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**A Research on Adaptation and
Determination of Some Characteristic
with Grafted Dwarf M9 Apple
Rootstocks onto Some Standart Apple
(*Malus comminus* L.) Cultivars in East**

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**A Research on Adaptation and Determination of Some
Characteristic with Grafted Dwarf M9 Apple Rootstocks onto
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Abstract

Many of apple cultivars widely are grown onto Malling Merton rootstocks. M9 dwarf rootstocks are most common rootstock among Malling Merton rootstocks. As is known is important the effect to cultivars of rootstocks. The relation of cultivars and rootstock effect climate, soil and nutrition conditions. Experimental orchard was established in 2006 year and first data was taken in 2008 between 2011 years. In this study was analyzed such as characteristics; blooming time, sapling diameter, productivity (tree/kg), fruit diameter, fruit length, fruit weight, fruit aside, pH, soluble dry matter, fruit flesh toughness, commercially important and onto grafted dwarf M9 rootstock in East Anatolia Region that Breaburn, Fuji, Granny Smith, Golden, Jonegoret apple cultivars. In the result of analyzing; in point of sapling diameter, the best development were Golden (45.3 mm) and Granny Smith (39.9 mm), the highest yield were Mondial Gala (18.1 kg), Granny Smith (16.9 kg) and Fuji (12.9 kg) cultivars. The highest fruit weights were measured Fuji (220.9 g), Golden (219.1 g) ve Mondial Gala (218.4 g). Granny Smith and Fuji cultivars' fruit flesh toughness is relatively higher than those other cultivars. In the fruit aside data Granny Smith and Golden's is higher than those other cultivars. The highest soluble dry matter was determined in Granny Smith, Fuji and Mondial Gala cultivars. The aim of this study; to determine the best apple cultivar in point of yield and quality to grow in East Anatolia Region.

Keywords: Dwarf rootstock, Fuji, Mondial Gala, Granny Smith, Fruit characteristic, yield, East Anatolia.

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Introduction

Apple is a type of fruit that has been cultivated for a long time whose cultivation route followed Anatolia, Greece and Italy towards Europe and then from Europe to Americas, the New World (Ozcagiran *et al.*, 2005). The annual apple production in the world totals 58.431.995 t (FAO,2012) with world's largest producers being China (37.000.000 t), the USA (4.110.000 t), Turkey (2.889.000 t), Poland (2.877.336 t) followed by India (2.203.400 t), Italy (1.991.312 t), Iran (1.700.000 t), Chile (1.625.000 t), Russia (1.403.000 t), France (1.382.901 t) and Argentina (1.250.000 t) in descending order of production capacity (FAO, 2014). Apples have been cultivated in Turkey for a considerable period of time. Production of apples is the leading type of cultivation among temperate fruits in terms of both the extent of production and the amount of trees. Furthermore, apple can be cultivated in almost all regions in Turkey. The leading regions in descending order of production are Central-Southern, Aegean, Central-Northern, Mediterranean, the Black Sea and Marmara regions (TUIK, 2013). Apple is an important fruit in human nutrition owing to the mineral salts and vitamins in its content. The chemical makeup of the fruits are shaped by their rootstock and variety, the climate of cultivation, cultivation conditions and the growth characteristics of the tree (Holland *et al.*, 1992; Wolfe *et al.*, 2003; Paganini *et al.*, 2004; Nogueira *et al.*, 2006; Petkovsek *et al.*, 2007; Wu *et al.*, 2007; Drogoudi *et al.*, 2008). The apple varieties that are most popularly commercialized in the world market and the European markets are Jonagold, Gala varieties and Granny Smith owing to their superior biochemical content, fruit quality and storage characteristics in comparison to the other species. The adaptation capabilities and the productivity performance of many different apple varieties have been tested on various regions in Turkey. The mean fruit weight was determined as 162.4 g and 224.1g for the Royal Gala and Braeburn varieties, respectively, in the ecological conditions prevailing in Egirdir (Ozongun *et al.*, 2011). Gala and Fuji varieties were reported to outperform the standard varieties in terms of weight in a study investigating the fruit characteristics of Gala, Braeburn, Jonagold and Fuji varieties grafted onto M9 rootstocks (Baytekin and Akca, 2011). The fruits of the Braeburn apple variety grafted onto M9 rootstock were determined to have 11.88% water soluble dry matter with an acidity of 0.80 % in a study conducted in the ecological conditions prevailing in Samsun to determine the performance of different apple varieties on different rootstocks (Kaplan *et al.*, 2007). The water soluble dry matter content was reported to vary with respect to differences in rootstocks (Ak and Ozcan, 1993; Daugaard *et al.*, 1999; Robinson *et al.*, 1983). The period from full bloom until harvest was determined as 125-135 days for the Royal Gala variety, as 160 - 170 days for the Braeburn variety in a study conducted the ecological conditions prevailing in Egirdir (Akgul *et al.*, 2011). The harness of the fruit flesh was determined as 7.50kg and 6.79 kg in the first year and as 7.4 and 6.6 kg in the second year for the Starking Delicious and Golden Delicious varieties, respectively, in a study by Koyuncu *et al.* (1997) conducted on Delicious

