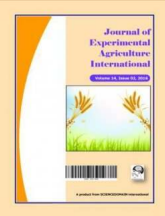

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Investıgatıon on the Rootstock Characterıstıcs of Tahar Apple (*Malus sylvestrıs* spp. *Orıentalıs*) Genotypes Grown ın Ürgüp Dıstrıct

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Authors' contributions

This work was carried out in collaboration between both authors. Authors SB and SÇ designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors SB and SÇ managed the analyses of the study. Author SB managed the literature searches. Both authors read and approved the final manuscript.

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ABSTRACT

This study was conducted on local Tahar apples, which are under extinction, grown in Ürgüp District of Nevşehir Province of Turkey between 2010-2013 in order to evalute their potantial as a dwarfing rootstock for cultivated apples. Since dwarf growing Tahar apple trees are propagated by vegetative means, the population in the region was surveyed in order to find morphologically different genotypes, if possible. Seventeen putative different genotypes were labeled. Several morphological charactersitics of plants such as plant vigor, growth habit, ramification degree, internode lenght and root suckering status were determined. The data collected from pro-selected 17 genotypes were evaluated with a Weighted Rankit Method with an emphasis to the requirement of dwarfing rootstock.

Three individuals with highest scores 50TE001, 50TE002 and 50TE012 were selected out of seventeen genotypes. Since there were very limited shoots on the pre-selected 17 genotypes, their budsticks were collected and budded on apple seedlings in the nursery to increase the shoot

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numbers for propagation experiments.The propagation ease of Tahar apples by green, soft wood and hard wood cuttings were investigated. The rooting ability of pre-selected genotypes was found to be very low or none; however, propagation by stoolbed was a success. On these plants, a detailed morphological characterisation according to UPOV criteria was performed. Also, molecular analysis (AFLP) were done in order to determine the genetic relativeness. The pre-selected genotypes fell into four phylogenetical groups. These genotypes were found to be genetically partly close to M.9. Because there were distinct differences among the individuals, the selected three Tahar apple genotypes 50TE001, 50TE002 and 50TE012 were considered as promising materials for developing a new dwarf apple rootstocks.

Keywords: Dwarfing rootstock; selection; propagation; morphological characterization; AFLP.

1. INTRODUCTION

Turkey is one of the countries with high agricultural potential and it became the 3rd biggest apple producing country in the world with its 2,569,759 tons of apple production in 2015 [1]. The objective of modern fruit breeding is to achieve abundant and high quality products per unit area at early ages. Dwarf rootstocks are of great importance in apple breeding in order to achieve this purpose. Although dwarf apple rootstocks are known well before in Turkey, commercial interest began in the aftermath of the Second World War. Instead of standard and semi-dwarf apple breeding which are rapidly rising from the 1990s onwards, High density planting of apple orchards began to be established with full-dwarf rootstocks. The number of apple varieties in the world is over 6,500. There are over 500 apple cultivars which are breeded locally and in accordance with each different ecology in our country that differs greatly in terms of ecological characteristics [2,3]. In recent years, understanding the importance of genetic resources of fruits in the world encourages hope for studies to be conducted in this field. It is very important for selection activities to be performed in the regions rich in populations to identify seed-originated genotypes with the local cultivars that find a place among our apple genetic resources and grown in various regions of Anatolia, to select the ones exhibiting superior characteristics and to prevent them from being lost [4]. The studies conducted with local apple varieties by the researchers in our country are invaluable with respect to protect our genetic resources [5,6,7,8,9,10,11,12,13,14,15,16,17, 18,19,20] However, apple breeding activities in our country remain limited by cultivar selection. In addition, since the studies conducted were not carried out under a comprehensive program they did not become continuous, only the characteristics of types have been identified and in fact these materials have not been protected most of the time [21]. The local cultivars which do not have too much economic value and generally appeal to family consumption or to the local market are of great value genetically and are a unique material for the breeding activities. Yet, the cultivars appropriate for this purpose of breeding have been selected from such populations and have been improved as a result of selection studies. These types which are situated in seedling rootstock populations and perhaps each of which provides a cultivar have disappeared either by cutting or drying up by itself in time. For this purpose, numerous studies for determining local cultivars, for imroving and protecting them are in progress both in our country and abroad [22]. Tóth et al. [23] indicated that the former local apple cultivars trying to continue living in their original growing place could be an important gene source for the breeding programs for apple cultivars and reported that they gathered the local apple cultivars in Ukraine in a collection garden since 1997 and evaluated them and offer them for the service of geneticists.

Biological diversity is indispensable and important in meeting the basic needs of the people mainly the food. It is estimated that the global biodiversity will be lost by 20% by 2020 due to the pollution caused by human activities as well as the continuous and misuse of natural resources [24]. Similarly, Tahar apples that we studied on are under treat. In the interviews performed with local residents of Ürgüp, they reported that very few Tahar apples which are formerly intensively cultivated have remained today because they have lost their significance as a result of cultivating new cultivars, they are left to their own as a result of migration from villages to cities, suffered from lack of care and also for reasons such as having destroyed during works such as road opening and land expansion.

