at Regional Research Station faculty of agriculture Sher-e- Kashmir University of Agriculture Sciences and Technology of Kashmir, Shalimar, Srinagar, Jammu & Kashmir. The present investigation was carried out with the objective of evaluation of different rootstocks of apple for graft-take success and other vegetative characteristics of exotic cultivars of apple in Kashmir conditions. The study consisted of three scion cultivars (Red Chief, Red Velox, Gala Mast) cleft grafted on six different rootstocks (M-9, MM-106, MM-111, M-27, P-22 and seedling). The experiment was laid in Randomized Complete Block Design (RCBD) with three replications. Rootstocks play a vital role in providing better adaptation of scion varieties to various soil and growing conditions, and also improve their growth, precocity, productivity and quality. Most of the existing apple orchards in the union territory of Jammu and Kashmir are on seedling rootstocks and have long juvenile period taking years to come into bearing. In Kashmir valley, Delicious group of apple cultivars are predominant and covers almost entire apple plantation. They are characterized by excessive vigour, susceptible to insect pests and diseases and acute biennial bearing tendency. Further, most of Delicious cultivars have similar maturity duration causing glut in market. To get rid of such emblematic situation clonal rootstocks complimented with new exotic cultivars offer a viable solution to this problem. Clonal rootstocks are uniform in growth characteristics and impart desirable characters (dwarfing and precocity) Therefore, this study was initiated to assess the effect of selected rootstocks on graft success, vegetative growth and other characteristics of selected apple cultivars. Data on graft success and other parameters were collected and analyzed using software OP stat. Results revealed that scion rootstock combination significantly (P<0.05) influenced graft success and other vegetative parameters of exotic cultivars of apple. The maximum graft-take success (95. 30%) was recorded in Gala Mast grafted on MM-106 and minimum (84.53%) in Red Chief on seedling. Gala Mast grafted on seedling rootstock registered maximum plant height (110.18cm) and maximum number of leaves/plant (38.97). Least plant height and number of leaves/plant was recorded in Red Chief grafted on M-27 (73.46cm) and (20.77) respectively. The results of this study demonstrated that scion-stock combination had a considerable effect on graft success and other vegetative characteristics of exotic cultivars of apple.

Keywords: Apple, Rootstock, Cleft Grafting, Vegetative growth, Cultivar.

INTRODUCTION

The apple, king of temperate fruits is undoubtedly the most ubiquitous of all fruits. The primary center of origin of apple is thought to be the region which includes Asia Minor, the Caucasus, Soviet central Asia and Himalayan India and Pakistan (Wilcox, 1962). It existed in Europe, both in wild and cultivated forms since prehistoric times and has been well developed there at the beginning of Christian era (Shoemaker and Teskey, 1959). It has been cultivated in Europe and Asia from the earliest times, being known to the Greeks and Romans and mentioned by Theophrastus in the third century B.C. Since then it has been spread by man into almost all parts of the world because of the great amount of genetic variability found in the apple which has allowed adapted types to be selected for different environments.

The apple (*Malus* × *domestica* Borkh) belongs to the family Rosaceae with basic chromosome No. 17. The apples, pears, quinces, medlars and some less well known genera have been classified into the sub-family *Pomoideae* or the pome fruits. These are characterized by having fruits consisting of two to five carpels enclosed in a fleshy covering. The genus *Malus* has according to most authorities 25 to 30 species and several sub-species of so called crab apples many of which are cultivated as ornamental trees for their profuse blossom and the attractive fruits. Many of the species intercross freely, since self-incompatibility is common, trees grown from seeds obtained from a botanic garden or arboretum where collections of *Malus* and thus are frequently interspecific or inter-varietal hybrids. *Malus pumila* is generally considered to be the parent of most of our cultivated apples and is endemic

in the area from the Balkans and southeastern Russia eastwards through the Transcaucasus, Iran, Turkestan and north to the Altai Mountains in central Russia. Almost certainly *M. sylvestris*, which is distributed over much of Europe and into western Turkestan, was involved in the early development of the apple as was *M. baccata* from eastern Asia including eastern Siberia, Manchuria, eastern Mongolia, China, Japan and the Himalayas.

