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Full Length Research Paper

Nursery growing of some apple varieties using different grafting methods in greenhouse and orchard

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This study was carried out at the Eğirdir Horticultural Research Institute, between the years 2006 and 2007. The aim of this study was to investigate the advantages of apple nursery growing greenhouse rather than outdoor medium. Scions of Red Chief (dwarf), Braeburn (semi dwarf) and Mondial Gala (vigorous) apple varieties were grafted by the bench grafting and chip budding techniques on MM106 and M9 apple rootstocks. In result to evaluation of all factors, it was found that the percentage of graft survival was between 82% (greenhouse) and 69% (outdoor), sapling height 84.86 (outdoor) -146 cm (greenhouse), shoot diameter 6.84 (outdoor) -10.71 mm (greenhouse). Sapling development grafted on MM 106 apple rootstock more than M9 apple rootstocks in greenhouse and outdoor medium. On the other hand, development of Mondial Gala apple varieties was higher than Breaburn and Red Chief varieties in every medium. As graft techniques graft, survival ratio in bench graft were 82% and this ratio 64% in chip budding. In addition to sapling height, shoot diameter and shoot height was not significant. In outdoors, it could not produce branching in saplings and first quality, but in greenhouse conditions differences were been determinated according to rootstocks and varieties.

Key words: Apple, varieties, rootstock, grafting, sapling, greenhouse.

INTRODUCTION

Apple belongs to *Malus* genus of *pomoideae* sub-family in Rosacae family. There are 25 classes in *Malus* (Mitra, 2003). Culture apples come from *Malus pumila* (*Malus communis* or *Pyrus malus*). Some researchers prefer to divide these classes in three as *Malus domestica, M. pumila* and *Malus sylvestris* (Mitra, 2003). Apple is one of the outstanding temperate climate fruit which has been grown since ancient times. It is reported that apple has been grown since pre-historic times in Asia and Europe and that it has been cultured for more than 4,000 years (Özbek, 1978; Mitra, 2003; Özçağiran et al., 2004).

Cultured apple has spread to almost all areas of North and South hemisphere with temperate climate. Although, the history of cultivation of apple in North America, South Africa, New Zealand and Australia is new, today they have become centers where apple cultivation is performed with the most advanced techniques (Özçağiran et al., 2004). Apple is grown in East and West India, mountainous regions of tropic regions in America and to some extent only in Morocco in North Africa (Soylu, 2003). As for Turkey, North Anatolia along the coast of Black Sea, the passage regions of Central Anatolia and East Anatolia plateaus and the Lakes region in the south are important places for apple growing (Özkan, 1998). Turkey with its 2,550,000 ton annual yield is the third largest apple growing country after China and the USA. Turkey, which can only rank the 18th (2112 kg/da) in terms of the amount of yield from unit area, is only export 1% of its production (Anonymous, 2006a).

As a result of long improvement studies in the world, many rootstocks and varieties are offered in the market (Barritt, 2001). Among these varieties, frequent plantation based on Samur Red and Jersey Mac as early varieties, Galaxy Gala and Mondial Gala as early varieties and as late varieties Red Chief, Braeburn and Fuji dwarf (M9) and semi-dwarf (MM106) rootstocks has increased in Turkey (Yildirim, 2006). Turkey is far behind of advancements in this field. To improve fruit growing in Turkey,

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correct, healthy, qualified and sufficient amount of new varieties that have higher market value are to be grown in a short time and offered to growers (Güleryüz, 1991). In Turkey, growing of fruit sapling in the last 2 years apply traditional methods under the conditions of present applications. This method is used in the growing of almost all saplings in Turkey. Shortening this period will help sapling growers to be ready for new varieties. As new rootstocks and varieties of fruit varieties are rapidly offered in the market, the combination of new rootstocks and varieties that grower's desire can be achieved in a year or within a shorter period (Özongun et al., 2002). Şen (1986) studied rapid sapling in terms of cost and pointed out that any study with the aim of shortening this period is prominent in agriculture sector where production costs are high. He also pointed out that high cost of work force and land rents are among the most problematic matters.

Eğirdir, where 4% of apple production in Turkey is done, is an important apple and fruit sapling production center with its high number of certificated temperate climate fruit sapling production enterprises (103) and with sapling production (1,555,514) (Anonymous, 2007a).

One of the ways of reducing the cost of sapling production is to shorten the production period. It is possible to reduce sapling production season from 2 years to 8 to 9 months (Özongun et al., 2006). Şen (1986) marked that cheaper and easier labor force can be available in resting period in interior grafting. Besides, it was noted in Şen's study that mechanization opportunity can be available in grafting.

This study aims to determine a practical sapling growing method with lower cost, shorter period of production and higher quality for the town of Eğirdir and places with similar ecological characteristics.

MATERIALS AND METHODS

The study was carried out in outer environment with high plastic tunnels in Eğirdir on the field of Orchard Cultivation Research Institute located in the province of Isparta with an altitude of 940 m between 37°52' eastern latitudes and 30°49' northern longitudes. The live materials-rootstocks and scions used in this study were obtained from the same institute. In the experiment, M9 and MM106 were used as rootstocks and scions of Red Chief, Mondial Gala and Braeburn varieties taken from the cleft breeding parcel of the same institute were used as varieties. The research field is the most important apple production environment of Isparta province.