Ulkumen [25] who is one of the first scientists of our country in fruit growing, emphasized the importance of Tahar apple as a breeding material nearly 40 years ago. Tahar apples can grow without any irrigation and cultural process in an ecology that the annual rainfall is around 400 mm [26].

In this study, it has been aimed that new dwarf apple rootstock candidates contribute to the country's economy by selecting and reproducing the genotypes that may have the potential to be dwarf rootstock among the local Tahar apple (*Malus sylvestris* spp*. orientalis*) population grown in Urgup district of Nevsehir province located in the Central Anatolia Region and facing extinction, determining the relationship degree of the genotypes with molecular markers and and by making morphological characterization.

2. MATERIALS AND METHODS

2.1 Materials

This study was conducted on Tahar apple population which is a local cultivar grown in Ürgüp District and its vicinity between the years of 2010 and 2013 and on the materials obtained from this population in Kahramanmaraş Sütçü İmam University Faculty of Agriculture, Department of Horticulture.

2.2 Methods

It is determined by making species diagnosis before starting activities on the material selection that Tahar apple exist in *Malus sylvestris* subsp. *orientalis*. For the selection activities of Tahar apple genotypes, the genotypes which are observed to be morphologically different from each other when examining the existing population at the dates of 27-28-29 March 2010 during which plants are stagnant is noted to the rootstock selection card with land information form by considering them. The main plants among the selected genotypes were labeled and their coordinates were determined by the GPS device. Tahar apple genotypes of which selection number have been evaluated according to the UPOV (International Union forthe Protection of New Varieties of Plants) specifications table given in Table 1 [27].

A stagnant T-budding was conducted on seedling rootstocks by taking graft from selected genotypes in the fall of 2010. In this way, both the genotypes were protected and their propagation characteristics with cutting were examined. The studies on propagation with cutting were done using 0, 1000, 2000, 3000 ppm doses of IBA under greenhouse conditions in three ways including softwood cutting, semi-hardwood cutting and hardwood cutting. In addition, the propagation of genotypes was tried with stoolbed layering method. M.9 (control) apple rootstock plantings on land (1 x 2 m) was performed with the rooted genotypes obtained, morphological characterization studies were conducted on genotypes according to UPOV. In this context; in spring when the leaves attain their massiveness fully; regarding the leaves; leaf blade length, leaf blade width, the ratio of leaf blade length to the leaf blade width, the petiole length, the ratio of leaf blade to the petiole length, young leaf intensity of anthocyanin coloration, young leaf hue of anthocyanin coloration, leaf blade attitude in relation to shoot, leaf blade profile in cross section, leaf blade length of pointed tip, leaf blade incisions of margin, leaf blade pubescence on lower side, leaf blade anthocyanin coloration of veins, petiole length, and the characteristics of plants such as plant vigor, plant number of branches, plant habit, one year old shoots; shoot growth, shoot pubescence shoot glossiness of bark, shoot thickness, shoot length of internodes, shoot number of lenticels, shoot size of lenticels, shoot shape of lenticels, shoot predominant color on sunny, shoot size of vegetative bud, shoot shape of tip of bud, shoot position of bud relative to axis, shoot size of vegetative bud support, shoot color of growing tip, time of beginning of bud burst were studied after leaf fall in autumn.

Table 1. Selection scoring according to the characteristics used for the selection of genotypes

Feature	Score	Categories	Note
Plant vigor		Weak	10
	35	Medium	5
		Strong	1
Plant habit		Upright	1
	25	Semi upright	3
		Spreading	7
		Weeping	10
Plant numbers		Weak	10
of branches	10	Medium	7
		Strong	3
Length of		Short	10
internodes	15	Medium	7
		Long	1
Suckering		Absent	10
tendency		Low	7
	15	Medium	3
		High	1
Total	100		

The degree of relationship between genotypes has been tried to determine by analysis of the AFLP (Amplified Fragment Length Polymorphism). In determining the relationship between 17 genotypes of Tahar apple with each other and M.9 dwarf apple rootstocks, a total of 4 marker combinations including 4 EcoRI (EcoR I-AAT, EcoR I-AAC, EcoR I-ATA, EcoR I-AGT) markers including 3 selective nucleotides labeled with 6-FAM, NED and VIC fluorescent dyes and 1 MseI (MseI_CTC) unlabeled marker including 3 selective nucleotides have been used at the selective PCR stages in the AFLP analysis. The genetic diversity analyzes were carried out by using Popgen 3.2, while the genetic tree was made using the Mega 3.1.

