

**PERFORMANCE OF MONDIAL GALA APPLE CULTIVARS GRAFTED ON M9 APPLE  
ROOTSTOCK IN THE MEDITERRANEAN REGION OF TURKEY**

**Safder Bayazit, Kazim Gunduz, Sevki Sen**

Mustafa Kemal University, Faculty of Agriculture, Hatay, Turkey

Corresponding author: sbayazit@mku.edu.tr

**Abstract**

This research was carried out on eight-year-old trees of the Mondial Gala (*Malus domestica* Borkh) cultivars grafted on the M9 rootstock in order to determine its performance in the Mediterranean region with subtropical climatic conditions in Mersin, Turkey. In the study, flowering times, yield and fruit quality parameters were investigated. Mondial Gala planted with planting spaces of 1x3 m. According to the results, first flowering was observed on April 1, full flowering on April 10 and end of flowering on April 17, and fruits were harvested at the end of July. The fruit weight (average 223.2 g), the yield per tree (average 22.6 kg), and yield per trunk cross-sectional area was observed as 0.56 kg/cm<sup>2</sup> at the end of the eighth year. Observed values indicated that Mondial Gala summer apple cultivars were found to be promising for early apple growing in the higher parts of subtropical ecological conditions of Turkey.

**Keywords:** Apple cultivar, phenology, pomology, yield, quality.

**Introduction**

Among pome fruit species, apple is the oldest and most cultivated species. Due to the high level of adaptability and the high number of varieties, apple is the most produced and consumed species among fruit species in temperate climates. *Malus* genus in *Rosaceae* family has more than 30 apple species that it grows in different countries (Özbek, 1978; Way et al. 1990; Devenci 2000).

Wilcox (1962) reported that the origins of apple were Anatolia, Caucasia and Central Asia. Like many fruit species, Turkey is also among the gene centre of apple species (Özbek, 1978; Akgül et al. 2011). The fact that a considerable part of the Asian continent is a gene centre for some species of apple and the presence of various species, subspecies and forms in which it has influenced the spread of apple cultivation in this continent. Europe-wide apple cultivation extends to the southern parts of the northern Scandinavian peninsula. Although, it is prevalent up to the 35<sup>th</sup> latitude in the southern Europe, apple is economically grown at the 58<sup>th</sup> northern latitude in Denmark and 60<sup>th</sup> northern latitude in Sweden. The apple is grown in high places to the south of this latitude. In Africa, Morocco and the Republic of South Africa gained importance in apple cultivation. In addition, the high parts of Central America, New Zealand and Australia have become major apple production centres (Özçağiran et al. 2004).

Apple is one of the most produced and consumed temperate climate fruit species in the world. According to FAO's 2014 data, world apple production was 84.6 million tons. China has a production volume of 41 million tons, accounting for 48.5% of world production. It was followed by the USA (5.2 million tons, 6.1%), Poland (3.2 million tons, 3.8%), Turkey (2.9 million tons, 3.4%) and India (2.5 million tons, 2.9%), respectively (FAO 2017).

Because of its geographical position and ecological conditions, Turkey has a very important place for the cultivation of all fruit species apart from tropical fruit species. In this respect, Turkey is the gene centre of the fruit cultivars and the gene centre of many cultivated species in the world (Ağaoğlu et al. 1997). In Anatolian geography, there is a great variety of fruit richness of pome fruits like apples, pears and quince (Gündüz, 1997; Kaşka, 1997). It is stated that apple variety is around 6.500 in the world and 460 in Turkey (Özbek, 1978). The number of apple varieties in Turkey has increased in recent years.

Apple was produced almost everywhere of Turkey. Amasya, Starking Delicious and Golden Delicious are largely produced apple cultivars in temperate climate regions of Turkey. But, trade value of these cultivars in international market is very low. In newly planted apple orchards, new cultivars are harvested from July to October. By increasing production of mid-season apple cultivars, Mondial Gala and Galaxy Gala would supply more profit and also prevent the accumulation of crops in the late season.

In the present study, phenological and pomological features of 'Mondial Gala' apple cultivar were evaluated at high altitudes of Mersin with subtropical climates of Turkey.

