BAHÇE 47 (Özel Sayı 2: Uluslararası Tarım Kongresi (UTAK 2018)): 103–111 (2018)
ISSN 1300–8943

DETERMINATION OF THE ROOTING AND GROWTH PERFORMANCES OF CERTAIN CLONAL ROOTSTOCKS IN DIFFERENT MEDIA

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Geliş Tarihi / Received: 02.07.2018 Kabul Tarihi / Accepted: 03.12.2018

ABSTRACT

In this study, it was aimed to determine the root abilities and growth performances of 9 different clonal rootstock cuttings, which were planted at two different times, in pumice and zeolite media. According to the testing results, while the maximum rooting was observed in the cuttings of Pixy (87,7%) rootstock planted in zeolite medium in March, the minimum rooting was in the cuttings of M9 (1,1%) rootstock planted in zeolite medium in February. While there was no rooting in MaxMa14 and GF677 rootstocks in both periods, no rooting was also observed in the cuttings of M9 rootstock planted in pumice medium in February. While the most different diameter increment and the best shoot growth were observed in SL64 rootstock planted in pumice medium in February, the best root growth was determined to be in MM111 rootstock planted in zeolite medium in March.

Keywords: Clonal rootstock, rooting, pumice, zeolite

INTRODUCTION

Rootstocks used in fruit growing are divided into 2 groups as seedling rootstock and clonal rootstock. In a garden setting, rootstock selection is almost as important as the product or variety selection, in fact, in some cases, it gains even more importance than those. With rootstock selection, good and effective precautions are taken against certain factors limiting the fruit growing. The yield of rootstocks differs depending on fruit quality characteristics such as fruit size, ripening time and colour, taste and aroma (2) Clonal rootstocks are obtained from the production of easily rooted rootstocks with vegetative methods. The facts that the mass production of clonal rootstocks is easy and that they adjust to different soil characteristics are among the most distinct advantages of clonal rootstocks (2).

In many countries developed in fruit growing, the classical growing has given its place to the modern growing, which is performed with thick planting. In the thick planting or intense growing system that is performed by using dwarf rootstock or spur variety, more in number and more quality products are obtained from the unit area, the product cost decreases, harvest time is brought forward, and fruit growing can be performed in graded and even small areas (3). In the world, the most studies on thick planting and intense growing have been conducted on apples. In these studies, standard and spur varieties were tested on dwarf apple rootstocks such as M9, MM106 and M26 (4; 10, 11, 15).

The lack of dwarf cherry rootstocks, which has been the most important factor limiting the development in cherry production for many years, has been overcome with rootstocks with different characteristics and developmental strength as a result of the breeding studies that have been going on in recent years. Gisela–5 rootstock, which is evaluated as a dwarf, early and fertile rootstock, is the most promising rootstock due to its characteristics in terms of intense growing (18). In fruit growing in our country, thick and very thick planting with semi or full dwarfing rootstocks is becoming increasingly widespread. In these systems, particularly in apples, M9, M26, MM106 dwarfing rootstocks are generally used. Some spur apples are also grafted on a strong MM–111 rootstock. In spur apple varieties, usually apple seedlings and MM106 rootstocks, which exhibit a similar behaviour, in other words, of which roots go deep as seedlings, are used (9). In this study, some of the clonal rootstocks used for the propagation of drupe and pome fruit varieties were tried out in different media and different planting periods, and it was estimated to separately evaluate these rootstocks by their rooting and growth performances in media.

MATERIAL AND METHOD

In the experiment, 20–25 cm wood cuttings of the mentioned rootstocks were used. These cuttings were obtained from a certified, registered breeding rootstock parcel of a private arboriculture enterprise in Isparta/Eğirdir. In the experiment, 1620 cuttings in total (180×9) were used for 9 rootstocks, with 180 cuttings in total in both media, with 90 cuttings for 5 repetitions, 18 cuttings per repetition from each rootstock. Clonal Rootstocks used in the experiment were Pixy (*P. institia*), Myrobolan 29–C (*P. cerasifera*), GF–677 (*P. persica × P. amygdalus*), SL–64, Maxma–14, M9, MM106, MM111 and Quince A. Zeolite and Pumice were used as a rooting medium in the study.