3. RESULTS AND DISCUSSION

3.1 Selection of Tahar Apple Genotypes

Tahar apple genotypes that seem to be morphologically different were tried to be selected during selection considering the danger of extinction of the type. Various plant characteristics of selected Tahar apple genotypes are given in Table 2.

Tahar apple genotypes were selected at minimum 1220 m altitude (50TE009) and at maximum 1469 m altitude (50TE012). In this case, it should be considered that the genotypes can be used in areas with similar altitude and conducting apple cultivation in our country. If Tahar apples are desired to be cultivated in regions with lower altitude, their chilling requirement should be considered. The estimated ages of genotypes vary between 4 (50TE006) and 40 (50TE003) and genotype lengths vary between 105 cm (50TE012) and 185 cm (50TE005). The cultivars grafted on rootstocks have important implications downsizing their length by acting on the growth characters [28]. That the length of the 50TE003 numbered 40 years old genotype which is found to be the oldest plant is 120 cm shows that Tahar apple has a a continuous potential of being dwarf. In general, apple rootstocks are classified as full-dwarf, dwarf, semi-dwarf, semi-strong and very strong according to the development vigor. According to this classification, M.27 is included in full-dwarf group, M.9 is included in dwarf group, while M.7 or MM.106 is included in semi-dwarf group [28]. The length of Tahar apple genotypes determined in this study shows that these genotypes can be included in full-dwarf group. In addition, that development vigor of some of these genotypes is weak suggest that they can also be used for the purpose of “Super High Density Planting”.

Table 2. Various plant characteristics of studied tahar apple genotypes

Number	Selection code	AP	LP	SS	PV	PH	B	BA	ST	LI	FT
1	50TE001	30	120	3	1	2	2	3	1	1	2
2	50TE002	30	125	1	1	3	1	3	2	1	3
3	50TE003	40	120	3	3	2	1	3	4	1	1
4	50TE004	30	136	3	1	1	1	3	4	1	3
5	50TE005	20	185	3	3	1	2	2	4	1	3
6	50TE006	4	150	3	3	3	1	3	1	1	2
7	50TE007	30	175	3	3	2	2	2	4	1	2
8	50TE008	20	140	3	3	3	3	2	2	1	2
9	50TE009	5	110	1	3	3	2	2	1	1	1
10	50TE010	30	120	1	3	3	3	2	2	1	2
11	50TE011	30	130	1	2	1	3	3	2	1	1
12	50TE012	10	105	1	1	3	1	2	2	1	2
13	50TE013	10	150	3	3	1	1	3	4	1	2
14	50TE014	20	160	1	2	1	1	2	1	1	2
15	50TE015	8	150	3	3	3	3	3	3	1	1
16	50TE016	10	130	3	3	1	2	2	3	1	1
17	50TE017	25	160	3	1	3	3	3	4	1	1

AP (The estimated age of the plant); LP (The height of the plant(m); SS (stem status): single stem (1), 2-3 stems (2), bush (3); PV (Plant vigor): weak(1), medium (2), strong (3); PH: (plant habit): upright(1), semi upright(2), spreading(3), weeping(4); B (branching): weak (1), medium (2), strong (3); BA (branch angles): narrow (1), medium (2), large (3); ST (suckering tendency): absent (1), low (2), medium (3), high (4); LI (length of internodes): short (1), medium (2), long (3); FT (flowering time): early (1), medium (2), late (3)

The genotypes weighted rankit methods are determined by considering morphological characteristics such as dwarf apple rootstock which is one of the pre-selected genotypes, plant vigor, plant habit, branching, length of internodes, suckering tendency. The 50TE002 and 50TE012 numbered genotypes having the highest value with 880 score and 50TE001 numbered genotype with the score of 795 which closely following them stand out as genotype rootstock candidates among Tahar apple genotypes. It has been concluded that the 50TE002 and 50TE012 numbered genotypes that share being the first by taking the highest score can be taken into account in terms of rootstock characteristics since the plant vigor is weak, they are growing as a single spreading stem, having weakly branching, short length of internodes, low tendency to suckering in both of them. Similarly, it is especially important that the 50TE001 numbered genotype that closely following these two genotypes does not create a suckering. It is a major problem that M.9 apple rootstock, which is widely used around the world, creates a tendency suckering. In order that the tree growth is healthy and there is no problem of fire blight, the suckering of M.9 apple rootstock should be cleaned. For this purpose, at a 1.5-2% dose of NAA (Naphthalene Acetic Acid) administration when the shoots are young is recommended for avoiding the suckering [29]. Or the young suckering should be cleaned with the pruning shears. This leads to an increase in the labor force particularly in commercial orchards [30]. In this case, it is important in this respect that 3 selected genotypes create few or no suckering. Because of that the 50TE005 numbered genotype which had the lowest score of 295 grew stronger than other genotypes and their potantial of creating suckering is higher, it is the last at the ranking among genotypes.