Kashmir valley although enjoys lions share in acreage and production in the country, the productivity is far below compared to developed countries. One of the main reasons of this low productivity is the uneven and unpredictable yields registered by the use of incompatible and seedling rootstocks. Apple trees grown on seedling rootstock often tend to develop into large and vigorous trees and thus only few trees can be accommodated per hectare making the productivity less profitable. There is more competition between vegetative growth and fruit production within these trees and their internal self-shading makes them more vulnerable to various diseases. There must be a paradigm change in the understanding of farmers from production to sustainability and then to viability with an increasing population, urbanisation and constant degradation of natural resources. Despite the prominent position of apple in the country's socio-economic, ecological and nutritional status, the present scenario of apple industry does not commensurate with its actual capacity. In fact, the Jammu and Kashmir apple industry has not yet reached to its full strength, with stagnation in productivity, looming threat of imported fruits and land prices touching new peaks in the valley, it becomes imperative to go for high-density plantation for which change in rootstock from vigorous to size controlling rootstock is a prerequisite.

Apple rootstock testing is important for the identification of the most productive orchard systems in each area. Almost all rootstock research focuses on rootstock success in the orchard, but very little research is conducted at the nursery level. In order to use the rootstock for propagating different promising cultivars in the nursery the grafting must be consistent with the scion cultivar. Graft compatibility is illustrated as a good union of rootstock and scion and is typified by the movement of assimilates between the two sections, the continuous development of the vascular transport tissues. Research conducted so far indicate that compatibility is very unique, that a particular rootstock is usually not consistent with all commercial varieties of a given species. Apple rootstocks contribute to food security primarily by the productive use of natural resources *viz*., water and soil combined with the yield capacity of elite varieties and narrowing the yield gap under sub-optimal growing conditions. Tree vigor and size, precocity, fruit consistency and flavour, harvestable yield, pest tolerance and resilience to edaphic and environmental factors are influenced by the use of rootstocks in fruit plants by invigorating and increasing nutrient absorption, transport and use. Nutrient uptake and translocation capability of the various rootstocks must also be taken into consideration for plant development, since these variations can have an effect on yield and quality. In addition, assessing plant nutrient uptake ability is necessary in order to know how much nutrient is required for a cultivar. Baring ambri cultivar which is indigenous to Kashmir all other varieties were introduced by European settlers, missionaries and later by elite growers, nursery men and research introduction centers. From very inception there has been a trend of adding new cultivars with good consumer preference and market demand. All the commercial cultivars of apple are derived from careful planned crossing and selection programme with specific objectives. In spite of consistent increase in area under apple, the production has not proportionally increased. A good cultivar with desirable characteristics should be resistant to pests and diseases, more productive with good keeping quality. In Kashmir, apple acreage is dominated by major proportion of few varieties notably Red Delicious, American Apirouge, Royal Delicious, Golden Delicious, Cox' Orange Pippin, White Dotted Red etc. In the recent past, many exotic cultivars were added to the fruit bowl of apple. The new exotic apple cultivars are superior in quality with greater marketing potential as they fetch premium prices besides bearing on short stem and spurs. The commercial cultivars now cultivated are much better in terms of yield and quality than the wild apples from which they have originated for many generations.