apples in Van. Eren (2002) investigated the changes in the diameter of Golden Delicious, Starking Delicious, Idared, Imperatore and Granny Smith apples throughout the development of the trees in a study on the optimum harvest times and cold chain storage options for several apple varieties growing in Egirdir area and they were determined to vary in the range of 65.52 mm – 77.92 mm, 71.30 mm – 86.32 mm, 78.95 mm - , 76.62 mm – 93.08 mm and 70.89 mm – 79.72 mm for Golden Delicious, Starking Delicious, Idared, Imperatore and Granny Smith apples, respectively, with the first diameters determined as 74.32 mm, 78.82 mm, 84.92 mm and 84.34 mm. The present study aims to investigate the growth performance and productivity of Breaburn, Gala, Fuji, Jonathan, Golden and Granny Smith varieties grafted on M9 clone, which is commonly used as the shrub rootstock in the East Anatolia Region.

Materials and Methods

The study was conducted during four years (2006 – 2011) in four commercial ‘Breaburn, Mondial Gala, Fuji, Jonathan, Golden Delicious’ apple orchards in Muradiye - Van, a major apple production site in Eastern Turkey. The plants material comprised of 4 year old ‘Breaburn, Mondial Gala, Fuji, Jonathan, Golden Delicious’ trees grafted on M9 rootstocks and planted with a distribution of 2 × 4 m on a sandy - clay loam . The irrigation system available in the apple orchard is dripping irrigation system. The apple orchard was established in triplicates with 10 apple trees in each parcel. The young apple trees were monitored in the year following their plantation in their main locations during the spring of 2006 for morphological and phenological changes. The phenological changes that were annually monitored were time of initial blossom, time of full bloom, harvest time, defoliation, time from full bloom to harvest and the sapling diameter. Time of budding, initiation of blossoming, time of full bloom and the time of harvest were previously investigated as the phenological observations (Tekintas *et al.*, 2006). The diameter of the sapling (mm), the flower and the leaf characteristics were investigated as the morphological properties of the trees.

Physical Analysis

The fruit samples were collected from 2008 onwards and the parameters including fruit weight, fruit diameter, fruit length, fruit flesh hardness, acidity, water soluble dry matter content and pH were monitored. The productivity per tree (kg/tree) was determined by weighing the whole produce of each tree individually. The mean fruit weight was calculated as the average weight of 10 fruits from each tree weighed to a precision of 0.01 g (Radvag PS 4500/C/1, Poland). The mean fruit length (mm) and diameter (mm) were determined by measuring 10 fruits per tree using a caliper gauge. The fruit flesh hardness

(FFH) (kg) at every sampling period was determined at three equatorial locations of 10 fruits per each tree following the removal of the peel using a penetrometer (FT – 327; McCormick Fruit Tech, Yakima, WA) with 11.1 mm tip.

Chemical Analysis

The water soluble dry matter content (in % ratio to the total) was determined as the water soluble dry matter of the filtered fruit juice of the samples whose fruit flesh hardness was previously measured, using a hand refractometer (PAL-1, McCormick Fruit Tech., Yakima, Wash.). The pH of the filtered fruit juice samples was measured using a pH meter (Hanna, HI9321). The titratable acidity (TA) (%) was determined as the malic acid equivalent that would be required for the titration of the filtered fruit juice up to pH = 8.1 using 0.1 N sodium hydroxide as documented elsewhere (Kucuker *et al.*, 2011).