The saplings in the trail were planted according to "factorial experiment in random blocks" design in the greenhouse and outer environment with 1 m line interval and 0.2 m line order and with three repetitions and with 10 graft plants at each repetition (Kalayci, 2005). The experiment Red Chief, Mondial Gala and Braeburn varieties were planted on M9 and MM106 rootstocks by using bench grafted and chip grafted drop techniques in April 2006 on high plastic tunnel and outer environment.

After M9 and MM106, rootstocks taken from stool bed parcels on December 15 (after defoliation) were uprooted, they were washed with pressurized water and their roots and trunks were cleaned off soils. These rootstocks used in grafting and the clefts taken from Red Chief, Mondial Gala and Braeburn trees in cleft stock 1 week before grafting are kept in 2,2-dichlorovinyl dimethyl phosphate (DDVP) Dichlorvos and Rowral mixture and preserved in polyethylene bags and at 90% humidity in storehouse at 1 to 4°C until the grafting date (February 25). The grafting of the rootstocks used in grafting was done in the last week of February (Anonymous, 2005; Özongun et al., 2006). Plastic graft tie was used to tie the grafts. In order to prevent loss of moisture rate, the tips of the grafts were tipped into paraffin. As for bench grafts, the whole clefts were submerged into water (Anonymous, 2006b).

The saplings were planted in the experiment places prepared in the open and greenhouses and all necessary cultural processes were applied. The hoeing was done in April and then repeated every 20 or 30 days depending on the weeds (Yapici, 1992). The irrigation of the saplings was repeated every 4 days for 3 h with drip irrigation method. Fertilization was applied with drip irrigation (fertilization method) according to soil analysis report taken from Eğirdir agricultural analysis laboratory.

During the experiment, the meteorological data from outer environment and greenhouse were determined with an HOBO device (Sasaki et al., 2002). Monthly means and the highest and lowest mean temperatures in outer environment and greenhouse during vegetation period were recorded as centigrade.

The dates for bud bubbling, bud burst and leaf fall (Güleryüz, 1977; Özongun et al., 2006) and the success rates of grafting after the saplings rooted in November 2006 were determined in numbers and marked in percentage (Yilmaz ve Akça, 2003). The length and diameter of shoots and the length of the sapling was determined according to Anonymous (1984b), the number of laterals was according to Küden and Kaşka (1992) and the quality of the sapling was according to Anonymous (2004b). The data obtained were assessed with JMP statistical program (Kalayci, 2005).

RESULTS

In this study, interior grafts of varieties with different development characteristics (Mondial, Gala, Braeburn and Red Chief) were applied on different rootstocks (M9 and MM106) and opportunities to grow saplings in greenhouses (high plastic tunnel) are sought for transition zones. In this study, the differences between outer fields and greenhouses in terms of graft success rates, sapling lengths and length of shoots, the numbers of lateral and 1st class sapling rates were assessed.

The saplings were planted in experiment places in open and greenhouse and necessary cultural processes are applied. Among this procedure, irrigation was done with drip irrigation method and the fertilization program was applied with water whereas fertilization method according to analysis results from Eğirdir agricultural analysis laboratory (Table 1).

Meteorological data during the experiment period in outer environment and greenhouse where the research was started and ended are given in Table 2 as mean monthly temperature, the lowest and highest monthly temperature.

When the temperature differences between greenhouse and outer environment during the experiment period was examined, it was seen that the total daily average temperature in greenhouse was 1193.7°C more than the outside in the period between the plantation of

Table 1. The amount of fertilizer given to parcels experiment (g/saplings).

	Fertilizer	February	March	April	May	June	July	August	September	October	Total
Fertigasyon application	Ammonium nitrate	-	-	-	16.5	22	9.63	1.375	-	5.5	55
	Mono ammonium phosphate	-	5	10	6.25	1.25	-	-	-	2.5	25
	Phosphoric acid	Applied to 2.5 kg per hectare per year									
	Potassium nitrate	-	-	-	-	10	9	4	-	3	26
	Total	-	5	10	23	33	18	5	-	11	105

Table 2. Greenhouse environment and the monthly average values of ambient temperature.

Month	The monthly average temperature (°C)		The monthly average highest temperature (°C)		The monthly average lowest temperature (°C)		Relative humidity mean (%)	
	Outdoor media	Greenhouse media	Outdoor media	Greenhouse media	Outdoor media	Greenhouse media	Outdoor media	Greenhouse media
April	12.20	16.61	16.41	24.99	8.30	9.01	61.2	62.2
May	15.57	22.29	21.25	21.99	11.01	15.79	58.9	58.7
June	20.23	25.43	23.78	28.09	13.93	19.25	53.7	55.1
July	22.38	25.42	24.47	28.10	18.74	20.86	53.4	51.2
August	24.46	30.97	28.86	34.11	21.68	28.19	53.2	50.8
September	18.33	24.04	26.96	28.74	13.79	18.20	62.1	60.4
October	13.11	17.90	17.18	22.65	8.97	12.82	73.5	70.5
November	5.43	8.00	10.43	13.87	-0.69	1.87	72.6	70.2
December	2.15	3.93	6.30	8.15	-4.30	2.54	67.6	65.1

materials to the parcels. When Table 2 was examined, daily average temperature of the inner environment was 4 to 6°C higher than the outer environment during the period from April to August when most of the grafting and sapling development occurs.