Clonal rootstocks were first planted in the Kashmir valley under the aegis of Indo-Bulgarian Project in 1989-90 at the Advanced Center for Horticulture Development (ACHD), Zainapora. ACHD served as a source for all the clonal rootstocks of the apple, wherefrom rootstocks were spread to other areas of the valley. Thereafter, many centrally sponsored schemes have been launched by Ministry of Agriculture and Farmers Welfare to boost horticulture. MIDH (Mission for Integrated Development of Horticulture) is one of the such schemes which has been launched for holistic development of horticulture in the union territory of Jammu and Kashmir which integrates National Horticulture Mission and Horticulture Mission for North East and Himalayan States with major component on Research and Development, production of planting material and area expansion. The planting material was imported from Italy and Netherlands under Prime Ministers Development Package and CAPEX. The planting material is being disseminated in every nook and corner of the valley which needs to be evolved for different horticultural traits under the temperate conditions of valley. The need of the hour is to upgrade the varietal status of apple through the use of spur varieties and colour mutants for better productivity and marketability. The use of clonal apple rootstocks in the Kashmir Valley is gaining prominence, but no nursery level research has been undertaken to determine the best scion-stock combination of these clonal rootstocks yet. There is disagreement between researchers and farmers as to which cultivar to select and on which rootstock to graft. The choice of rootstock or rootstock/cultivar combination is significant not only in the orchard, but

also in the field of propagation.

In the recent past, many exotic cultivars were added to the fruit bowl of apple. The need of the hour is to upgrade the varietal status of apple through the use of spur varieties and colour mutants for better productivity and marketability. Hence the clonal rootstocks in combination with specific scion variety offer great potential to improve both quality and productivity of apple.

MATERIAL AND METHODS

The present research was conducted in the Experimental fields of Division of Horticulture, Sher-e-Kashmir University of Agricultural Science and Technology of Kashmir, Wadura, Sopore, Jammu and Kashmir. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications Three apple cultivars namely Red Chief, Red Velox, and Gala Mast were cleft grafted on six different rootstocks (M-9, MM-106, MM-111, M-27, P-22 and seedling) in open field. Both the rootstock and cultivar used were of uniform size. The cultural practices were same for all the experiment. The present investigation was carried out with the objective of evaluation of different rootstocks of apple for graft-take success and other vegetative characteristics of exotic cultivars of apple in Kashmir conditions.

Parameters: Data were recorded on the following parameters

Graft Success: After complete sprouting and successful growth of scion, the percent graft-take success was calculated three months later after in all the treatment combinations by the following formula and their means were calculated

$$\% \text{ graft success} = \frac{number\ of\ grafted\ plants\ survived}{total\ number\ of\ plants\ grafted} \times 100$$

Number of leaves/plant: For the determination of number of leaves/plant, ten plants were randomly selected in each treatment combination and then means were calculated.

Final Plant Height: Final plant height was measured with the help of measuring scale from the ground level to the top of the plant. The average of ten plants in each replication was worked out and was expressed in meters (cm).

RESULTS

Graft Success: Mean values pertaining to graft-take is presented in Table 1, Fig. 1 which clearly infers that rootstocks and scion cultivars had a significant effect on the graft-take success of exotic cultivars of apple. The maximum graft-take success (94.25%) was registered on semi-dwarf rootstock MM-106 which was significantly higher than all other rootstocks. This was closely followed by M-9 which recorded graft success to the tune of 91.49%. However minimum graft-take success (85.63%) was recorded on super-dwarfing rootstock M-27.

In addition to the rootstocks, varieties also promoted significant influence on the graft success. Maximum graft-take success to the tune of 90.18% was recorded in Gala Mast and minimum (88.08%) was recorded in Red Chief. Amongst the various rootstock-scion combinations, graft success varies between 85.63 to 94.25%. Present findings are in accordance with the findings of Rabi *et al.* (2012) who also obtained 75.10% to 95.55% graft success in apple grafted on MM-111, MM-106, M9, M-26 and crab apple. Iqbal *et al*. (2016) reported 56% and 100% graft success in Red Chief and Pink Lady respectively grafted on MM-111.

Table 1: Effect of clonal rootstocks on graft success of exotic cultivars of apple.

