Effect of different Exotic and Indigenous Apple Rootstocks on the Graft Success of Scion Cultivar Anna

Bashir Ahmad*, Muhammad Jiyad Khan†

Abstract

An experiment was conducted to find out the effect of different apple rootstocks on the graft success of apple cultivar Anna. According to the experimental results maximum plant height (204.62 cm), root thickness (63.21 mm), root weight (308.03 g) and root length (18.40 cm) were noted in crab apple rootstock, maximum root top ratio (0.48), lodging (12.00%), number of nodes per plant (87.89) and number of leaves per plant (322.33) were observed for MM-111 rootstock and maximum stem weight (1103.8 g), number of shoots per plant (16.11), sprouting (93.66%), number of roots per plant (40.55) were recorded for EM-7 rootstock, while minimum number of roots per plant (28.83), plant height 150.71 cm), (plant girth 68.23 cm), number of nodes per plant (67.22), number of shoots per plant (9.22) and stem weight (571.79 g) were recorded for EM-27 and minimum number of leaves per plant (230.2), root thickness (22.4 mm) and root weight (246.71 g) were noted for MM-106 rootstock. Crab apple, MM-111 and EM-7 root stocks offered excellent response to Anna cultivar of apple.

Keywords: Apple root stock, Scion, Plant Physiology, Anna

Introduction

Apple (Malussylvestris) is a deciduous fruit plant which belongs to the family Rosaceae and sub family pomoideae with a basic chromosome number 17. It is one of the famous and most important fruits of temperate zone which supports much of the population of the world. It has beautiful shape with good taste for which it is called king of deciduous fruits. Dwarf trees are planted much more closely in the orchard than the standard trees. The strong growth at the top of the trunk is cut back to keep the trunk down to a convenient height. Dwarf trees are grown as bushes and pruned severely each year. Dwarf trees come into bearing sooner than standard trees especially when the orchard is at high altitude. Fruits n dwarf trees generally, are of better quality than fruit of the same variety on standard trees, various rootstocks e.g. East

*Department of Horticulture, the University of Agriculture Peshawar, Pakistan.

†Department of Chemical and Life Sciences, Qurtuba University of Science and IT Peshawar, Pakistan.

Malling (EM) and Malling Merton (MM) series have been successfully tried by various researchers, which can be used efficiently by utilizing the orchard space economically with high standard of early bearing and size controlling clones.

Apple, being a major horticultural crop of the world has been subjected has been subjected to various rootstock trials for improving the yield and growth. Recent trend of using dwarfing rootstock has increased interest in the study of different rootstock materials. Greulich*etal*. (1983) studied the performance of apple trees on different rootstocks (M-9, M-26 AND MM-106) and found that all produced highest and most regular yields of high-quality fruits, provided they were not too densely planted and were summer pruned together with partial renewal of fruiting wood every 3-5 years. Lord (1983) (Koutinas et al. 2009) compared the effect of M-27, M-9, M-27/M-111, M-106, M-9/M-106, M-26 rootstocks on the growth, leaf nutrition and fruit quality of apple cv, Empire. Trees on M-9 and M-27 rootstocks were much smaller than trees on M-26 rootstock. Yields were highest on M-26, M-9/106 and M-27/M-106 rootstocks and interstocks had little effect on fruit size and maturity. Fiorino*et al.* (1988) reported that different rootstocks affect the shape of tree, amount of growth and mineral composition of the apple cultivar Golden Delicious. It was found that shoot growth is faster on EM-26 than on EM-27 after emergence. Joshi and Lal (1990) reported that apple cultivars Fanny and Chaubattia princess grafted onto clonal rootstocks MM-111, MM-104, MM-115, MM-109, MM-25 and pareo and crab apple seedling rootstock, showed maximum growth on pareo rootstock and minimum growth on MM-109.