Statistical Analysis

Statistical analysis of the data was carried out using the statistical package SPSS (SPSS, Version 16.0, SPSS, Chicago, IL, USA). For each year, significant differences between the means were determined by Duncan's multiple range tests at a threshold of $P \leq 0.05$.

Results and Discussion

The test orchard was located in the East Anatolian Region, along the north - eastern shore of the Van Lake at an altitude of 1700 m and the growth performance of the Breaburn, Mondiel Gala, Fuji, Jonathan, Golden Delicious, Granny Smith varieties grafted onto the apple rootstock; M9 on the orchard was monitored over 4 years. The phenological characteristics of the varieties displayed differences as shown in Table 1. The earliest bloom was observed in M. Gala and Golden (19.05) varieties whereas the latest one was observed in Granny Smith apples (24.05). The varieties did not display significant differences in the time of full bloom although M. Gala (23.05) and Breaburn (24.05) were the earliest and Granny Smith (27.05) variety was the latest to reach full bloom.

Table 1. *Results Phenological of Apple Cultivars*

Cultivars	Dat of First flowering	Date of Full flowering	Date of harvesting	Date of Falling leaf	The number of passing day after flowering until harvesting
Breaburn	21.05	24.05	12.10	12.10	159
M.gala	19.05	23.05	20.09	12.10	142
Fuji	21.05	25.05	28.09	08.10	154
Jonathan	20.05	26.05	17.09	12.10	143
Golden	19.05	25.05	29.09	7.10	143
G.Smith	24.05	27.05	14.10	15.11	163

The time to harvest, defoliation and time from full bloom to harvest also displayed differences among the varieties. Jonathan (17.09) was harvested the earliest and Granny Smith the latest (14.10). The earliest defoliation was observed in Fuji (08.10) whereas the latest in Granny Smith (15.11). The shortest duration between full bloom and harvest was measured for Jonathan and Golden (143) whereas the longest duration was observed in the Granny Smith variety (163) (Tekintas *et al.*, 2006; Baytekin and Akca, 2011).

Granny Smith (23.5 mm) and Golden (23.2 mm) displayed the fastest growth with respect to their diameter as recorded in 2008 (Table 2). The slowest tree growth was observed in the Breaburn variety (19.4 mm). The fruit acidity was determined to vary significantly among the varieties. M. Gala (7.1 %), Fuji (8.5 %) and Golden (10.9 %) had lower acidity than Breaburn (13.1 %) and Granny Smith (14.9 %). The water soluble dry matter content of the varieties under investigation in the present study did not display significant differences. The determined values were comparable to those that were previously reported (Redalen, 1986 and Kucuker, 2010). The differences in the fruit juice pH were statistically insignificant (Sotiropoulos, 2006, Wu *et al.*, 2007). The fruit diameter and length in 2008 was higher for the Jonathan and Golden apple varieties than the remaining varieties. The fruit flesh hardness was shown to significantly vary among the different varieties under investigation. The hardest fruit flesh was determined for Granny Smith (8.73 kg) and Fuji (8.33 kg). The productivity in 2008 was the highest for the M. Gala variety (Eren, 2002., Ozdemir *et al.*, 2009, Ozongun *et al.*, 2011).

Table 2. *Sapling Diameter, Fruit Weight, Fruit Acidness, Amount of Dry Matter in Water Soluble, pH, Fruit Width, Fruit Length, Hardness of Fruit Flesh, Yield Data of Apple Cultivars*

2008	Sapling diameter (mm)	Fruit weight (gr)	Fruit acidness (%)	Water soluble matter (%)	pH	Fruit width (mm)	Fruit length (mm)	Hardness of fruit flesh (kg)	Yield (kg)
Breaburn	19.4 b	224.6a	13.1b	12.133c	3.1	8 ac	7.5ab	7.4c	1.7
M.gala	20.1 ab	227.1a	7.1e	14.1ab	3.5	7.9bc	7.8ab	7.9bc	2.2a
Fuji	21.1 ab	226.8a	8.5d	14.7a	3.4	8.3ab	7.6ab	8.3ab	1.9ab
Jonathan	21.9 ab	214.5a	9.3d	12.9bc	3.2	8.4a	7.7ab	5.6d	1.6b
Golden	23.2 a	225.5a	10.9c	14.3ab	3.5	8.4a	8.1a	5.2d	1.7ab
G.smith	23.5 a	181.9b	14.9a	13.7ab	3.4	7.7c	7.3b	8.7a	1.5