Cutting plantings were performed in pumice and zeolite media, in bed culture with a width of 250 cm, a depth of 35 cm and a length of 600 cm. The cuttings were planted according to the randomized parcels experimental design as one repetition in each row with an interval every 10 cm, 5 repetitions for each rootstock and 18 cuttings per repetition. Cutting planting was performed in two times in February (19.02) and March (10.03). After applying 4000 ppm IBA (indole butyric acid) as a rooting–inducing hormone, planting was performed and maintenance works were performed in standard form.

RESULTS

Results Regarding Pixy Rootstock

The characteristics related to the rooting of Pixy rootstock in pumice and zeolite media as of February 19 (early spring) are presented together in Table 1.

It was determined that there was a statistical difference between the diameter increment at the end of the vegetation period, diameter difference, shoot diameter increment, shoot height development and root wet and root dry weights in the planting of Pixy rootstock as of February 19. The diameter increment of 8,94 mm in zeolite medium increased to 14,61 mm in pumice medium and similarly, the diameter difference of 3,14 mm in zeolite medium became 7,66 mm in pumice medium. The shoot diameter of 5,94 mm in zeolite medium increased to 12,00 mm in pumice and the shoot height increased from 53,16 cm to 103,96 cm. In root wet weights, the value of 30,17 g of the cuttings planted in zeolite medium was found to be 67,8 g in pumice medium and the root dry weight was found to be 13,33 g in zeolite and 27,42 g in pumice. As of this period, the rooting percentages of Pixy rootstock were found to be 22,24% in zeolite medium and 21,12% in pumice and no statistically significant difference was observed depending on the media.

The characteristics of the rooting of Pixy rootstock in pumice and zeolite media as of March 10 (late spring) are presented together in Table 2.

In the statistical evaluations made, it was determined that there was a statistical difference in the percentages of Pixy cuttings which rooted at the level of (5%) in terms of the media and that rooting occurred at higher percentages in zeolite medium with 87,7% compared to pumice medium (44,4%). Similarly, it was determined that the shoots from the cuttings exhibited a better development in zeolite medium in terms of their height development. The shoot height was determined to be 81,7 cm in pumice medium and 101,8 cm in zeolite medium. Furthermore, it was determined that there was no statistical difference between the post–vegetation period diameter increment, diameter difference, shoot diameter, root wet and root dry weights. According to this, while the diameter increment at the end of the vegetation period was 11,05 mm in pumice medium, it was determined to be 11,27 mm in zeolite medium, the diameter difference of 3,11 mm in pumice medium was found to be 2,90 mm in zeolite medium, the diameters of the shoots formed from cuttings were 8,33 mm in pumice and 7,97 mm in zeolite. While the root wet weight was determined to be 38,07 g in the cuttings in pumice medium, it was 25,57 g in zeolite medium and the root dry weight was 17,2 g in pumice and 14,39 g in zeolite medium.

Results Regarding Myrobolan 29–C Rootstock

The characteristics of the rooting of Myrobolan 29–C rootstock in pumice and zeolite media as of February 19 are presented together in Table 3.

In the planting of Myrobolan 29–C rootstock on February 19 (early spring), only the shoot diameter increment at the end of the vegetation period was found to be significant at the level of 5% in the analysis of variance (Table 3). In fact, the shoot diameter, which was determined to be 8,22 mm in zeolite medium, increased to 15,07 mm in pumice medium. As can be seen from Table 3, there was no statistical difference in Myrobolan 29–C rootstock in terms of cutting rooting rate, diameter increment and diameter difference at the end of the vegetation period, shoot height development, root wet and root dry weight in terms of the media. While the cutting rooting rate of this rootstock in zeolite medium was 3,34%, it was 12,24% in pumice. The cutting diameter thickness at the end of the vegetation period was determined to be 12,46 mm in zeolite medium and 17,83 mm in pumice medium. While the resulting cutting diameter difference was 5,71 mm in zeolite, it was 11,17 mm in pumice medium. The heights of the shoots showing a good development were determined to be 92,5 cm in zeolite medium and 123,1 cm in pumice. The root wet weights were measured to be 36,06 g in zeolite and 136,05 g in pumice and the root dry weights were measured to be 13,4 g in zeolite and 51,75 g in pumice.