Phenological findings

In Table 3, phenological observations were given. Differences were determined between varieties and environments in revival and blossoming dates. The first budburst (April 8) was in Mondial Gala variety grafted on M9 and MM106 rootstocks in greenhouse and the last budburst was outside in Braeburn and Red Chief (April 12) grafted on M9 and MM106. The first blossoming of the buds was in greenhouse in Mondial Gala (April 16) grafted on M9 and MM106 rootstock, the last vegetative bud blossoming was in Braeburn variety (April 23) grafted on M9 and MM106 rootstock. The first defoliation was outside in Mondial Gala (November 5) grafted on M9 and MM106 rootstock and the last defoliation was in greenhouse in Braeburn (November 17) grafted on M9 and MM106 rootstock (Table 3).

After the plantation of the experiment material during the first month, the total greenhouse temperature was 132.1°C and daily average was 4.4°C higher than outside. The differences between varieties stem from different cooling needs of varieties. In their study, Özongun et al.

Table 3. Phenological observations.

Media	Rootstock	Variety	Shoot bubling	Shoot bud-burst	Defoliation
Greenhouse	M9	Mondial gala	8 April	16 April	9 November
		Braeburn	9 April	18 April	17 November
		Red chief	9 April	17 April	16 November
	MM106	Mondial gala	8 April	16 April	9 November
		Braeburn	9 April	18 April	17 November
		Red chief	9 April	17 April	16 November
Outdoor	M9	Mondial gala	10 April	20 April	5 November
		Braeburn	12 April	23 April	6 November
		Red chief	12 April	22 April	6 November
	MM106	Mondial gala	10 April	20 April	5 November
		Braeburn	12 April	23 April	6 November
		Red chief	12 April	22 April	6 November

(2004) determined similar differences in phenological observations of varieties. Jonkers (1980) reported that defloration quickens at 9 to 13°C in apple and pear trees grown in outer environment and controlled temperature conditions. When mean temperatures in Tables 2 and 3 were examined, it is seen that the temperature which was 13.11°C in October outside dropped to 5.43°C in November and that the temperature in the greenhouse was 17.9°C and dropped to 8°C in November. According to these results, defloration is parallel to the decrease inner and outside temperatures.

Morphological results

When experiment criteria are assessed all together, the highest rate of grafting was in Braeburn in greenhouse with 93%, which was grafted on M9 rootstock with chip budding and bench grafting techniques and the difference was found to be statistically significant ($P < 0.01$). The lowest grafting rate was 40% in Red Chief, which was grafted on MM106 rootstock outside (Table 4). High rate of grafting in greenhouse is an expected result. As a matter of fact, many studies carried out on various fruit varieties reported similar results. Many researchers noted that temperature is one of the most important factors in graft success (Özongun et al., 2006; Yilmaz and Akça, 2003; Polat et al., 1998; Polat and Kaşka, 1991, 1992, 1996; Gadalina, 1995) and it is similar to our results, as well.

When multi interactions are examined, the length of sapling (181.60 cm), sapling diameter (12.07), sapling shoot length (163.49 cm) and the rate of 1st class sapling (100%) was in Mondial Gala in MM106 grained bud graft in greenhouse environment and statistically significant ($p < 0.01$) and in Braeburn variety-which was grafted on MM106 rootstock with grained bud graft- the sapling shoot diameter was 12.27 mm and the number of lateral was 4.43 and was statistically significant ($P < 0.01$). All other multi interactions and applications were found to be insignificant (Table 4).

When the lengths of saplings were assessed, it is seen that Mondial Gala is the strongest developing variety in terms of the sapling length development, which was followed by Braeburn and Red Chief (Table 4). When Table 4 was examined, it is seen that even the developmental characteristic of the strongest variety (Mondial Gala) grown outside has shorter sapling than the weakest variety (Red Chief) in greenhouse. The reason for this is that the vegetation period in greenhouse is longer and total temperature is higher compared with outside environment. In this study, depending on the variety of sapling, vegetation period varies between 215 and 225 days in greenhouse, while it ranges between 205 to 210 days outside. The average daily temperature in greenhouse was 4.7°C higher than the outside. Bağci et al. (2003) grafted golden delicious and starking delicious varieties of M9, MM26 and MM106 rootstocks and obtained 99.2 cm average sapling length in greenhouse and 64.6 cm sapling length outside. In this study, Gadalina (1995) determined developmental differences in regions with different climatic conditions and Yilmaz and Akça (2003), in their study with inside grafts on apple, reported that if they had planted the fruit saplings outside, the development of the plants would have been different because of vegetation and environmental conditions.

When the thicknesses of the different varieties of saplings in greenhouse and outside were examined in terms of shoot thickness, it was noted that the shoot diameter of Mondial Gala with its strong development characteristic and Braeburn variety with its mild development characteristic were in the same group and Red Chief variety with weak development characteristic had thinner shoots as expected (Table 5).