3.2 Studies Conducted for Propagation of the Selected Genotypes with Vegetative Method

In order to develop the genotypes which selection stage has been completed as dwarf apple rootstock candidate, they were grafted on seedling rootstocks with stagnant T-budding by taking grafts from the genotypes in the fall of 2010 for the purpose of examining the propagation characteristics. Seventeen genotypes out of a total of 1200 grafts were performed and a graft success with the rate of 95% has been achieved. The top cutting was done before awaking the buds belonging to the genotypes grafted on seedling rootstock in the plantation and it was ensured that the graft buds were maintained. The graft shoots grew in a healthy way and flowers were observed on all shoots in mid-April. These flowers then fructified; however, these fruits were plucked to prevent the shoot growth. This feature shows that Tahar apple genotypes have a potential of fructifying at an early age. Similarly, it can be expected that the standard varieties grafted on Tahar apple to fructify at an early age.

3.2.1 Propagation by cuttings

Rooting was tried to be conducted in fogging unit at perlite medium in the greenhouse by taking 25 softwood cuttings from each genotype in June 2011 in order to induce rooting by using 0, 1000, 2000 and 3000 ppm doses of IBA (Indole Butyric Acid) as a growth regulator. Although the softwood cutting created callus layer, no rooting occured. When no succesful propagation was achieved with the softwood cutting, 25 semi-hardwood cuttings were taken from each genotype in September 2011, rooting was tried to be conducted in fogging unit at perlite medium in the greenhouse by using 0, 1000, 2000 and 3000 ppm doses of IBA. However, although the cuttings created callus layer, no rooting occured again. At least 25 hardwood cuttings from each genotype were prepared in February 2012 when the plants are at rest. Rooting was tried to be conducted at perlite medium in the bottom heated greenhouse by using 0, 1000, 2000 and 3000 ppm doses of IBA. In the rooting work carried out, rooting occured only in 4 cuttings. These rooting plants creating good degree of callus with 20 plants were placed in pots in a greenhouse environment. However, the plants lost their vitality after a while despite optimal care conditions. This suggests that Tahar apple genotypes cannot be propagated with cutting easily. In fact, propagation with cuttings is a preferred method for easily rooting plant types [31]. While for propagation by the stoolbed method is recommended in some apple clone rootstocks such as Tahar apple instead of propagation with cutting [32].

3.2.2 Propagation by layering

The stoolbed method was performed on Tahar apple genotypes in the first week of May 2012 in plantation conditions. The rooted plants obtained by stoolbed were planted with M.9 apple rootstock as a control to a parcel when the soil became appropriate for planting (1 x 2 m). A total

of 90 rooted plant belonging to various genotypes were obtained with the stoolbed method.

3.3 Morphological Characterization of Selected Tahar Apple Genotypes

Determining the morphological characteristics of Tahar apple was started in June 2012 when the leaves begin to get their full size. In order to compare the morphological characteristics of rootstock candidate genotypes and also M.9 dwarf apple rootstock with the rooted plants at the same age and planted at the same time were examined as witness. The data regarding quantitative characteristics such as measured leaf blade length, leaf blade width, the ratio of leaf blade length to leaf blade width, petiole length, the ratio of leaf blade length to petiole length of the leaves of the selected rootstock candidate genotypes and M.9 rootstock are given in Table 3.

The leaf blade length of quantitative characteristics performed for the leaves of the selected rootstock candidate genotypes and M.9 rootstock are found between 3.20 and 6.60 cm. The width of leaf blade varied between 1.40 and 4.95 cm. The ratio of leaf blade length to leaf blade width varied between 1.29 and 2.66. The petiole length varied between 1.15 and 2.20 cm. The ratio of leaf blade length to the petiole is between 2.46 and 5.90.

The analyzed values such as the young leaf intensity of anthocyanin coloration in genotypes and M.9 apple rootstock leaves, young leaf hue of anthocyanin coloration, leaf blade attitude in relation to shoot, leaf blade profile in cross section, leaf blade length of pointed tip, leaf blade incisions of margin, leaf blade pubescence on lower side, leaf blade anthocyanin coloration of veins, petiole length are given in Table 4.

When the analyzed characteristics in the leaves of genotypes in morphological characterization studies and the characteristics of M.9 apple rootstock used as a control in this experiment, they were found to be similar partially.

The characteristics such as the development of the plant vigor, plant number of branches, plant habit, one-year-old shoot growth after defoliation in selected rootstock candidate genotypes and M.9 rootstock shoots in fall, and in one year old shoot pubescence, one year old shoot glossiness of bark, one year old shoot thickness, one year old shoot length of internodes, one year old shoot number of lenticels, one year old shoot size of lenticels, one year old shoot shape of lenticels, one year old shoot predominant color on sunny, one-year-old shoot size of vegetative, one year old shoot shape of tip of bud, one year old shoot position of bud relative to axis, one year old shoot size of bud support, one year old shoot color of growing tip, time of beginning of bud burst are provided totally in Table 5.