Granny Smith (31.9 mm) and Jonathan (30.6 mm) displayed the fastest growth with respect to their diameter as recorded in 2009 (Table 3). The weight of M. Gala (219.9 g) and Fuji (222.8 g) fruits was higher than those of the remaining varieties. Previous studies reported similar results to the present findings (Ozongun *et al.*, 2011). The fruit acidity was higher for Granny Smith (15.4 %) and Breaburn than that of the remaining varieties. The water soluble dry matter content was the highest for Granny Smith (15.4 %), Breaburn (12.9 %) and Golden (11.00 %) although the differences in both water soluble dry matter content and pH were statistically insignificant among the varieties (Eren, 2002, Ozdemir *et al.*, 2009, Ozongun *et al.*, 2011).

Table 3. Sapling Diameter, Fruit Weight, Fruit Acidness, Amount of Dry Matter in Water Soluble, pH, Fruit Width, Fruit Length, Hardness of Fruit Flesh, Yield Data of Apple Cultivars

2009	Sapling diameter (mm)	Fruit weight (gr)	Fruit acidness (%)	Water soluble matter (%)	pH	Fruit width (mm)	Fruit length (mm)	Hardness of fruit flesh (kg)	Yield (kg)
Breaburn	27.6bc	218.9ab	13b	12.6	3.2	7.5	7.3c	7.3b	3.8b
M.gala	26.6c	219.9a	7.6e	14.8	3.6	7.7bc	7.9ab	7.9bc	6.5a
Fuji	28.6ac	222.8a	8.6e	15.2	3.7	8.2ab	7.5bc	8.4b	4.6ab
Jonathan	30.6ab	196.2bc	9.8d	12.2	3.8	8.3ab	7.6bc	5.7c	3.4b
Golden	32a	218.9ab	11 c	14.6	3.5	8.5a	8.3a	5.4c	3.3b
G.smith	30.2ac	174.3c	15.4a	13.1	3.1	7.8bc	7.2c	9.1a	5.1ab

The differences in fruit diameter and length were also statistically insignificant although the Golden variety appears to stand out among the others both with respect to diameter (8.5 mm) and length (8.3 mm). The results were in accordance with those that were previously reported (Eren, 2002). The fruit flesh hardness was significantly higher for Granny Smith (9.06 kg) and Fuji (8.4 kg) than for the remaining varieties. The highest productivity per tree in 2009 was determined for the M. Gala, Granny Smith and Fuji varieties. Koyuncu *et al.* (1997) reported similar values to those determined in the present study. The highest productivity per tree was determined for M. Gala (6.7 kg/tree) and for Granny Smith (5.1 kg/tree). The present results are in accordance with previously reported values (Autio and Krupa, 2001; Marini, 2002; Eren, 2002, Ozdemir *et al.*, 2009; Kucuker *et al.* 2010, Ozongun *et al.*, 2011).

The highest increase in sapling diameter was observed for the Granny Smith (31.6 mm), Golden (27.5 mm) and Jonathan (24.5 mm) varieties in 2010 (Table 4). The weight of Golden (217 g) and M. Gala (217 g) fruits was higher than those of the remaining varieties. The fruit acidity was determined to vary significantly among the varieties. The highest fruit acidity was determined for Granny Smith (15.4 %), Breaburn (13.6 %) and Golden (11.00 %). Significant differences were observed among the water soluble dry matter content and the pH of different varieties.