Yilmaz and Akça (2003) grafted Granny Smith on different apple rootstocks with different graft techniques.

Table 4. Evaluation of all factors in the experiment.

Media	Rootstock	Graft technique	Variety	Grafting on hold rate (%)	Sapling size (cm)	Sapling shoot diameter (mm)	Sapling shoot length (cm)	Lateral branch number (number)	Ist class sapling rate (%)
Greenhouse media	M9	Bench graft	Mondial gala	93.00^{a} (4.63)	160.74^{c} (5.06)	10.46^{bcd} (0.37)	133.23^{c} (5.13)	1.68^{bc} (0.39)	96.70^{ab} (5.77)
			Braeburn	93.00^{a**} (4.63)	135.68^{e} (3.79)	9.62^{de} (0.41)	106.26^{de} (3.76)	2.69^{b} (0.56)	92.50^{ab} (3.82)
			Red chief	83.00^{abc} (6.92)	116.17^{gh} (4.82)	9.81^{cde} (0.39)	84.24^{gh} (4.58)	0.00 (0)	93.30^{ab} (6.67)
		Chip budding graft	Mondial gala	87.00^{ab} (6.31)	153.51^{cd} (5.80)	10.36^{bcd} (0.43)	130.69^{c} (6.19)	0.50^{de} (0.44)	96.30^{ab} (3.73)
			Braeburn	83.00^{abc} (6.92)	120.81^{fg} (6.23)	9.53^{def} (0.48)	98.33^{ef} (5.91)	1.63^{bcd} (0.43)	87.80^{ac} (6.19)
			Red chief	77.00^{abcd} (7.85)	114.18^{gh} (6.33)	10.13^{bcd} (0.52)	93.81^{fg} (6.58)	0.19^{e} (0.23)	87.50^{ac} (7.22)
	MM106	Bench graft	Mondial gala	90.00^{a} (5.57)	175.61^{ab} (6.54)	11.84^{a} (0.49)	151.55^{ab} (6.36)	2.55^{b} (0.64)	100.00^{a} (0.00)
			Braeburn	57.00^{def} (9.20)	153.25^{cd} (6.01)	11.24^{ab} (0.53)	127.51^{c} (6.19)	1.93^{bc} (0.60)	95.20^{ab} (4.77)
			Red chief	76.00^{abcd} (7.85)	142.36^{de} (4.82)	10.72^{bc} (0.34)	114.08^{d} (5.15)	0.07^{e} (0)	96.30^{ab} (6.47)
		Chip budding graft	Mondial gala	67.00^{bcde} (8.75)	181.60^{a**} (7.75)	12.07^{a} (0.62)	163.49^{a**} (7.82)	0.95^{cde} (0.47)	100.00^{a**} (0.00)
			Braeburn	60.00^{df} (9.09)	166.08^{bc} (6.66)	12.27^{a**} (0.72)	141.14^{bc} (6.62)	4.43^{a**} (1.12)	100.00^{a} (0.00)
			Red chief	63.00^{cde} (8.95)	132.27^{ef} (6.67)	10.40^{bcd} (0.43)	103.09^{def} (6.35)	0.14^{e} (0.12)	86.70^{ac} (13.33)
Outdoor media	M9	Bench graft	Mondial gala	87.00^{ab} (6.31)	84.57^{kl} (3.41)	6.58^{jk} (0.23)	57.51^{j} (3.36)	-	87.10^{bd} (17.11)
			Braeburn	87.00^{ab} (6.31)	89.31^{jk} (4.03)	6.66^{ijk} (0.39)	59.18^{j} (3.92)	-	69.20^{ce} (10.83)
			Red chief	77.00^{abcd} (7.85)	65.61^{no} (2.44)	5.74^{kl} (0.21)	33.73^{mn} (2.73)	-	42.10^{hg} (13.05)
		Chip budding graft	Mondial gala	67.00^{bcde} (8.75)	71.70l^{mno} (3.96)	5.81^{jkl} (0.29)	45.61^{klm} (3.81)	-	45.90^{fh} (7.74)
			Braeburn	60.00^{def} (9.09)	76.69^{klmn} (4.39)	6.16^{jkl} (0.42)	52.31^{jkl} (4.55)	-	53.30^{eg} (3.33)
			Red chief	60.00^{def} (9.09)	60.52^{o} (2.51)	5.34^{l} (0.25)	31.76^{n} (2.51)	-	30.60^{h} (10.02)
	MM106	Bench graft	Mondial gala	87.00^{ab} (6.31)	106.69^{hı} (3.38)	8.49^{fgh} (0.37)	78.44^{hı} (3.51)	-	92.10^{ab} (3.97)
			Braeburn	73.00^{abcd} (8.21)	103.29^{hı} (4.32)	7.75^{ghı} (0.35)	71.67^{ı} (3.99)	-	90.50^{ab} (4.77)
			Red chief	83.00^{abc} (6.92)	71.04^{mno} (3.83)	5.90^{jkl} (0.33)	40.98l^{mn} (3.74)	-	39.30^{gh} (8.85)
		Chip budding graft	Mondial gala	57.00^{def} (9.20)	105.34^{hı} (5.17)	8.69^{efg} (0.45)	77.33^{hı} (5.13)	-	95.80^{ab} (4.17)
			Braeburn	53.00^{ef} (9.26)	99.15^{ij} (4.09)	8.02^{gh} (0.42)	73.18^{hı} (4.91)	-	100.00^{a} (0.00)
			Red chief	40.00^{f} (9.09)	84.39^{klm} (4.67)	7.19^{hıj} (0.36)	56.74^{jk} (3.97)	-	63.90^{df} (7.34)

*P < 0.05. There is no difference between the groups with the same letter;** P < 0.01, there is no difference between the groups with the same letter. ( ); standard error.