When investigated characteristics of in the plants and shoot genotypes in morphological characterization studies and the characteristics of M.9 apple rootstock used as a control in this experiment; it has been found that they are similar partially; however, they are found to be quite different than M.9 when considered together with all the characteristics.

Table 3. The measurement results of some quantitative characteristics studied in leaves of M.9 apple rootstock with genotypes

Genotypes	Blade Length (cm)	Blade Width (cm)	Blade Ratio length/width	Petiole length (cm)	Ratio length of blade/ length of petiole
M.9	6.60a	4.95a	1.29f	1.15c	5.90a
50TE001	5.75c	2.80d	2.07b	1.20c	4.96b
50TE002	5.95bc	4.00b	1.39ef	2.20a	2.73de
50TE003	5.70c	3.15c	1.80cd	1.30c	4.60b
50TE004	3.70d	1.40g	2.66a	1.20c	3.20cde
50TE007	3.75d	1.75f	2.17b	1.20c	3.32cd
50TE008	3.90d	2.40e	1.65de	1.25c	3.20cde
50TE011	3.90d	2.40e	1.50ef	1.20c	3.40cd
50TE012	3.20e	2.40e	1.34f	1.30c	2.46e
50TE015	5.60c	2.75d	2.08b	1.80b	3.10cde
50TE016	5.75c	2.80d	2.13b	1.20c	4.94b
50TE017	6.40ab	3.25c	1.95bc	1.80b	3.62c

** The difference between the values indicated by different letters is significant at the p<0.05 level.*

Table 4. Observation results of some morphological characteristics studied in M.9 apple rootstock leaves with genotypes

Genotip	YAC	YHAC	LARS	LPCS	LPT	LİM	LPS	LAC	PL
M.9	9	2	7	2	5	1	3	3	3
50TE001	1	1	3	1	5	2	3	3	3
50TE002	9	2	3	1	5	2	3	3	3
50TE003	1	1	7	1	3	2	3	3	3
50TE004	9	2	3	2	5	1	3	3	3
50TE007	1	1	3	2	3	2	3	3	3
50TE008	1	1	3	2	3	2	3	3	3
50TE011	1	1	3	2	5	1	5	3	3
50TE012	1	1	3	2	5	1	3	3	3
50TE015	1	1	3	2	3	1	3	3	3
50TE016	1	1	3	2	5	1	3	3	3
50TE017	1	1	7	2	7	1	3	3	3

YAC (Young leaf intensity of anthocyanin coloration): absent (1), present (9); YHAC (Young leaf hue of anthocyanin coloration): bronze (1), purple (2); LARS (Leaf blade attitude in relation to shoot): semi upward (3), outwards (5), semi downwards (7); LPCS (Leaf blade profile in cross section): concave (1) straight (2) convex (3)LPT (Leaf blade length of pointed tip): short (3), medium (5), long (7); LİM (Leaf blade incisions of margin): crenate (1), serrate (2); LPS (Leaf blade pubescence on lower side): weak (3), medium (5), strong (7); LAC (Leaf blade anthocyanin coloration of veins): weak (3), medium (5), strong (7); PL (Petiole length): small(3), medium (5), large (7)

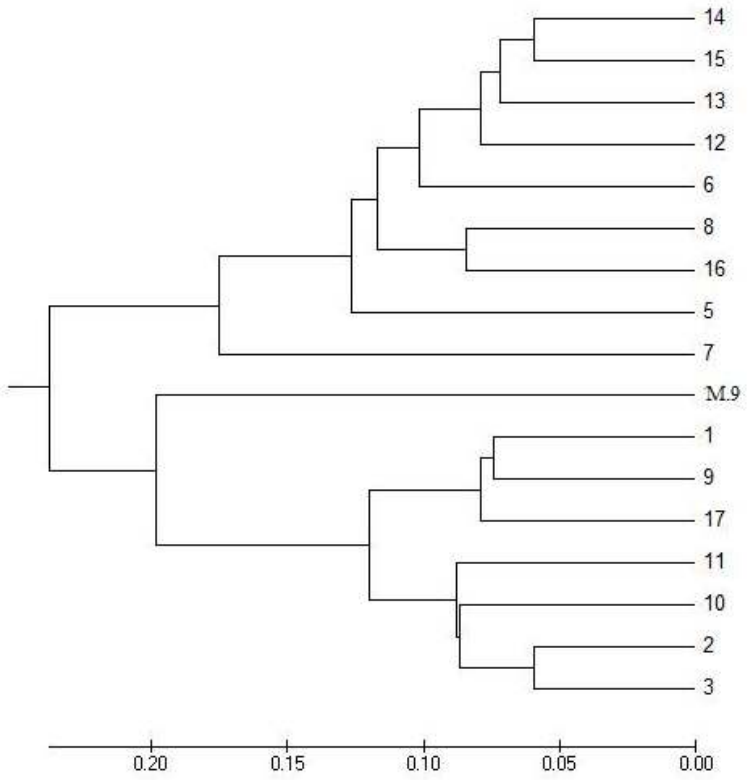

Fig. 1. The genetic similarities of genotypes between eachother and in terms of M.9 dwarf apple rootstock (50% scaled genetic tree)