However, the greatest increase in stock and scion girth occurred on seedling rootstock. The highest yields were obtained on MM-109. Seedling rootstock gave intermediate values for yield. There were few significant differences in fruit quality on different rootstocks. Shao *et al*. (1991) (Blanco et al., 2008; McAfee and Rom, 2003; Neem et al., 2006). found that SH rootstock series (developed from the cross Rolls x MannusHenanthesis) using young and golden Delicious as scion, showed greater stress resistance, early flowering, early maturity, more flowers, high yield, good appearance and taste and a high content of soluble solid, when compared against M-9 and M-7 rootstocks as control. Hansen (1992) observed that scions of six cultivars, Aroma, Filippa, Rod Torstein, Summerred, Tohuku 2 and Akero Hassel when grafted onto B-9, P.1, P.2, J-TE-B, J-TE-C, J-TE-E, J-TE-F, J-TE-G, J-TE-H, M-26 and MM-106 gave more than 90% success except the grafts made on J-TE-C and P.2.

A significant interaction between rootstock and scion cultivar was found for both tree height and stem diameter. A study of East Malling was conducted during 1982-83 to find out the effect of scion cultivar (Spartan or Discovery) on shank rooting of blanched M-9 stems. Shank rooting was not affected by the scion cultivar used, but was affected by factors like nursery environment and rootstock propagation method (Sharma *et al.,* 1992). Uzun and Sen (1992) Omer and Ismail (2011), grafted scions on seedling rootstocks. They found that Amasya apple trees gave the highest percentage (92.50% of grafts that took and StarkingDelecious and Starkspur Golden Delicious had the lowest percentage (81.25%). Amasya had the shortest shoot length (6.0 cm) and Starkspur Golden Delecious had greatest shoot length (13.5 cm). Highest survival of grafts (75.62%) was obtained by grafting in January while the lowest survival was obtained in October (26.25%). Callesen (1994) evaluated the apple rootstocks M-9, M-26 and MM-106 for their efficiency in bringing discovery apple trees into production. Tree vigor differences between rootstocks were measured in terms of trunk growth, tree volume, weight of pruned branches and weight of the above ground parts of the trees. M-9 was the most productive rootstock. M-26 performed poorly; its vigorous was similar to M-9 but it produced the lowest yields. Hirst and Ferree (1995) grafted Gala and Triple Red Delicious scion onto M-9 EMLA, MM-106 EMLA, MM-111 EMLA and B-118 (Gala only) in a green house. They found that rootstock exerted more influence than cultivar on total growth of the tree. Branch density, however, was primarily under scion control.

Materials and Methods

The research work was conducted on apple cultivar Anna at the field of Agricultural Bio Technology Centre, Agricultural Research Institute Tarnab, Peshawar. The experiment was laid out in Randomized Complete Block Design (RCBD) having three replications. The different rootstocks (treatments) of the experiment were:

T1:	CrabApple
T2:	EM-26
T3:	EM-27
T4:	EM-7
T5:	EM-9
T6:	MM-111
T7:	MM-106

There were 45 plants comprising three replications of each treatment with fifteen plants per replication. These rootstocks were

grafted with the scion cv. Anna apple. All the scions were grafted fifteen cm above the ground level on stocks. The grafting method used was tongue grafting.

Results and Discussion

Percent Sprouting

From the table it is clear that maximum sprouting (93.67%) was noticed for Anna cultivar grafted on EM-7 whereas maximum sprouting (57.0%) was observed when the same cultivar was propagated on EM-26 rootstock. As the main table shows that the highest number of shoots per plant and number of roots per plant were also observed for the mentioned rootstock so it can be conducted that it absorbed more nutrients and water from the soil with the result more sprouting took place in cultivar Anna grafted on EM-7 rootstock. In other words, cultivar Anna showed good compatibility with EM-7.

Number of leaves per plant

From the table it is clear that maximum number of leaves per plant (322.3) was noted for Anna cultivar grafted on MM-111 rootstock whereas minimum number of leaves per plant (230.2) was recorded for Anna cultivar grafted on MM-106 cultivar. Since the number of nodes was also maximum for MM-111 rootstock, therefore, number of leaves was also maximum for this rootstock because the leaves arise only on the nodal position of the stem.