The characteristics of the rooting of Myrobolan 29–C rootstock in pumice and zeolite media as of March 10 are presented together in Table 4.

Upon examining the rooting characteristics of Myrobolan 29–C rootstock in pumice and zeolite media as of March 10, it was determined that there was no statistical difference between the media in terms of the percentage of the rooted cutting number, diameter increment and diameter difference at the end of the vegetation period, diameter increments of the shoots from the cuttings, height developments of these shoots, root wet and root dry weights (Table 4). As can be seen from Table 4, while the cutting rooting rate of this rootstock was 30% in zeolite medium, it was 17,78% in pumice. The cutting diameter thickness at the end of the vegetation period was determined to be 12,4 mm in zeolite medium and 10,69 mm in pumice medium. While the resulting cutting diameter difference was 6,74 mm in zeolite, it was 4,55 mm in pumice medium. The shoot diameter was 10,07 mm in zeolite and 7,43 mm in pumice. The heights of the shoots showing a good development were 117,2 cm in zeolite medium and 80,4 cm in pumice. The root wet and root dry weights were measured to be 50,88 g and 22,38 g in zeolite and 52,89 g and 23,51 g in pumice, respectively.

Results Regarding SL–64 Rootstock

Since no cuttings of this rootstock were obtained on February 19 (early spring), the rootstock was not tested. Upon evaluating the data obtained from the planting of SL64 rootstock on March 10 (late spring), it was determined that there was no statistical difference between the percentage of the rooted cutting number, the diameter increment and diameter difference at the end of the vegetation period, diameter increments of the shoots from the cuttings, height developments of these shoots, root wet and root dry weights (Table 5). As can be seen from Table 5, while the cutting rooting rate of this rootstock was 5,58% in zeolite medium, it was 10,02% in pumice medium. The cutting diameter thickness at the end of the vegetation period was determined to be 11,81 mm in zeolite medium and 13,5 mm in pumice medium.

Table 1. Rooting and growth characteristics of Pixy rootstock as of February 19

Media	Root number (%)	Initial diameter (mm)	Final diameter (mm)	Diameter difference (mm)	Shoot diameter (mm)	Shoot height (cm)	Root wet wt. (g)	Root dry wt. (g)
Zeolite	27,99 a (22,24)	5,81 a	8,94 b	3,14 b	5,94 b	53,16 b	30,17 b	13,33 b
Pumice	26,52 a (21,12)	6,95 a	14,61 a	7,66 a	12,00 a	103,96 a	67,80 a	27,42 a

LSD (5%) The values in root number percentages are the values calculated according to transform arc–sinus and the real mean values are given in parentheses. The differences between the means shown with different letters are statistically significant (P<0.05).

Table 2. Rooting and growth characteristics of Pixy rootstock as of March 10

Media	Root number (%)	Initial diameter (mm)	Final diameter (mm)	Diameter difference (mm)	Shoot diameter (mm)	Shoot height (cm)	Root wet wt. (g)	Root dry wt. (g)
Zeolite	71,7* a (87,7)	8,36 a	11,27 a	2,90 a	7,97 a	101,8 a	25,57 a	14,39 a
Pumice	41,6* b (44,4)	7,94 a	11,05 a	3,11 a	8,33 a	81,7 b	38,07 a	17,20 a

LSD (5%) The values in root number percentages are the values calculated according to transform arc–sinus and the real mean values are given in parentheses. The differences between the means shown with different letters are statistically significant (P<0.05).