Table 5. The observation results of some morphological characteristics studied in M.9 apple rootstock plant and its shoots with genotypes

Genotype	Plant						Shoot											
	PV	NB	PH	SG	SP	SGB	ST	SLI	SNL	SL	SSL	PCS	SB	SST	SPB	SSB	SCG	TB
M 9	3	3	1	1	7	7	3	3	3	5	3	2	7	1	2	3	3	3
50TE001	3	3	2	1	5	5	3	3	7	3	3	4	5	1	2	3	3	3
50TE002	3	3	1	1	5	5	3	3	3	5	3	2	3	1	2	3	3	3
50TE003	3	5	2	1	5	5	3	3	3	3	3	2	5	1	2	3	3	3
50TE004	3	5	1	1	5	7	3	3	5	3	3	2	3	1	2	3	3	3
50TE007	3	3	1	1	5	5	3	3	3	5	3	2	3	1	2	3	3	3
50TE008	3	3	2	1	5	5	3	3	5	3	3	3	3	2	1	3	3	3
50TE011	3	1	1	1	5	3	3	3	3	5	3	3	3	1	2	3	1	3
50TE012	3	1	1	1	5	3	3	3	5	3	3	3	3	1	1	3	1	3
50TE015	3	1	1	1	5	3	3	3	5	3	3	2	3	1	2	3	3	3
50TE016	3	1	1	1	5	7	5	3	3	3	3	2	3	1	2	3	3	3
50TE017	3	3	1	1	7	5	3	3	3	5	3	2	5	2	2	3	1	3

PV (Plant vigor): weak (3), medium (5), strong (7); NB (Plant number of branches): Very few (1), few (3), medium (5), many (7), very many (9); PH (Plant habit): upright (1), spreading (2), weeping (3); SG (One year old shoot growth): straight (1), wavy or zigzag (2); SP(One year old shoot pubescence) absent or weak (1), weak (3), medium (5), strong (7), very strong (9) SGB (One year old shoot glossiness of bark) absent or weak (1), weak (3), medium (5), strong (7), very strong (9); ST (One year old shoot thickness): thin (3), medium (5), thick (7); SLI (One year old shoot length of internodes) short (3), medium (5), long (7); SNL (One year old shoot number of lenticels): absent or very few (1), few (3), medium (5), many (7), very many (9); SL (One year old shoot size of lenticels): small (3), medium (5), large (7); SSL (One year old shoot shape of lenticels): elliptic (1), broad elliptic (2), circular (3); PCS (One year old shoot predominant color on sunny):greenish brown (1), reddish brown (2), medium brown (3), dark brown (4); SB (One year old shoot size of vegetative bud): small (3), medium (5), large (7); SST (One year old shoot shape of tip of bud): pointed (1), rounted (2); SPB (One year old shoot position of bud relative to axis): adpressed (1), slightly held out (2), markedly held out (3); SSB (One year old shoot size of bud support): small (3), medium (5), large (7); SCG (One year old shoot color of growing tip): whitish (1), greenish (2), reddish (3), blackish (4); TB (Time of beginning of bud burst): very early (1), early (3), medium (5), late (7), very late (9)

Table 6. The genetic distances of genotypes between each other and in terms of M.9 dwarf apple rootstock (%)