For M9 rootstock 107 cm shoot with bench graft, 90.21 cm shoot with chip graft, as for MM106 rootstock, 105.08 cm shoot length with bench graft and 127.17 cm shoot length with chip graft was obtained. Fere and Barden (1971) grafted Golden Delicious variety on M7, MM106 and

Table 5. Retention rates of the factors used in the vaccine trial, sapling length, shoot diameter, shoot length, lateral branch number and first class nursery in terms of interactions taken place between each couple.

Interaction		Graft hold rate (%)	Sapling length (cm)	Shoot diameter (mm)	Shoot length (cm)	Lateral branch (number)	1st class sapling rate (%)
Rootstocks X Variety	M9 x Mondial gala	83.00 (3.56)	117.63 (4.58)	8.31bc (0.27)	91.76 (4.51)	1.09 (0.30)	79.24 (7.48)
	M9 x Braeburn	81.00 (4.22)	105.62 (3.39)	7.99bc (0.26)	79.02 (3.28)	2.16 (0.36)	75.67 (5.51)
	M9x Red Chief	74.00 (4.25)	89.12 (3.66)	7.75c (0.30)	60.89 (3.74)	0.09 (0.11)	63.38 (9.22)
	MM106 x Mondial gala	75.00 (4.01)	142.31 (4.78)	10.27a* (0.30)	117.70 (4.74)	1.75 (0.38)	96.98 (1.58)
	MM106 x Braeburn	61.00 (4.22)	130.44 (4.31)	9.83a (0.35)	103.37 (4.54)	3.18 (0.70)	96.43 (1.87)
	MM106 x Red chief	66.00 (4.55)	107.52 (4.49)	8.55b (0.32)	78.72 (4.49)	0.11 (0.05)	71.53 (7.66)
Media X Variety	Outdoor x Mondial gala	74.00 (4.22)	92.07d (2.49)	7.40 (0.21)	64.72d (2.49)	-	78.24b (7.26)
	Outdoor x Braeburn	68.00 (4.77)	92.11d (2.44)	7.14 (0.21)	64.08d (2.34)	-	77.99b (6.08)
	Outdoor x Red chief	65.00 (4.56)	70.39e (1.81)	6.04 (0.15)	40.80e (1.78)	-	43.98c (5.65)
	Greenhouse x Mondial gala	84.00 (3.69)	167.87a** (3.24)	11.18 (0.25)	144.74a** (3.30)	-	98.23a** (1.19)
	Greenhouse x Braeburn	73.00 (4.25)	143.96b (3.08)	10.68 (0.28)	118.31b (3.11)	-	93.88a (2.29)
	Greenhouse x Red chief	75.00 (4.44)	126.25c (2.90)	10.26 (0.21)	98.80c (2.89)	-	90.94ab (3.82)
Graft techniqe X Variety	Bench x Mondial gala	89.00 (3.21)	131.90 (4.30)	9.34 (0.27)	105.18 (4.15)	2.11b (0.22)	91.73 (4.57)
	Bench x Braeburn	78.00 (4.28)	120.39 (3.30)	8.83 (0.27)	91.15 (3.48)	2.31ab (0.24)	86.84 (4.22)
	Bench x Red chief	80.00 (4.59)	98.79 (3.96)	8.04 (0.29)	68.26 (3.99)	0.03c (0.31)	67.78 (8.98)
	Chip x Mondial gala	69.00 (4.52)	128.04 (5.56)	9.24 (0.35)	104.28 (5.60)	0.72c (0.17)	84.50 (7.04)
	Chip x Braeburn	64.00 (4.61)	115.68 (4.49)	8.99 (0.36)	91.24 (4.48)	3.03a** (0.37)	85.28 (5.95)
	Chip x Red chief	60.00 (5.04)	97.84 (4.35)	8.26 (0.40)	71.35 (4.38)	0.17c (0.09)	67.15 (8.13)
Media X Rootstocks	Outdoor x M9	73.00 (0.03)	74.73 (1.63)	6.05 (0.12)	46.68 (1.66)	-	53.21c (5.48)
	Outdoor x MM106	66.00 (0.04)	94.99 (2.14)	7.67 (0.18)	66.39 (2.18)	-	80.27b (5.60)
	Greenhouse x M9	86.00 (0.03)	133.52 (2.51)	9.98 (0.18)	107.76 (2.51)	-	92.34a (2.05)
	Greenhouse x MM106	69.00 (0.03)	158.53 (2.94)	11.43 (0.22)	133.47 (2.98)	-	96.36a** (2.35)
Graft technique X Rootstocks	Bench x M9	87.00 (3.65)	108.68b (3.12)	8.14b (0.20)	79.02b (3.12)	1.45a (0.15)	78.66 (5.82)
	Bench x MM106	78.00 (3.68)	127.37a (3.62)	9.33a (0.25)	97.37a (3.64)	1.52a (0.17)	85.57 (5.36)
	Chip x M9	72.00 (3.78)	99.57c (3.62)	7.89b (0.26)	75.42b (3.62)	0.77b (0.14)	66.89 (6.43)
	Chip x MM106	57.00 (4.31)	128.14a** (4.49)	9.77a* (0.29)	102.49a** (4.37)	1.84a** (0.30)	91.06 (3.86)
Media X Graft techniqe	Outdoor x Bench	82.00a** (3.56)	86.75 (1.88)	6.85 (0.15)	56.92 (1.89)	-	68.56 (6.32)
	Outdoor x Chip	56.00c (4.83)	82.97 (2.35)	6.87 (0.19)	56.15 (2.38)	-	64.92 (6.53)
	Greenhouse x Bench	82.00a (3.61)	147.30 (2.59)	10.62 (0.18)	119.48 (2.60)	-	95.67 (1.56)
	Greenhouse x Chip	73.00b (3.29)	144.74 (3.19)	10.79 (0.23)	121.76 (3.26)	-	93.03 (2.72)