Number of shoots per plant

Different rootstocks of the Malling series had significant effect on the number of shoots/ plants of Anna cultivar. Maximum number of shoots per plant (16.1) was observed in the Anna cultivar of apple grafted on EM-7 rootstock while minimum number of shoots per plant (9.2) was recorded when Anna was grafted on EM-27 rootstock. The highest values for the number of roots and sprouting were observed for EM-7 rootstock. In other words, the water and nutrients were efficiently absorbed by EM-7 rootstock due to maximum number of roots which resulted in a greater number of shoots in Anna scion grafted on the mentioned rootstock.

Stem weight

It is clear from the table that maximum stem weight (1103.8g) was recorded for Anna cultivar grafted on EM-7 apple rootstock, while minimum stem weight (571.79g) was observed when the mentioned cultivar was propagated on EM-27 rootstock. The highest values for the

number of roots and shoots were also observed in EM-7 rootstock. In other words, the water and nutrients were efficiently absorbed by EM-7 rootstock due to the maximum number of roots with the result more stem weight was also recorded by Anna grafted on EM-7 rootstock.

These results are in agreement to that of Callesen (1994) who observed that tree vigor differs between rootstocks in terms of trunk growth, tree volume, weight of pruned branches and final weight of the above ground parts of the tree.

Number of nodes per plant

Maximum number of nodes per plant (88.0) was observed for Anna cultivar grafted on MM-111 rootstock and minimum number of nodes per plant (67.2) was recorded when mentioned cultivar was propagated on EM-27 rootstock. From the table it is clear that maximum number of leaves per plant was also observed for MM-111 rootstock. These leaves might have prepared more photosynthetic that resulted excellent growth and therefore a greater number of nodes per plant was observed in this rootstock.

Stem thickness (cm)

It is revealed from the table that maximum stem thickness (2.5cm) was recorded for Anna cultivar grafted on EM-27 while minimum stem thickness (1.8cm) was noticed when the mentioned cultivar was propagated on EM-9 rootstock. The increase in root diameter may be due to lengthier shoots and large number of leaves which finally might have increased the root thickness as well as the stem diameter. A significant interaction between the rootstock and scion cultivar was found for both tree height and stem diameter by Hansen, 1992. Stem thickness is directly related to stem length and number of leaves. Maximum number of leaves contributes to the preparation of additional photosynthesis which enhance the growth and development of the stem. Minimum number of leaves results in less production of photosynthesis and the stem thickness remains less.

Plant girth (cm) (circumference)

Maximum plant girth (89.57 cm) was observed for ANNA cultivar grafted on EM-9 rootstock while the minimum plant girth (62.83 cm) was recorded when the mentioned cultivar was propagated on EM-27 rootstock. These results do not agree with the findings of Kumashairo *et al.* (1992) who reported that shoot growth and trunk girth of the tree on M-27 rootstock were superior to those of trees on M-9 rootstock, and

Ferree and Schmid (1994) also observed vigorous growth, resulting in relatively large tree for apple.

Percent lodging

From table it is clear that maximum lodging (12.0%) was observed for Anna cultivar grafted on MM-111 rootstock whereas maximum lodging (0%) was observed for Anna grafted on the rest of the rootstocks. The results did not resemble to those of Schupp (1992), who compared the growth and fruiting of cultivars Cortland, Empire, Delicious and Mclntosh on the rootstocks Mark (formerly MAC-9) and MM-111.Delicious and Mclntosh were also grown on M-7a and M-26 rootstocks. Tree leaning was severe for trees on Mark or M-26 rootstock.

Plant height

From table it is revealed that maximum plant height (206.72) was observed for Anna cultivar grafted on crab apple while the minimum plant height (150.70 cm) was noted when the mentioned cultivar was propagated on EM-27 rootstock. Increased in plant height was also observed by Mullins and Straw (1993), as well as by Carpenter and Dana (1988). Hansen (1992) who observed significant interaction between rootstock and scion cultivar for both tree height and stem diameter. Maximum plant height may be attributed to the maximum root parameters. The vigorous root system may have absorbed sufficient nutrients and water that were utilized for the growth and development of the aerial plant parts with the result more plant height was obtained for Anna grafted on crab apple.