	1	2	3	5	6	7	8	9	10	11	12	13	14	15	16	17
1																
2	0.2763															
3	0.2877	0.1189														
5	0.7463	0.4631	0.4495													
6	0.7463	0.4361	0.3969	0.2318												
7	0.6427	0.5792	0.4495	0.3469	0.3969											
8	0.4631	0.2650	0.2538	0.2538	0.2763	0.3716										
9	0.1484	0.1892	0.2210	0.6105	0.6427	0.5489	0.4098									
10	0.2318	0.1686	0.1789	0.4909	0.4909	0.4909	0.3347	0.1686								
11	0.3347	0.1585	0.1892	0.3716	0.3716	0.4495	0.2318	0.2877	0.1789							
12	0.4769	0.2763	0.1997	0.2427	0.2210	0.3841	0.1997	0.4495	0.2992	0.2210						
13	0.6931	0.4229	0.3591	0.2210	0.2427	0.2650	0.2427	0.6592	0.4495	0.3591	0.1484					
14	0.6592	0.3969	0.3347	0.2650	0.1789	0.2650	0.1997	0.5947	0.4495	0.3591	0.1686	0.1286				
15	0.6761	0.3591	0.3469	0.2318	0.1686	0.3469	0.2318	0.6105	0.4098	0.2763	0.1585	0.1585	0.1189			
16	0.4361	0.2427	0.2538	0.3228	0.2763	0.4229	0.1686	0.3591	0.2877	0.2318	0.1997	0.2650	0.2210	0.2318		
17	0.1585	0.1997	0.2318	0.6592	0.6265	0.5639	0.4495	0.1585	0.1789	0.2763	0.4361	0.6427	0.6105	0.5947	0.3716	
M9	0.3969	0.3969	0.4098	0.6427	0.7833	0.6427	0.5792	0.3716	0.3228	0.3841	0.5051	0.6931	0.6931	0.6427	0.5489	0.4909

Because a portion of the observation and measurement in the morphological characterization studies that we conducted on our genotypes are visual, their reliability may not be certain as morphological markers. Considering that morphological characteristics are also influenced by environmental factors, morphological characterization studies should be read in conjunction with molecular techniques. In addition, further studies are needed so that morphological criteria can be used as molecular marker in the identification studies.

3.4 Molecular Characterization of Selected Tahar Apple Genotypes

The genetic diversity of genotypes has been revealed by isolating the genomic DNAs of the genotypes with the method of AFLP (Amplified Fragment Length Polymorphism). As a result of the analysis; the genetic differences between the genotypes of Tahar apple and M.9 dwarf apple rootstock has been found as between 11% and 78%. The maximum genetic diversity has been found as 78% (0.7833) between 50TE006 numbered genotype and M.9 dwarf apple rootstock, the minimum genetic diversity has been found as 11% (0.1189) between 50TE002 numbered genotype and 50TE003 numbered genotype. Because the difference between 50TE004 numbered genotype that studied and the other genotypes are found as over 100%, it is excluded from comparisons since it is thought to arise from an error made during analysis (Table 6). Basic phylogenetic groups were created by using the UPGMA (Unweighed Pair Group Method of Aritmetic Averages) also known as the unweighted pair group using the arithmetic mean. As seen in Fig. 1, 50TE002 and 50TE003 numbered genotypes created a group, while 50TE001, 50TE009 and 50TE017 numbered genotypes created another group. Similarly 50TE012, 50TE013, 50TE014 and 50TE015 numbered genotypes created a group, while 50TE008, 50TE016 numbered genotypes created a seperate group. Thereby, it has been determined that the plants included in the experiment in 4 main phylogenetic groups. According to the obtained results, Tahar apple genotypes and M.9 apple rootstock has been found to be genetically different.

4. CONCLUSIONS

The objective of modern fruit growing is to achieve abundant and high quality products per unit area at early ages. In order to achieve this purpose, dwarfing rootstocks are of great importance in apple cultivation. New dwarf apple rootstocks for various purposes are tried to be obtained in recent years in different countries engaged in apple cultivation. Within the scope of this study, as breeding material the potential of Tahar apples having dwarf growth characteristic of which importance is emphasized and located in the vicinity of the Ürgüp district to be a rootstock to the cultivated apples has been suggested. As a result of this study; while the studies for propagation of Tahar apple genotypes with cuttings were unsuccessful a rate of 95% success has been achieved with the stoolbed layering method. It has been determined that 50TE001, 50TE002 and 50TE012 numbered genotypes stand out for the rootstock candidates having higher scores than the weighed gradation method according to the UPOV criteria and that they can be an alternative to M.9 dwarf apple rootstock.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Anonymous. Turkish Statistical Institute; 2015.
   Available:www.tuik.gov.tr
   (Accessed 15 November 2016)
2. Guleryuz M. Lecture notes on fruit and vegetable breeding. Ataturk University, Faculty of Agriculture, Department of Horticulture, Erzurum. 1988;189.
3. Özbek S. General fruit. Çukurova University publications of the Faculty of Agriculture, N, 1977;111:6.
4. Gürel HB. Phenological, pomological and morphological features of apple types grown in Central Ordu (*Malus communis* L.). Ordu University Graduate School of Natural and Applied Sciences. Master thesis. Ordu. 2010;114s.
5. Eltez M, Kaska N. Selection of superior Kasel-Amasya apple varieties bearing fruit