Table 3. Rooting and growth characteristics of Myrobolan 29–C rootstock as of February 19

Media	Root number (%)	Initial diameter (mm)	Final diameter (mm)	Diameter difference (mm)	Shoot diameter (mm)	Shoot height (cm)	Root wet wt. (g)	Root dry wt. (g)
Zeolite	6,63 a (3,34)	6,75 a	12,46 a	5,71 a	8,22 b	92,5 a	36,06a	13,40 a
Pumice	18,00 a (12,24)	6,66 a	17,83 a	11,17 a	15,07 a	123,1 a	136,05a	51,75 a

Table 4. Rooting and growth characteristics of Myrobolan 29–C rootstock as of March 10

Media	Root number (%)	Initial diameter (mm)	Final diameter (mm)	Diameter difference (mm)	Shoot diameter (mm)	Shoot height (cm)	Root wet wt. (g)	Root dry wt. (g)
Zeolite	32,95 a (30,00)	5,65 a	12,40 a	6,74 a	10,07 a	117,2 a	50,88 a	22,38 a
Pumice	23,34 a (17,78)	6,13 a	10,69 a	4,55 a	7,43 a	80,4 a	52,89 a	23,51 a

Table 5. Rooting and growth characteristics of SL–64 rootstock as of March 10

Media	Root number (%)	Initial diameter (mm)	Final diameter (mm)	Diameter difference (mm)	Shoot diameter (mm)	Shoot height (cm)	Root wet wt. (g)	Root dry wt. (g)
Zeolite	10,29 a (5,58)	4,77 a	11,81 a	7 03 a	10,28 a	106,6 a	70,07 a	34,66 a
Pumice	16,27 a (10,02)	5,39 a	13,50 a	8,11 a	10,64 a	120,6 a	69,24 a	35,40 a

While the resulting cutting diameter difference was 7,03 mm in zeolite medium, it was 8,11 mm in pumice medium and the shoot diameter was 10,28 mm in zeolite medium and 10,64 mm in pumice medium. The height of shoots showing a good development was 106,6 cm in zeolite medium and 120,6 cm in pumice medium. The root wet and root dry weights were measured to be 70,07 g and 34,66 g in zeolite medium and 69,24 g and 35,4 g in pumice medium, respectively.

Results Regarding MM111 Rootstock

The characteristics of the rooting of MM111 rootstock in pumice and zeolite media as of February 19 (early spring) are presented together in Table 6.

In the planting of MM111 rootstock in the early spring (19 February) period, there was a statistical difference at the level of 5% between the media in terms of the criteria of the diameter increment and diameter difference at the end of the vegetation period, the diameter increment of the shoots from the cuttings, and the height development of these shoots. It was determined that there was no statistical difference between the media in terms of the percentage of the rooted cuttings, root wet and root dry weights (Table 6). As can be seen from Table 6, at the end of the vegetation period, the cutting diameter of 8,93 mm in zeolite medium was found to be 13,25 mm in pumice medium. While the diameter differences of the shoots formed were 1,11 mm in zeolite medium, they were 5,57 mm in pumice medium, and the shoot diameters and heights were recorded to be 5,47 mm and 41,75 cm in zeolite medium and 10,79 mm and 90,66 cm in pumice medium, respectively. It was observed that the rooting percentages, which had no statistically significant difference between themselves, remained at low levels such as 3,34% in zeolite medium and 3,36% in pumice medium and root wet and dry weights were 31,78 g and 11,17 g in zeolite and 84,33 g and 28,44 g in pumice medium, respectively.

It is observed that there is a statistical difference at the level of 5% in the rooting percentages of the MM111 cuttings planted on March 10 (late spring) (Table 7). As can be seen from Table 7, while 22,24% of the cuttings planted in zeolite medium rooted, only 3,36% rooted in pumice medium. There was no statistical difference between the media in terms of the diameter increment and diameter difference at the end of the vegetation period, the diameter increments of the shoots from the cuttings, the height development of these shoots, root wet and dry weights. The diameter thickness at the end of the vegetation of late spring cuttings of MM111 rootstock was found to be 11,86 mm in zeolite medium and 11,73 mm in pumice medium and while the resulting cutting diameter difference was 5,53 mm in zeolite medium, it was 4,55 mm in pumice medium. The diameter of the shoots from the cuttings was 10,04 mm in zeolite medium and 9,66 mm in pumice medium and the heights of these shoots were 93,94 cm in zeolite medium and 80,66 cm in pumice medium. The root wet and dry weights were measured to be 70,16 g and 24,52 g in zeolite medium and 102,41 g and 39,16 g in pumice medium, respectively.