*P < 0.05, There is no difference between the groups with the same letter; ** P < 0.01; there is no difference between the groups with the same letter. ( ); standard error.

apple seedling and reported that shoots on seedling and MM106 were developed better than dwarf rootstocks.

In this study, no difference was found between grafting methods in terms of shoot and sapling development. Rajesh and Ananda (2002) used spur and redspur as varieties and wild apple seedling as rootstock and bench grafting, English grafting and grained grafting as grafting techniques and reported that chip grafting had the best development linear and radial development.

When two way interactions were examined, it was found that the effect of Rootstock and Variety interaction was significant ($P < 0.05$) in terms of shoot diameter but not significant for other features. The highest shoot diameter was in Mondial Gala variety grafted on MM106 rootstock. The environment and variety interaction was found to be leading to statistically significant difference in Mondial Gala variety in greenhouse environment, in which the sapling length was 167.87 cm, the length of the shoot was 144.74 cm and the 1st class sapling rate was 98.23% compared with other environment and variety combinations ($p < 0.01$). In terms of grafting technique and variety interaction, the number (3.03) of side branch was found to be statistically significant in Braeburn variety to which chip budding grafting was applied ($p < 0.01$). In terms of environment and rootstock interaction, the rate (96.36%) of 1st class grafting was found to be statistically significant ($p < 0.01$). In terms of grafting technique and rootstock interaction, the sapling length was (128.14 cm) ($P < 0.01$), the shoot diameter was (9.77 mm) ($p < 0.05$), the shoot length was (102.49 cm) and the side branch number (1.84) ($P < 0.01$) was found to be statistically significant in MM106 rootstock. When the interactions were examined again in terms of environment and grafting technique, the rate of grafting success was found to be statistically significant in outer environment with bench grafting ($P < 0.01$). All other interactions and applications were found to be statistically insignificant (Table 5).

When the factors in the trail were examined one by one, there found to be statistical differences in terms of rootstock, varieties, growing environment and grafting technique. When the rootstocks were examined, the rate was found to be the highest in M9 rootstock (79.00%) ($P < 0.01$), the longest sapling (126.76 mm), the largest shoot diameter (9.55 mm), the longest shoot (99.93 mm) ($p < 0.01$). The highest number of side branch (1.68) ($P < 0.05$) and the highest rate of 1st class sapling (88.13%) ($P < 0.01$) was in MM106 rootstock.

When the rate of grafting success in outer environment and greenhouse was examined, it was seen that the rate of success was 82% in greenhouse and 69% in outer environment (Table 6). The daily temperature means in April was 16.6°C in greenhouse and 12.2°C outside. When the grafting success was examined in terms of grafting technique, with bench grafting technique, the rate was 82% in greenhouse and outside, the rate was 73% with chip budding grafting technique in greenhouse and in outer environment it was as low as 56% (Table 6).

In their study, Bağci et al. (2003) reported that the rate of grafting was 86 to 89% in Golden Delicious and Starking Delicious varieties applied on M9 and MM106 rootstocks with chip budding grafting technique in greenhouse, which was higher compared with outer environment. Yilmaz and Akça (2003) found that graft life rate was 30 to 35% in Granny Smith varieties applied to different apple rootstocks with chip budding grafting and bench grafting technique in greenhouse. In their study on Starking Delicious variety in outer environment, Özongun et al. (2006) obtained 80% success with bench grafting technique and 33% with chip budding grafting technique. Howard and Quinlan (1984) reported similar results with bench grafting, English, bench grafting and chip budding grafting methods. Yilmaz and Akça (2003) reported that the graft junction surface was larger in bench grafting method as the scar surface in bench grafting method was larger compared with chip budding graft and this had a positive effect on graft success.