annually in the province of Nigde. Doga Science Journal. 1985;1-9.
6. Akca Y, Sen SM. A study on the morphological and pomological characteristicsof local apple varieties grown in and around the province of van. Journal of Agricultural Faculty of Yuzuncu Yil University. 1991;1(1):109-128.
7. Sen SM, Bostan SZ, Cangi R, Kazankaya A, Oguz HI. Morphological and pomological characteristics of local apple varieties grown in and around Ahlat. Journal of Agricultural Faculty of Yuzuncu Yil University. 1992;2(2):53-65.
8. Oguz HI, Askin MA. Studies on morphological and pomological characteristics of local apple varieties grown in Ercis. Journal of Agricultural Faculty of Yuzuncu Yil University. 1993;3(2):281-298.
9. Balta F, Uca O. Morphological and pomological characteristics of local apple cultivars grown in Igdır district. Yuzuncu Yil University Journal of Agricultural Sciences. 1996;6(1):87-95.
10. Edizer Y, Gunes M. A study on some pomological characteristics of local apple and pear varieties grown in the province of Tokat. Pome Fruits Symposium. Yalova. 1997;53–60.
11. Tekintas FE, Yarilgaç T, Islam A. Investigation of developmental status of significant local apple varieties grown in Van province on seedling rootstocks. The 3rd National Horticultural Congress of Turkey. 1999;634–637.
12. Kaya T. Researches on local apple cultivars and types grown in Gevaş district. Ordu University Graduate School of Natural and Applied Sciences. Master thesis. 2000;70.
13. Doğan A. Breeding of sakı apple varieties by klonal selection growing in Erzincan. Master thesis Ataturk University Institute of Science. Erzurum. 2001;69.
14. Kaplan N, Ozcan M, Celik M. Clonal selection of Amasya Apples. Journal of Agricultural Faculty of Ondokuz Mayis University. 2002;17(1):49-56.
15. Karlıdağ H, Eşitken A. determination of some pomological characteristics of local apple and pear varieties grown in upper Coruh Valley. Yuzuncu Yil University Journal of Agricultural Sciences. 2006;16 (2):93-96.
16. Acar S. Morphological and pomological characteristics of local apple and pear varieties grown in and around the province of Unye (Ordu). Master Thesis, Ordu University Institute of Science. Ordu; 2007.
17. Osmanoğlu A. Phenological, morpho-logical, pomological and molecular identification of apple genetic resources from Posof (Ardahan) district. Yuzuncu Yil University Graduate School of Natural and Applied Sciences. PhD. Thesis. 2008;235.
18. Kazankaya A, Yonar Y, Baser S, Dogan A, Celik F, Yavic A. Some fruit and tree characteristics of local apple varieties naturally grown in Ercis and Muradiye regions. Research Journal of Agricultural Science. 2009;2(2):89-94.
19. Ülgen SA. Determination of some characteristics of local apple (*Malus* ssp.) cultivars grown in Rize province. Ordu University Graduate School of Natural and Applied Sciences. Master thesis. 2010;148.
20. Doğru B. Determination of phenological, morphological, pomological characteristics and molecular identification of local misket apple cultivars grown Iskilip province Çorum. Master thesis Ordu University Institute of Science. Ordu. 2012;136s.
21. Atay AN, Atay E, Koyuncu F. A General view to current apple breeding programs in the world. Bahce (Scientific Journal). 2010; 39(1):31–44.
22. Bostan SZ, Acar Ş. Pomological characteristics of local apple cultivars are grown in Unye province (Ordu/Turkey). Journal of Agricultural Sciences. 2009; 2(2):15-24.
23. Tóth M, Kása K, Szani ZS, Balikó E. Tradional old apple cultivars as new gene sources for apple breeding. Acta Hort. 2004;663:609-612.
24. Karagoz A, Zencirci N, Tan A, Taskin T, Koksel H, Surek M, Toker C, Ozbek K. Protection and use of plant genetic resources. The 4th Technical Congress of Agricultural Engineers; 1996.
25. Ulkumen L. Horticulture book. Ataturk University Publications No: 275. Agricultural Faculty Publications. 1973;128.
26. Caglar S. Potential of tahar apple to be utilized as dwarf rootstock. Pome Fruits Symposium. Yalova. 1997;155–160.
27. Anonymous. UPOV apple rootstock (*Malus* Mill); 1999.
Available:http://www.upov.int/edocs/tgdocs/en/tg014.pdf

28. Ozongun S. Apple rootstocks (Apple Cultivar Book). Egirdir Horticultural Research Institute. Isparta; 2011.
29. Childers FN, Morris JR, Sibbert GS, Modern fruit science. Horticultural publications 3906 NW 31 Place. Gainesville, Florida; 1995.
30. Cummins JN, Aldwinckle HS. Review: Breeding rootstock for tree fruit crops. New Zealand Journal of Crop and Horticultural Science. 1995;23:395-402.
31. Chanana YR, Gill MIS. Propagation and nursery management. Horticulture General Horticulture Punjab Agriculture University, Ludhiana; 2008.
32. Webster AD, Wertheim SJ. Apple rootstock. In apples. CABI Publishing. Cambridge, USA; 2003.

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