### Material and methods

The experiment was conducted in the orchard of private sector at Erdemli/Mersin (Latitude 36 35 27 N; 34 60 39 E; Elevation 750 m) in 2016. Regular agricultural practices were applied in orchards.

The experiment was conducted on eight-year-old 'Mondial Gala' apple cultivar grafted on a dwarf rootstock (M9). Trees were planted in 2008 at a distance 3×1 for M9 rootstocks.

All fruit samples were taken during the maturity stage which were visually determined and harvesting date of the cultivar also was determined. On the experimental trees, the number of fruits was counted, yielded (harvested and weighted per tree in kilograms) and weighted from 30 trees. Trunk diameter was measured at a height of 10 cm and was converted to Trunk Cross Sectional Area (TCSA/cm<sup>2</sup>). Some phenological properties of the cultivar were evaluated by determining in the beginning of flowering, full bloom, end of flowering, duration of flowering, harvest date, number of days from full bloom to harvesting time. Flowering was investigated by the recommendations of the International working group for pollination (Wertheim, 1996). The date of beginning of flowering was taken when 10% of flowers were opened, full when 80% of flowers were opened, end when 90% of petals were fallen. Duration of flowering was determined by the number of days from the beginning to the end of the flowering. The harvesting date is accepted as the time of maturing.

In this study, the pomological methods has been described by Bozbuga and Pırlak (2012). Fruit weight (g) was measured with a sensitive (0.01 g) scale (Precisa XB 2200 C). Fruit length (mm) and diameter (mm) were measured by a digital caliper (Mitutoyo, 0–150 mm). Flesh firmness was tested on two sides of each fruit by an Effegi penetrometer with a 11 mm plunger after removal of the peel and then it was measured as libre.

Total soluble solids (TSS) content were determined with a hand-held refractometer (NOW, 0–32% Brix) and pH (WTW InoLab pH meter) measurements were performed using a pH meter. Acidity (expressed as malic acid %) was determined by titrating with 0.1 N NaOH up to pH 8.10.

Skin colour was measured on opposite sides of the fruit using a Minolta chromameter (model CR-300; Minolta Camera Co., Osaka, Japan), which provided CIE L\* a\* b\* values.

### Results and discussion

The beginning of flowering date, the full flowering date and the end of flowering were observed 1 April, 10 April and 17 April, respectively. It is known that the flowering date and period varies depending on cultivars, altitude as well as ecological and cultural conditions.

Kulina et al (2013) stated that beginning of flowering date, the full flowering date and the end of flowering in Mondial Gala/M9, were observed as 24 April, 29 April, 07 May, respectively in Sarajevo region of Bosnia and Herzegovina. İkinci and Bolat (2013) reported that the first flowering of the Mondial Gala apple variety in Sanlıurfa ecology was carried out on 27 March, the full flowering was on 2 April and end of flowering was on 9 April. The average duration of flowering was 16 days. Comparing our results with the results of Kulina et al (2013), time of flowering of Mondial Gala cultivar occurred much earlier in agro–environmental conditions of Erdemli/Mersin. The flowering has occurred relatively later in environmental conditions of Sarajevo because of climatic conditions and later start of growing season, but the process and duration of flowering was in accordance with the characteristics of the examined clone.

The time of maturation of the studied apple cultivar was from 25 of July. Time of maturation depends, primarily, on genetic characteristics and environmental conditions, which may influence earlier or later ripening. As a matter of fact, İkinci and Bolat (2013) reported that Mondial Gala apple cultivar matured 09 August in Şanlıurfa ecological conditions.

At the trial, the trunk cross-sectional area values were established between 23.06 cm<sup>2</sup> and 65.29 cm<sup>2</sup>, mean value was obtained as 40.24 cm<sup>2</sup>. Considering the yield amounts (yield effect) per trunk cross-sectional area unit, the highest value was obtained 0.86 kg/cm<sup>2</sup>, and the lowest value was obtained 0.39 kg/cm<sup>2</sup>, the mean value was 0.56 cm<sup>2</sup>. The number of fruits per tree varied from 92 to 118, with an average of 105. The yield was varied between 6.6 ton/da and 8.4 ton/da, with an average yield of 7.5 ton/da (Table 1).