Variety / Rootstock	Red Chief	Red Velox	Gala Mast	Mean
Seedling	84.53 (9.24)	85.97 (9.32)	86.74 (9.37)	85.75 (9.31)
M_9	90.80 (9.58)	91.58 (9.62)	92.09 (9.66)	91.49 (9.62)
MM_{111}	89.77 (9.52)	90.29 (9.56)	92.60 (9.67)	90.89 (9.58)
M_{27}	84.78 (9.26)	85.49 (9.30)	86.61 (9.36)	85.63 (9.30)
MM_{106}	93.24 (9.70)	94.21 (9.75)	95.30 (9.81)	94.25 (9.76)
P_{22}	85.36 (9.28)	85.83 (9.32)	87.72 (9.42)	86.30 (9.34)
Mean	88.08 (9.43)	88.89 (9.48)	90.18 (9.54)	
CD (P≤0.05)				
Rootstock (R)	:	0.04		
Varieties (V)	:	0.03		
Rootstock x Variety (R x V)	:	NS		

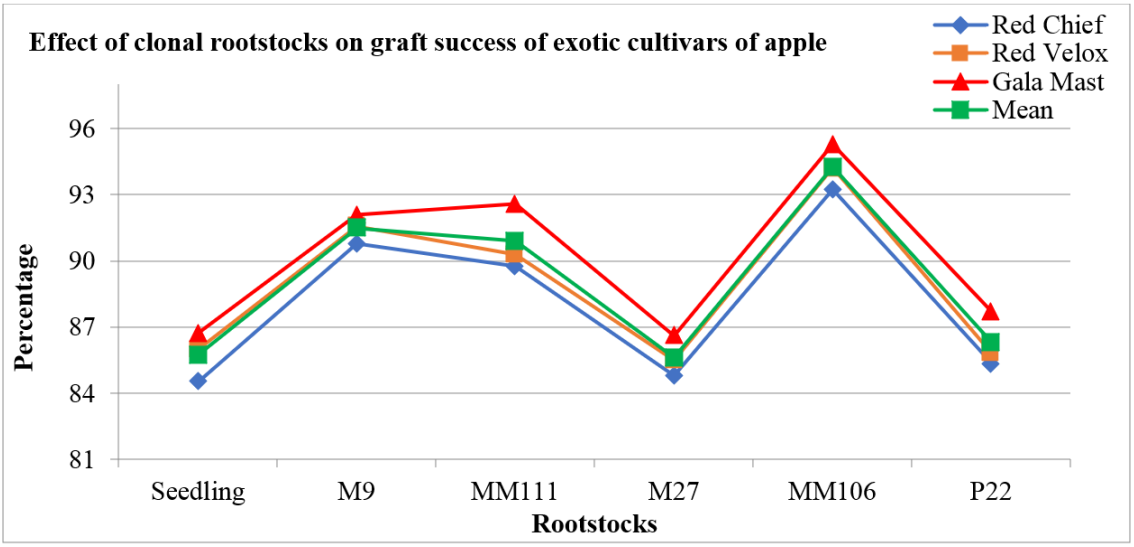

Fig. 1. Effect of clonal rootstocks on graft success of exotic cultivars of apple.

Number of leaves /plant: The data pertaining to the effect of clonal rootstocks on number of leaves per shoot is presented in the Table 2, Fig. 2. Perusal of the data reveals that rootstocks and varieties had a significant effect on the number of leaves per plant of the exotic cultivars of apple. Amongst the rootstocks evaluated maximum number of leaves (35.82) were recorded on the seedling rootstock which was at par with clonal rootstock MM-111 (34.69). The minimum number of leaves (22.44) were recorded on ultra-dwarfing rootstock M-27.

Varieties also showed significant influence on the number of leaves per shoot of apple. Gala Mast recorded the maximum number of leaves (32.72) and minimum number of leaves were observed in cultivar Red Chief (28.03).