Results Regarding MM106 Rootstock

The characteristics of the rooting of MM106 rootstock in pumice and zeolite media as of February 19 (early spring) are presented together in Table 8.

In the statistical analysis performed between the media, a statistically significant difference at the level of 5% was found in terms of the criteria of the percentages of the rooted cuttings, diameter increment and diameter difference at the end of the vegetation period, the diameter increment of the shoots from the cuttings, the height development of these shoots, and root wet and dry weights. Only 1,12% of the cuttings of MM106 clonal rootstock, 21,12% of which rooted in zeolite medium, rooted in pumice medium. While the diameter increment at the end of vegetation was 9,31 mm in zeolite medium, it reached 17,59 mm in pumice. According to this, while the diameter thickness difference was 1,28 mm in zeolite medium, it was 8,89 mm in pumice medium. The diameter of the newly formed shoot was 4,7 mm in zeolite medium and 13,48 mm in pumice medium. Upon comparing the heights of the formed shoots, the shoot height, which was 40,24 cm in zeolite medium, reached 131 cm in pumice medium. Root wet and dry weights were 29,98 g and 11,64 g in zeolite medium and 110,35 g and 47,15 g in pumice medium, respectively.

It was determined that there was a statistically significant difference at the level of 5% between zeolite and pumice media upon comparing the rooted percentages of MM106 cuttings planted on March 10 (late spring). The diameter increment and diameter difference at the end of the vegetation period, the diameter increment of the shoots from the cuttings, height development of these shoots, the mean root wet and dry weights of the cuttings rooting in the 2006 plantings of MM106 rootstock were found to be statistically insignificant when the media were compared (Table 9). As can be understood from Table 9, only 17.8% of the cuttings of MM106 apple clonal rootstock, 35,54% of which could root in zeolite medium, rooted in pumice medium. The diameter increment at the end of the vegetation period of the rooted cuttings was 11,13 mm in zeolite medium and 9,94 mm in pumice medium, while the diameter difference at the end of vegetation was 4,3 mm in zeolite, it was 3,38 mm in pumice. The diameter formed from the cutting was 8,58 mm in zeolite and 7,37 mm in pumice; the length of the shoot formed was 85,97 cm in zeolite and 54,10 cm in pumice. Root wet weights were determined to be 59,03 g in zeolite medium and 70,56 g in pumice medium, and root dry weights were determined to be 21,86 g in zeolite medium and 24,18 g in pumice medium.

Table 6. Rooting characteristics of MM111 rootstock in pumice and zeolite media as of 2007 (early spring)

Media	Root number (%)	Initial diameter (mm)	Final diameter (mm)	Diameter difference (mm)	Shoot diameter (mm)	Shoot height (cm)	Root wet wt. (g)	Root dry wt. (g)
Zeolite	6,63 a (3,34)	7,82 a	8,93 b	1,11 b	5,47 b	41,75 b	31,78 a	11,17 a
Pumice	8,21 a (3,36)	7,68 a	13,25 a	5,57 a	10,79 a	90,66 a	84,33 a	28,44 a

Table 7. Rooting and growth characteristics of MM111 rootstock as of March 10

Media	Root number (%)	Initial diameter (mm)	Final diameter (mm)	Diameter difference (mm)	Shoot diameter (mm)	Shoot height (cm)	Root wet wt. (g)	Root dry wt. (g)
Zeolite	27,99 a (22,24)	6,33 a	11,86 a	5,53 a	10,04 a	93,94 a	70,16 a	24,52 a
Pumice	8,21 b (3,36)	5,76 a	11,73 a	5,97 a	9,66 a	80,66 a	02,41a	39,16 a