Number of roots per plant

Different rootstocks of the Malling series had significant effect on the number of roots per plant. Maximum number of roots per plant propagated for Anna cultivar. Maximum number of roots per plant (40.55) was noticed for the Anna cultivar grafted on EM-7while minimum number of roots per plant (28.83) was noted when the mentioned cultivar was propagated on EM-27 rootstock. Such increase in number of roots per plant was also observed by Mullins and Straw (1993).

Root thickness

From the table it is revealed that the highest root thickness (63.21 mm) was observed for Anna cultivar grafted on crab apple while the lowest root thickness (22.4 mm) was observed when the mentioned cultivar was propagated n MM-106 rootstock. It is evident that maximum

root length and root weight was observed for crab apple which showed high nutrients absorption capacity from the soil which resulted in the greatest root thickness and more root weight.

Root weight (g)

Maximum root weight 308 g) was observed for crab apple grafted by cv. Anna while the lowest root weight (241g) was noted when the mentioned cultivar was grafted n MM-106 rootstock. Maximum root weight f crab apple cud be due to its maximum root length (184 cm) and root thickness 63.21 mm) respectively while minimum root weight of MM-106 rootstock would be due to its sender roots having minimum root thickness.

Root length (cm)

Maximum root length (18.4 cm) was observed for crab apple grafted by Anna while minimum root length (9.5 cm) was recorded when the mentioned cultivar was propagated n EM-26 rootstock maximum root length of crab apple may be due t the we developed aerial parts directing more photosynthesis to the subterranean pant parts resulting in we developed and deeper root system. Minimum root length for EM-26 rootstock may be due to its shorter roots directing more photosynthesis to the aerial plant parts, results in minimum root length.

Root top ratio

From the table it is clear that maximum root top ratio (0.48) was noticed for Anna cultivar of apple grafted on MM-111 while the minimum root top ratio was observed for EM-9 rootstock this may be due to proportionate growth of roots and stem of MM-111 rootstock, because roots are dependent on shoots for carbohydrates, growth regulators and organic substances, shoots are dependent on roots for water, minerals and growth regulators. Successful growth of plants, therefore, depends on maintenance of a balance in growth and function between roots and shoots (Kramer, 1983). Minimum root top ratio in EM-9 rootstock may be due to the diversion of more photosynthetic to the aerial plant parts leaving little for the subterranean plant parts.

Means followed by similar letters are non-significantly different from each other at 0.05 level of significance.

Table 1: Effect of different rootstocks on various growth parameters of Anna cultivar of apple

Parameters	**Treatments**						
	Crab Apple	EM-26	EM-27	EM-7	EM-9	MM-111	MM-106
Percent Sprouting	73.6 C	60.3 D	57.0 D	73.0 C	93.7 A	86.3 B	88.7 AB
Number of leaves per plant	248	233	250	322	283	280	230
Number of shoots per plant	14.2 AB	9.2 C	10.1 BC	12.8 ABC	16.1 A	14.5 AB	11.4 ABC
Stem weight	1034.2 A	571.79 C	888.9 AB	701.1 BC	1103.8 A	901.0 AB	746.0 BC
Number of nodes per plant	84.2A	67.2 B	76.3 AB	88.0 A	83.1 A	86.5 A	81.8 A
Stem thickness	2.49 A	2.53 A	2.3 AB	2.45 AB	2.24 AB	1.83 C	2.07 BC
Plant girth	65.82 BC	62.83 C	77.2 ABC	84.21 AB	84.94 AB	89.57 A	82.5 ABC
Percent lodging	0.00 B	0.00 B	0.00 B	12.00 A	2.67 B	0.00 B	0.00 B
Plant height	204.62 A	150.71 D	177.53 B	161 BCD	170.5 BC	157.2 CD	160.9 BCD
Number of roots per plant	30.48 C	28.83 C	40.44 A	39.44	40.55 A	30.22 C	35.77 B
Root thickness	63.2 A	25.2 B	29.41 B	24.2 B	24.9 B	23.2 B	22.4 B
Root weight	308 A	267.7 AB	280.5 AB	282.3 AB	304.9 A	248.3 B	246.7 B
Root length	18.4 A	14.8 B	9.5 C	16.5 AB	16.2 AB	15.1 B	16.9 AB
Root top ratio	0.299	0.47	0.316	0.48	0.28	0.279	0.33