Table 2: Effect of clonal rootstocks on number of leaves per plant of exotic cultivars of apple.

Variety / Rootstock	Red Chief	Red Velox	Gala Mast	Mean
Seedling	32.23	36.27	38.97	35.82
M_9	28.22	29.00	31.26	29.49
MM_{111}	32.08	34.75	37.23	34.69
M_{27}	20.77	21.96	24.61	22.44
MM_{106}	30.34	30.85	34.89	32.03
P_{22}	24.53	26.84	29.32	26.90
Mean	28.03	29.95	32.72	
CD (P≤0.05)				
Rootstock (R)	:	1.50		
Varieties (V)	:	1.06		
Rootstock x Variety (R x V)	:	NS		

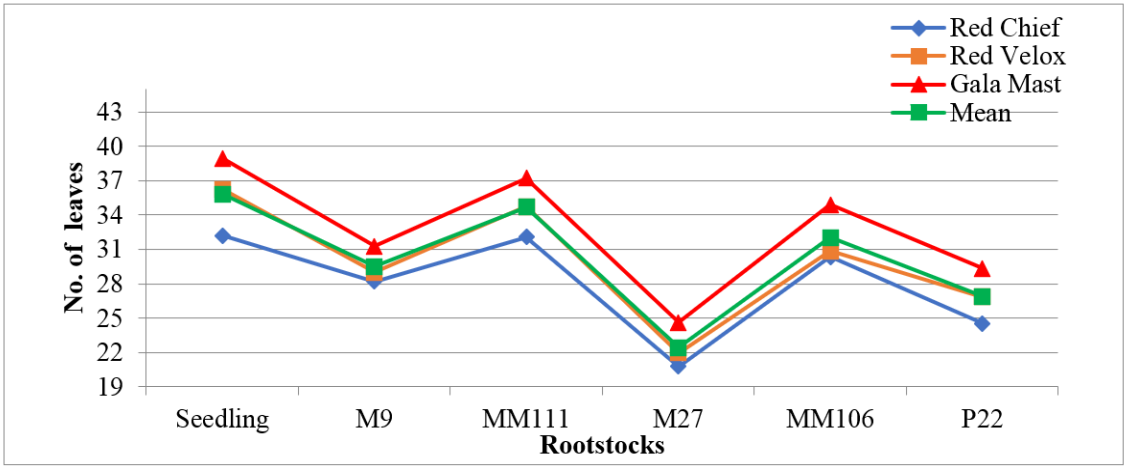

Fig. 2. Effect of clonal rootstocks on number of leaves per plant of exotic cultivars of apple.

Final Plant Height: The data depicted in Table 3, Fig. 3 indicates that rootstock had a significant effect on final plant height of exotic cultivars of apple. The results obtained during the study implicated that maximum plant height of 106.81cm was attained by plants on seedling rootstock which was significantly higher than all the treatments. This was followed by plants raised on clonal rootstock MM-111 (101.58cm). However, least height (75.58cm) was observed on super-dwarfing rootstock M-27.

As is evident from Table 3 that final plant height was significantly influenced by varieties. Amongst the varieties grafted, maximum plant height was recorded in Gala Mast (95.12cm) and minimum in Red Chief (89.47cm).

Table 3: Effect of clonal rootstock on final plant height (cm) of exotic cultivars of apple.