Table 8. Rooting characteristics of MM106 rootstock in pumice and zeolite media as of February 19 (early spring)

Media	Root number (%)	Initial diameter (mm)	Final diameter (mm)	Diameter difference (mm)	Shoot diameter (mm)	Shoot height (cm)	Root wet wt. (g)	Root dry wt. (g)
Zeolite	27,25 a (21,12)	8,34 a	9,31 b	1,28 b	4,70 b	40,24 b	29,98 b	11,64 b
Pumice	2,73 b (1,12)	8,70 a	17,59 a	8,89 a	13,48 a	131,00 a	110,35a	47,15 a

Results Regarding M9 Rootstock

The characteristics of the rooting of M9 rootstock in pumice and zeolite media as of 2007 (early spring) are presented together in Table 4.10.

A sample could be taken from a single plant in zeolite medium in the planting of M9 rootstock in 2007 (early spring) and since there was no rooted cutting in pumice medium, no data could be obtained and therefore, no comparison was made.

The rooting characteristics of M9 rootstock in pumice and zeolite media as of 2006 (late spring) are presented together in Table 11.

Upon examining the data of the March 10 (late spring) planting of M9 apple clonal rootstock, the percentages of the rooted cuttings, the diameter increment and diameter difference at the end of the vegetation period, the diameter increment of the shoots from the cuttings, height development of these shoots, the root wet and dry weights were found to be statistically insignificant according to the media. In general, the rooting rates, which can be defined to be at the insufficient level, were determined to be 15,54% in zeolite medium and 6,7% in pumice medium.

Table 9. Rooting characteristics of MM106 rootstock in pumice and zeolite media as of March 10 (late spring)

Media	Root number (%)	Initial diameter (mm)	Final diameter (mm)	Diameter difference (mm)	Shoot diameter (mm)	Shoot height (cm)	Root wet wt. (g)	Root dry wt. (g)
Zeolite	36,53 a (35,54)	6,83 a	11,13 a	4,30 a	8,58 a	85,97 a	59,03 a	21,86 a
Pumice	24,37 b (17,80)	6,55 a	9,94 a	3,38 a	7,37 a	54,10 a	70,56 a	24,18 a

Table 10. Rooting characteristics of M9 rootstock in pumice and zeolite media as of February 19 (early spring)

Media	Root number (%)	Initial diameter (mm)	Final diameter (mm)	Diameter difference (mm)	Shoot diameter (mm)	Shoot height (cm)	Root wet wt. (g)	Root dry wt. (g)
Zeolite	(1,11)	6,69	11,45	4,76	5,64	41,00	21,44	7,29
Pumice	0	0	0	0	0	0	0	0

Table 11. Rooting characteristics of M9 rootstock in pumice and zeolite media as of March 10 (late spring)

Media	Root number (%)	Initial diameter (mm)	Final diameter (mm)	Diameter difference (mm)	Shoot diameter (mm)	Shoot height (cm)	Root wet wt. (g)	Root dry wt. (g)
Zeolite	20, 75 a (15,54)	7,85 a	14,12 a	14,12 a	6,26 a	8,80 a	53,57 a	9,26 a
Pumice	13,03 a (6,70)	7,10 a	7,10 a	11,60 a	4,50 a	7,79 a	30,20 a	12,24 a

Results Regarding Quince A Rootstock

The characteristics of the rooting of Quince A rootstock in pumice and zeolite media as of February 19 (early spring) are presented together in Table 12.