LSD value at 5% for,

Parameters	Values
Percent sprouting	6.351 %
Number of shoots per plant	4.856
Stem weight	266.3 g
Number of nodes per plant	13.78
Stem thickness	0.3938 cm
Plant girth	19.92 cm
Percent lodging	5.866 %
Plant height	19.55 cm
Number of roots per plant	4.497
Root thickness	9.909 mm
Root weight	41.64 g
Root length	2.355 cm

Table 2: Means followed by similar letters are non-significantly different from each other at 0.05 level of significance.

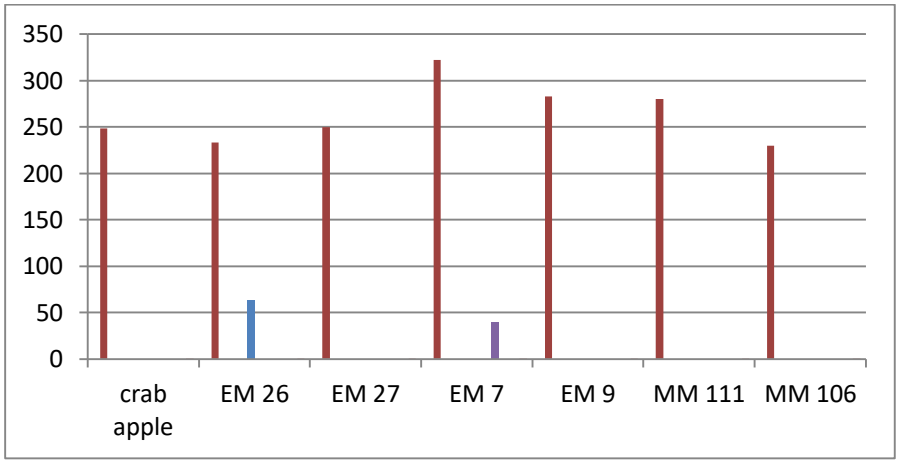

Figure 1: Graph showing values for different parameters investigated

Conclusion

As a result, two rootstocks i-e MM- 111and EM-7 have been found successful and are on the approved list for Anna cultivar of apple for better results in future.

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References

Carpenter, P.L and M.N. Dana 1990. Growth comparison of crab apples: own roots vs apple rootstock. *Combine proceedings International plant propagation society*, 1988, (38), 544-549. (CABOC Horticulture Abstracts 1990.060-06491)

Callesen O 1994. Performance of discovery apple on M-9, M-26 and MM-126rootstocks at two densities. *Journal of horticulture science* 69(2) 305-311 (CAB OC HORT, Absts 1994 064-07611)

Childers N.F 1983 Modern Fruit Science, Orchard and small fruit culture. *Hort, Publications, Gainesville*, Florida PP 1,17 and 19.

Ferree D.C. and J.C. Schimd. 1994. Early production of apple cultivars on M-9 and Mark rootstocks. *Fruit varieties Journal* 48(2): 130-132.

Fiorino, P, M.Tattini and L,Tazzari. 1988. Influence of rootstock on the space, amount of growth and mineral composition of apple trees (cv. Golden Delicious). Coltura del melo verso glianni, 90. *Conference, Cordenons*, Italy, 18-20 Dec. 1926 |Coordinator J. Youssef| 1988 493-499. CAB: OC Horticultural Abstracts 1990 060-02281; 75 Irrigation and drainage Abstracts 1991 017-00252).