Variety / Rootstock	Red Chief	Red Velox	Gala Mast	Mean
Seedling	104.13	106.11	110.18	106.81
M_9	80.73	81.86	86.46	83.02
MM_{111}	99.02	100.91	104.80	101.58
M_{27}	73.46	75.56	77.72	75.58
MM_{106}	92.88	94.02	96.83	94.58
P_{22}	86.57	87.88	94.72	89.72
Mean	89.47	91.06	95.12	
CD (P≤0.05)				
Rootstock (R)	:	0.25		
Varieties (V)	:	0.18		
Rootstock x Variety (R x V)	:	0.43		

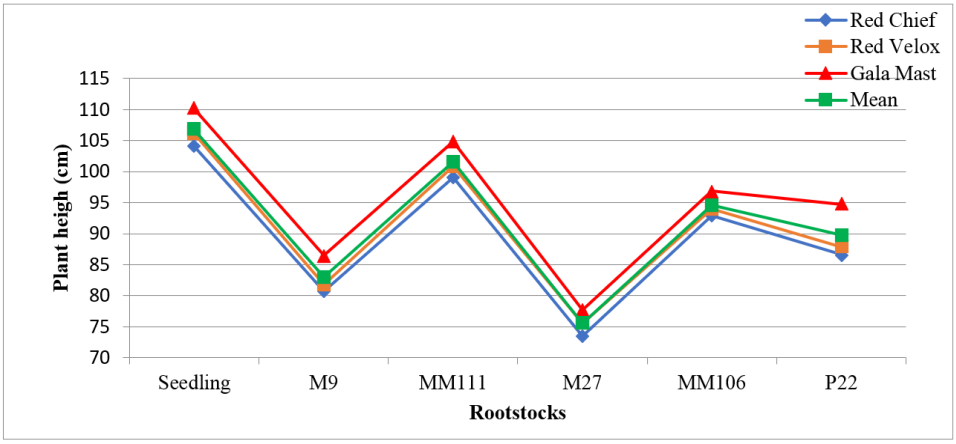

Fig. 3. Effect of clonal rootstock on final plant height (cm) of exotic cultivars of apple.

DISCUSSION

Graft Success: The success of the scion-stock relationship in fruit crops is determined by the desired cultivar on an effective rootstock which in turn is monitored by graft compatibility. Genetically identical clones and intra-species plants have high success rate for grafting provided vascular connections take place between the grafted tissues. Thus, even with a better scion cultivar, an inefficient or poorly performing rootstock will offer a lower percentage of graft performance. A better performance in grafting is also an indicator of a well-performing rootstock.

In the present investigation graft success of exotic cultivars of apple was significantly influenced by rootstocks and the scion cultivars, maximum graft-take success was registered on semi-dwarf rootstock MM-106 among all the rootstocks under study which was closely followed by dwarf rootstock M-9. However minimum graft-take success was registered on M-27. Amongst the various rootstock-scion combinations, graft success varies between 85.63 to 94.25%. while taking into cognizance the influence of rootstock. Gala Mast recorded the maximum graft-take success among all cultivars grafted. Present findings are in accordance with the findings of Rabi *et al.* (2012) who also obtained 75.10% to 95.55% graft success in apple grafted on MM-111, MM-106, M9, M-26 and crab apple. Iqbal *et al*. (2016) reported 56% and 100% graft success in Red Chief and Pink Lady respectively grafted on MM-111. Similar findings were reported by Aurangzeb *et al.* (2002) in peach, Nisar *et al.* (2002) in plum and Sharma and Kumar (2016) in stone fruits. The probable reason for maximum graft-take success might be assigned to the higher compatibility resulting in the early formation of callus tissue between scion and rootstock due to high activity of interacted vascular tissues of the scion and rootstock combinations. Another probable reason might be due to the fact that the favorable temperature and relative humidity at the time of grafting and rapid sap flow in the stock scion favors the healing process and established the

continuity of cambial and vascular tissues for the graft take.