When the varieties was examined as it can be seen in Table 6 in Mondial Gala variety, the rate of grating success was (79.00%) ($P < 0.05$), the sapling length (129.97 cm), the shoot thickness (9.29 mm), the shoot length (104.73 cm) and 1st class sapling rate (88.11%), were significantly higher compared with other varieties ($P < 0.01$), but the highest number (2.76) of side branch was determined in Braeburn variety ($P < 0.01$).

When sapling shoot lengths were examined according to the varieties, it was found that Mondial Gala variety-grown in outer environment and in greenhouse-was the strongest variety in terms of sapling shoot length, which was followed by Braeburn and Red Chief varieties (Table 6).

When the effect of rootstocks on the sapling shoot thickness was examined, it was found out that the saplings on MM106 rootstock developed better than the saplings on M9 rootstock (Table 6). In their study, Bağci et al. (2003) had similar results. They found out that shoot thickness of saplings grafted on MM106 rootstock was larger than those of the shoots grafted on M9 rootstock. Yilmaz and Akça (2003) reported that there was no significant difference between the shoot thicknesses of shoots grafted on M9 and MM106 rootstock.

The rate of graft success (82.00%), the sapling length (146.00 cm), the diameter of shoot (10.71 mm), the length of shoot and the rate of 1st class saplings (94.35%) in greenhouse were found to be statistically significant compared with open environment results ($P < 0.01$).

When grafting techniques were compared and the success rate of bench graft (82.00%) was found to be higher than chip budding grafting technique ($P < 0.01$), but the other results were not found to be statistically significant (Table 6).

Sapling quality

In the assessment of saplings grown according to sapling

Table 6. Evaluation of the factors applied in the experiment.

Parameter		Graft hold rate (%)	Sapling length (cm)	Shoot diameter (mm)	Shoot length (cm)	Lateral branch number (number)	Ist class sapling rate (%)
Rootstocks	M9	79.00a** (2.11)	104.00b (2.37)	8.02b (0.16)	77.22b (2.37)	1.11b (0.10)	72.77b (4.39)
	MM106	67.00b (2.37)	126.76a* (2.76)	9.55a** (0.19)	99.93a** (2.80)	1.68a* (0.16)	88.31a** (3.29)
Variety	Mondial gala	79.00a* (3.36)	129.97a** (3.39)	9..29a** (0.21)	104.73a** (3.34)	1.42b (0.15)	88.11a** (4.17)
	Braeburn	71.00b (3.27)	118.03b (2.75)	8.91a (0.22)	91.20b (2.77)	2.67a** (0.21)	86.06a (3.57)
	Red chief	70.00b (0.03)	98.33c (2.91)	8.15b (0.22)	69.80c (2.94)	0.10c (0.03)	67.46b (5.92)
Media	Outdoor	69.00b (2.46)	84.86b (2.04)	6.84b (0.12)	56.54b (1.49)	-	66.74b (1.57)
	Greenhouse	82.00a** (2.55)	146.00a** (2.40)	10.71a** (0.14)	120.62a** (2.06)	-	94.35a** (4.49)
Graft tchnique	Bench	82.00a** (2.66)	113.85 (2.40)	8.74 (0.16)	88.20 (2.41)	1.84 (0.12)	82.11 (3.94)
	Chip	64.00b (3.45)	117.03 (2.90)	8.83 (0.20)	88.96 (2.92)	1.31 (0.15)	78.96 (4.22)

*P < 0.05; There is no difference between the groups with the same letter; ** P < 0.01, there is no difference between the groups with the same letter. ( ), Standard error.

standards (clonal dwarf and semi-dwarf apple rootstocks) determined in the USA in 2004, the highest sapling standard was in the saplings of Mondial Gala variety which was grown in greenhouse and grafted on MM106 rootstock with chip graft technique. In terms of these standards, the lowest value was in the saplings of Red Chief variety grafted on M9 rootstock with chip graft technique (Table 4).

In terms of compliance with the standards, environment and variety interaction and environment and rootstock interaction were found to be significant. In terms of environment and variety interaction, while Mondial Gala variety (98%) in greenhouse obtained the highest rate, the lowest rate (44%) was in Red Chief variety grown in outer environment (Table 5).

When the factors in the trail were assessed within their own groups, while significant differences were found in terms of rootstocks, varieties and environments, there was no significant difference in terms of grafting technique, except for grafting success (P < 0.01). When rootstocks were examined, while the rate of standard saplings in MM106 rootstock was 88%, the rate was 73% in M9 rootstock. When varieties were examined, the rate of standard sapling in Mondial Gala was 88%, in Braeburn, it was 86% and in Red Chief it was 67% (Table 6).

When assessed according to sapling scale, only unbranched sapling was grown in outer environment (29.10%); however, in greenhouse environment, unbranched sapling was (57.30%), a few branched sapling (9.40%), branched sapling (13.50%) and extra branched sapling (11.0%). In total, 91.20% of the saplings grown in the greenhouse were in vendible sapling class according to the prepared scale (Table 7).