While the rooting percentages of Quince A rootstock planted in February 19 (early spring) were found to be significant at 5% level when compared by the media, the diameter increment and diameter difference at the end of the vegetation period of this rootstock, the diameter increment of the shoots from the cuttings, height development of these shoots, the root wet and dry weights were found to be statistically insignificant by the media. As can be seen from Table 12, while 11,14% of Quince A rootstock cuttings could root in zeolite medium, only 2.22% of the cuttings could root in pumice medium. While the mean cutting diameter at the end of the vegetation period was 11,09 mm in zeolite and 11,25 mm in pumice, the diameter differences were 4,51 mm in zeolite medium and 5,24 mm in pumice medium. Upon comparing the diameters and heights of the shoots from the cuttings, the shoot diameter, which was 6,60 mm in zeolite medium, was 11,25 mm in pumice medium and the shoot height, which was 81,28 cm in zeolite medium, was 87,50 cm in pumice medium. When the root wet and dry weights of the rooted cuttings were examined, the root wet weight was measured to be 69,56 g in zeolite medium and 39,17 g in pumice medium and the root dry weight was measured to be 24,80 g in zeolite and 16,76 in pumice medium.

The rooting characteristics of Quince A rootstock in pumice and zeolite media as of March 10 (late spring) are presented together in Table 13.

In the 10 March (late spring) plantings of Quince A rootstock, it was determined that there was a statistical difference between the media in terms of the percentages of the rooted cuttings and the heights of the shoots from the cuttings at the end of the vegetation period (Table 13). While the percentages of the rooted cuttings were 61,12% in zeolite medium, they remained at 7,82% in pumice medium. While the height of the shoots formed at the end of the vegetation period was 110,88 cm in zeolite medium, it was 72,00 cm in pumice medium. There was no significant difference in the cutting diameters at the end of the vegetation period, the differences between the initial and final diameters, the diameter of the shoots formed, and the root wet and dry weights of the rooted cuttings. While the cutting diameters at the end of the vegetation period were 12,94 mm in zeolite medium, they were 10,56 mm in pumice medium. Upon examining the diameter measurement differences of the cuttings, the diameter difference of 4,50 mm in zeolite medium was 2,93 mm in pumice medium. The diameter of the shoots from the cuttings was 8,06 mm in zeolite medium and 6,27 mm in pumice medium. The root wet weight was 34,23 g in zeolite and 41,95 g in pumice and the root dry weight was 18,16 g in zeolite and 18,80 g in pumice medium.

Results Regarding GF–677 and Maxma–14 Rootstocks

Since there was no rooting in GF–677 and Maxma–14 rootstocks, no data were obtained and no analysis was performed on these rootstocks.

Table 12. Rooting characteristics of Quince A rootstock in pumice and zeolite media as of February 19 (early spring)

Media	Root number (%)	Initial diameter (mm)	Final diameter (mm)	Diameter difference (mm)	Shoot diameter (mm)	Shoot height (cm)	Root wet wt. (g)	Root dry wt. (g)
Zeolite	18,65 a (11,14)	6,58 a	11,09 a	4,51 a	6,60 a	81,28 a	69,56 a	24,80 a
Pumice	3,89 b (2,22)	6,01 a	11,25 a	5,24 a	11,25 a	87,50 a	39,17 a	16,76 a

Table 13. Rooting characteristics of Quince A rootstock in pumice and zeolite media as of March 10 (late spring)

Media	Root number (%)	Initial diameter (mm)	Final diameter (mm)	Diameter difference (mm)	Shoot diameter (mm)	Shoot height (cm)	Root wet wt. (g)	Root dry wt. (g)
Zeolite	52,03 a (61,12)	8,44 a	12,94 a	4,50 a	8,06 a	110,88 a	34,23 a	18,16 a
Pumice	15,77 b (7,82)	8,42 a	10,56 a	2,93 a	6,27 a	72,00 b	41,95 a	18,80 a