Number of leaves/plant: Number of leaves per shoot was significantly influenced by scion cultivars and rootstocks. Maximum number of leaves per plant was recorded in the combinations of Gala Mast / seedling whereas, minimum number of leaves was found in the combination of Red Chief / P22. The increase or decrease in number of leaves might be because of increase or decrease in the photosynthetic rate due to compatibility of rootstock and scion. The higher number of leaves may be due to the influence of internal plant hormone present in the stem of the scion wood which is also influenced by the activity of the rootstock. Similar result were obtained by Wertheim and Webster (2005) who reported that IAA is a key leaf derived regulator of xylem cell differentiation and division within the cambial zone and initiator of vascular re-differentiation across the graft union. Dwarfing rootstocks reduce basipetal auxin transport thereby, limiting root growth and the amount of root synthesized cytokinin supplied to the scion. On the other hand, higher levels of IAA transport towards the roots will stimulate higher cytokinin production and transport to the scion. Consequently, higher cytokinin amounts transported to scion may promote lateral bud growth. Results obtained are in accordance to the findings of Zhang *et al* (2021) who reported that compared with vigorous rootstocks, dwarfing rootstocks reduce the number of branches & height of apple trees; Micheal *et al.* (2006), Ochmain (2007) and Malasi *et al.* (2017) in apple who reported that dwarfing apple rootstocks reduced the formation of nodes during shoot growth. Rabi *et al.* (2014) reported that scion cultivar and rootstock significantly affected the number of leaves per plant. Gangwar *et al.* (2005) reported that rootstock play a key role in growth characteristics of peach scions and total number of leaves were increased when grafted on plum rootstocks. Similarly, Bhuyan (2010) observed that the number of leaves produced per plant was appreciably influenced by the different combinations of rootstock and scion.

Final Plant Height: The use of dwarfing rootstocks is the primary method developed for the size control of scion. The plant height is an important character in determining the vigour of the graft. Plant height was observed to be influenced by characteristics of both scion cultivar and rootstocks and their interaction. Seedling rootstock was found superior among all the rootstocks and resulted in maximum plant height (106.81cm) whereas Gala Mast attained highest plant height among various cultivars. The maximum plant height to the tune of 110.18cm was obtained when Gala Mast was grafted on seedling rootstock followed by Gala Mast on MM-111 whereas, minimum plant height was recorded in Red Chief on ultra-dwarfing rootstock M-27. The variation in height of scion cultivars grafted on different rootstocks was according to vigor potential of scion or rootstock. These results are supported by the findings of Hayat *et al* (2019) wherein, the Red Fuji apple grafted onto more vigorous rootstocks such as Baleng, Chistock-1, and M26, rootstock increased shoot length and consequently the tree size of young apple trees was increased showing vigorous characteristics. Contrast, the Red Fuji apple grafted onto M-9 rootstock has shorter shoot length, and a reduced growth, showing dwarfing characteristics. Similarly, Malasi *et al.* (2017) who reported that Vance Delicious grafted on vigorous rootstock M-793 had shown highest graft height and Gold Spur on M-7 the least and Iqbal *et al.* (2016) and Rabi *et al*. (2014) in apple reported that plant height showed significant variations with respect to the cultivars and rootstocks used and confirmed that maximum plant height was obtained on more vigorous rootstocks. Carlson and Oh (1975), Tubbs (1980) and Ugolik and Kantorowiez (1993), who reported that both scion and rootstock exert influence on the vigour of a composite plant. However, McKenzie (1956) and Roger and Beakbane (1957) reported that the influence of a given clone on tree vigor was greater when used as rootstock than as a scion. While Santos *et al.* (2004) reported that the rootstock was the main influencing factor on plant growth. Gangwar *et al.* (2005) studied the compatibility behavior of plum rootstocks with peach scions and observed that plant height had positive influence on overall growth of the plant.

CONCLUSION

From the perspective of results procured in the present investigation, it can be concluded that morphological parameters *viz*., graft success, number of leaves & plant height were significantly influenced by the characteristics of both rootstock & scion cultivar, although it was also observed that the rootstock influence was more pronounced than the scion cultivar. Though these are preliminary observations in the initial years of growth which needs to be examined further during subsequent years through comprehensive trials on these graft combinations including studies on fruiting and yield behavior of scion cultivars to draw felicitous conclusions.

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Conflicts of Interest. No

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