Table 4. *Sapling Diameter, Fruit Weight, Fruit Acidness, Amount of Dry Matter in Water Soluble, pH, Fruit Width, Fruit Length, Hardness of Fruit Flesh, Yield Data of Apple Cultivars*

2010	Sapling diameter (mm)	Fruit weight (gr)	Fruit acidness (%)	Water soluble matter (%)	pH	Fruit width (mm)	Fruit length (mm)	Hardness of fruit flesh (kg)	Yield (kg)
Breaburn	21c	197.6ab	13.6b	12.5c	3.2c	7.7c	7.2bc	7.3c	6.8b
M.gala	22.3c	214.4a	7e	14.6a	3.5a	7.9bc	7.9a	7.8bc	12.5a
Fuji	24bc	217.9a	8.4d	15.1a	3.6a	8.2ab	7.2bc	8.3ab	7.7b
Jonathan	24.5bc	192 ab	9.5d	12.9bc	3.3bc	8.3a	7.4b	5.4d	7b
Golden	27.5b	217.2a	11.4c	14.3ab	3.4b	8.3a	8.1a	5.1d	6.9b
G.smith	31.6a	169.4b	15.4a	13.5ac	3.1c	7.6c	6.9c	8.8a	11.3a

The water soluble dry matter content was higher for Fuji (15.07%), M. Gala (14.6 %) and Golden (14.3 %) than for the remaining varieties whereas the pH of the juice of Fuji (3.6) and M. Gala (3.5) was higher than that of the remaining varieties. The highest productivity per tree was determined for M. Gala (12.5 kg/tree) and for Granny Smith (11.3 kg/tree) in 2010. The results regarding the weight of the fruit, water soluble dry matter content, acidity, fruit diameter and length were in accordance with a previously conducted study by Koyuncu *et al.* (1997).

The highest sapling diameter was measured for the Jonathan (33.4 mm) variety; the highest fruit weight was determined for Fuji (216.10g), Golden (215 g) and M. Gala (212.1 g) varieties; the highest fruit acidity was determined for the Granny Smith variety (15.4 %); the highest water soluble dry matter content was determined for the Fuji (15.1 %), M. Gala (14.6 %) and Golden (14.3 %) varieties; the highest juice pH was measured for the fruits of Jonathan (3.5) and Fuji (3.6); the highest fruit diameter was measured for the fruits of M. Gala (8.4 mm) and the highest fruit length was measured for the fruits of Fuji (8.1 mm); the hardest fruit flesh was determined for Granny Smith (8.8 kg) and Fuji (8.3 kg) and finally the highest productivity per tree was determined for M. Gala (18.1 kg/tree), Granny Smith (16.9 kg/tree) and Fuji (12.9 kg/tree) varieties in 2011 (Table 5).

Table 5. *Sapling Diameter, Fruit Weight, Fruit Acidness, Amount of Dry Matter in Water Soluble, pH, Fruit Width, Fruit Length, Hardness of Fruit Flesh, Yield Data of Apple Cultivars*

2011	Sapling diameter (mm)	Fruit weight (gr)	Fruit acidness (%)	Water soluble matter (%)	pH	Fruit width (mm)	Fruit length (mm)	Hardness of fruit flesh (kg)	Yield (kg)
Breaburn	26bc	195.4a	13.6b	12.5c	3.2c	7.7c	7.2bc	7.3c	12bc
M.gala	23c	212.1a	7 e	14.6a	3.5a	7.9bc	7.9a	7.8bc	18.01a
Fuji	24.8c	216.1a	8.4d	15.1a	3.6a	8.2ab	7.2c	8.3ab	12.9b
jonathan	33.4a	194.7a	9.5c	13bc	3.3bc	8.4a	7.4b	5.4c	9.9c
Golden	28.8b	215a	11.4c	14.3ab	3.4b	8.3a	8.1a	5.1c	11.3
G.smith	26.6bc	162.2b	15.4a	13.5ac	3.1c	7.6c	6.9c	8.8a	16.9a

The rootstocks were reported to have considerable effects ton the grafted fruit varieties both in terms of productivity and their biochemical content

(Autio and Krupa, 2001; Marini, 2002; Eren, 2002, Ozdemir *et al.*, 2009; Kucuker *et al.* 2010, Ozongun *et al.*, 2011).

As a conclusion, taking into consideration the results of this 4 - year study, Granny Smith, Fuji and Mondiel Gala were determined to outperform the remaining varieties although all varieties performed relatively well. The time of initial blossoming and the time to harvest was the latest for the Granny Smith and Breaburn varieties. The results obtained in the present study sheds light onto more detailed future studies on the subject and will hopefully aid in apple cultivation in areas such as the East Anatolian Region in Turkey with long and cold winters.

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