Greulich, E., H.J. Doch and G. Siele. 1983. Correlation between crown form. Cultivar rootstock combination, cropping regularity and pruning in orchards. *Gartenbau*. 30 (12): 369-371.

Hansen, O.B. 1992. Grafting take and subsequent growth of apple on dwarfing rootstocks. *Norst Land bruks forsking*. 1992, 6 (1), 39-44. (CAB: OC Horticultural Abstracts 1992 062-06324).

Hirst, P.M. and D.C. Ferree. 1995. Effect of rootstock and cultivar on the growth and precocity of young apple trees. *Fruit Varieties Journal*. 49(1): 34-41.

Joshi, K.R. and H.Lal. 1990. A short note on the performance of seedling and clonal rootstock on growth, yield and quality of apple cultivars

Fanny and Chaubattia princess. *Prog. Hort.* 22(1-4): 131-133.
Kumashiro, K., S. Tateishi, K. Kamijo and K. Arai. 1992. Effects of soil and rootstock on the tree growth, yield and fruit quality of "Tsugaru" apples. *Journal of the Faculty of Agriculture, Shinshu University*. 29(1); 1-7. (CAB: OC Hort. Absts. 1994 064-07612)
Kramer, P.J. 1983. *Water relations of plants. United Kingdom Edition, Published by Academic Press*, Inc. London, pp. 161-162.
Lord, W.J. 1983. Scion/rootstock and inter stems effect on growth nutrition and fruiting of apple trees and fruit quality. *Compact fruit trees 16 May, 65-69. Massachusetts University*. U.S.A. (Hort.Abst.53(8):552).
Mullins, C.A. and R.A. Straw 1993. Apple rootstocks evaluations. Tennessee farm and Home Science. No. 168: 35-39. (CAB: OP Plant Breeding Abstracts 1994 064-06295).
Schupp, J.R. 1992. Early performance of four apple cultivars on Mark and other rootstocks in Maine, Fruit Varieties Journal. 46(2):67-71.(CAB:OC Horticultural Abstracts 1993 063-00947).
Sharma, S., A.D. Webster and S.Sharam.1992. Effect of scion cultivar on adventitious root development in M-9 apple rootstock. Agricultural Science Digest-Karnal. 12(4): 223-225.
Shao, K.J., D.K. Li, Z.R. Zhang and X.M. Gao. 1991. A study on the characters and physiological traits of SH series apple dwarf stocks. Acta Horticulture Science. 18(4): 289-295. (CAB Abstracts 1/93-12/94).
Uzun, S. and S.M. Sen. 1992. Research on the propagation of different apple varieties with indoor grafting. *Yuzuncu Yil Universityesi Ziraat Fakultesi Dergisi.* 2(1): 1-15.
Blanco A, Mqta AP, Lasasosa A and Val J (2008) The P16 rootstock inhibits the growth but enhances the fruit quality of 'Jonagored' apples when grown under warm summer conditions. *Spanish J. Agric. Res.* 6 (3), 412-421.
McAfee JD and Rom CR (2003) Evaluation of size- Controling apple rootstock for high density 'Gala' apple orchards in *Arkanass Horticultural studies. Department of Horticulture, University of Arkanass*. pp: 21-23.
Neem U, Univer T and Tiirma K (2006) Effect of five rootstocks on growth and Yield of four apple cultivars in Young orchard. *Scientific works of the Lithuanian Institute of Horticulture andand Warrington* IJ (Eds), Cabi Publ., Wallingford, UK. pp: 345-407.
Koutinas, N., G. Pepelyankov and G. Koutina. 2009. Rootstock influence on the time of cessation of the shoot growth and the time of

differentiation of flower buds in two apple cultivars., *Acta Horticulture*. (825): 231-236.
Omer, F. K. and I. H. Kalyoncu, 2011. Nursery growing of some apple varieties using different grafting methods in greenhouse and orchard. *Afric. J. biotech*., 10(83): 19375-19384.