DISCUSSION AND CONCLUSION

It is of great importance for the arboriculture sector to develop or contribute to the development of the methods used for the rapid production and propagation of rootstocks, which are very important for fruit growing (6, 7, 8). In this study, the rooting rates, initial diameter, final diameter, diameter difference, shoot diameter, shoot height, root wet weight and root dry weight values of nine different rootstocks were examined in two different periods in zeolite and pumice media and the data obtained were evaluated. In this context, while Pixy rootstock, which is known to have a high rooting ability (1), reached the highest percentage of rooting rate with 87,7% in zeolite medium in the 2006 late spring period, it was also found to be significant in terms of the shoot height development. The fact that Pixy rootstock displays a high rooting rate and sapling performance in zeolite medium is positive and significant in demonstrating the ability of production with cuttings, one of the open field and conventional production techniques in sapling growing. While Myrobolan 29–C, another plum clonal rootstock, rooted at the rate of 30% in zeolite medium, the rooting of it was realized at 17,78% in pumice medium. In the case that this rooting success, which is yet far from being satisfactory and economical, is increased (when the rooting of young shoots as green cuttings in May–June is evaluated), it will be likely that the production of this largely imported rootstock will be performed in Turkey. In Quince A rootstock, of which cuttings belong to an easily rootable quince type, that has the characteristics of the most widely used clonal rootstock (5, 8, 12), very good results were obtained in terms of the high rooting and sapling development by early planting in zeolite medium. M9, MM106, and MM111 rootstocks, which are among the widely used apple clonal rootstocks in the world and in our country, are usually propagated in the stool bed system and presented to the arboriculture sector (Camia and Widmann, 1982, 16). In order to be produced in this way, firstly, a stool bed breeding plant is required. However, the cutting planting to be carried out in the field conditions will provide less expensive and easier production. However, it is important that the cuttings planted should be satisfactorily rooted so that such a production can become widespread. In this study, the rooting performances of the cuttings of MM106 apple clonal rootstock, 35,54% of which could root in zeolite medium and 17,8% in pumice medium, were not found to be sufficient. For the propagation with cuttings to be economical, it is expected that the rooting efficiencies are above 70%. Similarly, the rooting rates, which could be considered to be at the insufficient level, were realized in M9 rootstock and M9 rootstocks could root at 15,54% in zeolite medium and 6,70% in pumice medium. The cutting rooting rates in MM111 rootstock were 27,99% in zeolite medium and only 8,21% in pumice medium. The results obtained from the study reveal that the production with cuttings in apple clonal rootstocks is not at the level that can be an alternative to the production with the stool–bed system. However, it is possible to increase the rooting efficiencies in apple clonal rootstocks with a combination of different planting times (planting in December–January) and different applications (pre–callusation in the sand and the use of growth regulator in different doses). While no rooting and vitality were observed in both years in Maxma–14 rootstock, GF677 rootstock did not root in the 2006 late spring planting, but 3,3% rooting was ensured in the 2007 early spring planting. A similar case is in question for sl64 p. mahalep clonal rootstock and it is not recommended to produce these rootstocks with cuttings in pumice and zeolite media during these periods. Upon examining the anatomical course of the rooting in the cuttings, it was determined that the callus tissue was formed in the cuttings of Pixy, Myrobolan 29–C, SL 64, GF–677, Maxma–14, M9, MM106, MM111 and Quince A clonal rootstocks, which were removed 3 weeks after the planting and that lenticels became evident in the parts remaining in the medium. This development is consistent with the findings of researchers in many plant species (16; Cangi et al., 2000; Yildirim and Çelik, 2003). The first critical development in cutting rooting is the formation of the callus tissue at the wound site (base of the cutting). The callus tissue is very important because it is a barrier preventing rotting that may occur from the cutting base and it is a development that will provide the passage of water from the medium to the cutting within the period until rooting. Researchers have noted that cuttings that cannot form sufficient callus in the basal part rot in a short period of time (13, 14). Concerning these results obtained, the cutting plantings of Pixy and Quince A clonal rootstocks, especially in zeolite medium in March, will realise the rooting efficiencies at high levels. Green cutting applications should be tried in May–June with the use of annual fresh shoots in Myrobolan 29–C plum clonal rootstock. It is possible that more successful results will be obtained from this production to be realized under fogging. The planting time of the cuttings in SL64, Maxma–14 and GF–677 rootstocks and M9, MM106 and MM111 apple clonal rootstocks should be considered close to December and January. The cuttings to be planted in this period should be pre–callused in the sand 4–5 weeks before this. Thus, when the cuttings are transferred to the ground, it may be possible to prevent the rotting of the cutting base during the period until rooting is realized.

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