A significant difference was found in terms of unbranched sapling features of varieties and rootstocks in outer environment (P < 0.01). In terms of varieties, the highest rate was in Mondial Gala variety (44.80%), which was followed by Braeburn (33.90%) and Red Chief varieties (8.5%). In terms of rootstocks, the rate of unbranched sapling in MM106 was found to be significantly higher (P < 0.01) (43.50%) compared with M9 rootstock (17.60%) (Table 7).

According to fruit sapling scale, some applications in the greenhouse were found to be statistically significant (P < 0.01 and P < 0.05). While Red Chief variety (82.50%) had higher rate of unbranched sapling compared with other varieties, in total (a few branched sapling, branched sapling and extra branched sapling) Mondial Gala (98.3%) and Braeburn (91.6%) varieties reached higher numbers in terms of growing saplings. In terms of having extra branched sapling, Braeburn variety had the highest rate (22.50%) (Table 7).

According to sapling standards (Anonymous, 2004b), there were found differences in terms of growing environments, varieties and rootstocks, in

Table 7. The values obtained according to scala of clonal apple rootstocks (M9 and MM106) and fruit sampling.

Parameter		Whip sapling (%)	Branched low sapling (%)	Branched sapling (%)	Extra branched sapling (%)	General total (%)
Media	Outdoor media	29.10b (4.53)	-	-	-	29.10
	Greenhouse media	57.30a** (4.53)	9.40	13.50	11.00	91.20
Outdoor media	M9	17.60b (5.07)	-	-	-	17.60
	MM106	43.50a** (7.61)	-	-	-	43.50
	Breaburn	33.90a (7.90)	-	-	-	33.90
	Mondial gala	44.80a** (8.58)	-	-	-	44.80
	Red chief	8.50b (4.47)	-	-	-	8..50
	Bench	32.40 (7.12)	-	-	-	32.40
	Chip	25.80 (6.63)	-	-	-	25.80
Greenhouse media	M9	55.50 (5.51)	11.40 (3.81)	13.80 (3.65)	5.50 (2.15)	86.20
	MM106	59.10 (8.9)	7.40 (2.59)	13.20 (3.72)	16.50 (6.55)	96.20
	Breaburn	30.70c (8.17)	19.00a** (5.27)	19.40a (3.86)	22.50a* (8.15)	91.60
	Mondial gala	58.60b (6.86)	8.2b (2.59)	21.00a**(4.83)	10.50ab (5.38)	98.30
	Red chief	82.50a** (4.42)	1.00b (1.0)	0.00b (0)	0.00b (0)	83.50
	Bench	54.20 (6.61)	13.80 (1.84)	14.90 (3.26)	9.40 (5.63)	92.30
	Chip	60.30 (7.5)	4..90 (4.11)	12.10 (3.77)	12.60 (3.91)	89.90

*P < 0.05. There is no difference between the groups with the same letter; ** P < 0.01; there is no difference between the groups with the same letter. ( ), Standard error.

greenhouse environment (94.30%) there were higher numbers of saplings complying with standards compared with outer environment (66.7%) (Table 6). In their study, Bağci et al. (2003) found that the plant growth in greenhouse was better compared with outer environment. In terms of sapling standard, the highest rates were in Mondial Gala, Braeburn and Red Chief varieties, respectively (Table 6). Özongun et al. (2004) pointed out that Mondial Gala had strong growth character, Braeburn had semi-strong and Red Chief had weak growth character.

In terms of rootstocks, in MM106 rootstock standard, sapling rate (88.3%) was higher than that of M9 rootstock (72.8%), which is an expected result as the growth strength of MM106 rootstock was higher than that of M9 rootstock (Rom et al., 1987). In their studies, Ferre and Barden (1971), Bağci et al. (2003) and Yilmaz and Akça (2003) reported that different clonal apple rootstocks had different growth strength and that MM106 rootstock had better growth strength than M9 rootstock. The results are parallel to the results of our study.

DISCUSSION

As a result of this experiment in which we researched sapling growing with inner environment grafts in open environment and in high plastic tunnels in Eğirdir conditions, we obtained 82% graft success in inner environment and 69% graft success rate in outer environment. This result obtained with inner environment grafts and the fact that the experiment sapling that was grown reached a sufficient length indicates that this method emerges as an economic sapling growing technique.

With this method, sapling production season in inner environment grafts is reduced to a period as short as 8 months. Besides, the grafting expenses in summer are reduced by doing grafting in winter. Furthermore, the annual disturbance of workforce is balanced as the grafting is done in winter, instead of summer when there is a lot of work to do.

New varieties of apple are rapidly being introduced to world markets. The method we used

in our experimental study will help sapling growers to start growing new varieties in the world market as it shortens sapling growing period. Data obtained from the study indicates that sapling growing can be done in different regions of Turkey with different climatic conditions.

In Turkey, first class sapling features are considered to be the same for varieties with different growing characteristics, variety and rootstocks. In this experiment, the varieties and rootstocks with strong growth character grew better as expected. Moreover, considering the fact that the first top cutting is done at 60 to 80 cm especially in dwarf and semi-dwarf varieties- after the saplings are transferred to the field, it is a must that first class sapling growing instruction is to be revised and sapling standards are to be determined again.

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