Table 1. Yield parameters of Mondial Gala apple cultivars budded on M9 rootstock

	Trunk cross-sectional area (cm <sup>2</sup> )	Number of fruits/ tree	Yield (kg tree <sup>-1</sup> )	kg/cm <sup>2</sup>	Yield (ton da <sup>-1</sup> )
Minimum	23.06	92	19.76	0.39	6.6
Maximum	65.29	118	25.35	0.86	8.4
Average	40.24	105	22.56	0.56	7.5

Ten-year-old Mondial Gala varieties grafted on M9 and MM 106 rootstocks under Egirdir conditions, the trunk cross-sectional area between 67.75 cm<sup>2</sup> and 109.12 cm<sup>2</sup>, the yield per tree between 37.44 and 95.5 kg and the yield value per trunk cross-sectional area between 5.25 and 3.25 kg/cm<sup>2</sup> were obtained (Ozongun et al. 2016). In the same study, the tenth-year cumulative yield values of Mondial Gala/M9 and Mondial Gala/MM106 rootstock/variety combinations ranged from 35.17 tons/da to 31.88 tons/da.

The results of fruit physical characteristics of 'Mondial Gala' apple cultivar were given in Table 2. The fruit weight is one of the most important pomological characteristics because it affects a number of other properties, primarily yield. In our study, the minimum and maximum fruit weights were found as 178.7 g and 267.7 g, respectively. The mean fruit weight was 223.2 g. While the minimum fruit width was 72.04 mm, the maximum fruit width was 83.27 mm (Table 2).

Table 2. Fruit properties of Mondial Gala apple cultivar

	Fruit weight (g)	Fruit width (mm)	Fruit length (mm)	Flesh firmness (kg/cm <sup>2</sup> )	TTS (%)	Acidity (%)	pH	Number of seed
Minimum	178.7	72.04	59.83	1.08	10.8	0.77	3.97	2
Maximum	267.7	83.27	80.91	1.5	12.6	1.09	4.18	10
Average	223.2	77.66	70.37	1.29	11.7	0.93	4.08	6

Bozbuga and Pırlak (2012) observed average fruit weight, fruit diameter, fruit length, TTS, and seed number in Mondial Gala grafted on M9 was 152 g, 72.2 mm, 60.1 mm, 12.5% and 6.9 respectively in Nigde province. In another study, Baytekin (2006), fruit weights were obtained as 280.18g in Gala/M9 in Tokat province. Atay (2007) determined average fruit weight as 150.98 g in Galaxy Gala cultivar. Kulina et al. (2013) conducted a study in Sarajevo province and observed average fruit weight, fruit diameter and fruit length in Mondial Gala grafted on M9 as 168.36 g, 75.8 mm and 67.9 mm, respectively.

The weight, width, length, flesh firmness, soluble solids content, juice pH and titratable acidity (TA) levels of the Mondial Gala apple variety grafted on M9 under Egirdir conditions were between 147 g, 69.04 mm, 61.73 mm, 9.25 kg/cm<sup>2</sup>, 13.03%, 3.70 and 0.30%, respectively (Ozongun et al. 2016).

Our results share some similarities with some studies, but partly different from others. The difference may be resulted due to cultural practices, ecological conditions as well as variations in fruit formation.

The L value varied between 38.48 and 61.38 and the L value average was 54.70. The fruit skin a\* value, which indicates red colour, changed between -3,95 (negative values are green colour) and 28.09. Its average value in Mersin province ecological conditions was 16 (Table 3).

Table 3. Fruit skin color of Mondial Gala apple cultivar

	L	a	b
Minimum	38,48	-3,95	19,45
Maximum	61,38	28,09	33,25
Average	54,70	12,07	26,35

### Conclusions

Turkey being the original source of apple has sites suitable for apple production; however, studies in Subtropical conditions of Turkey, particularly in the Mersin province, is not sufficient. In recent years, apple varieties that have matured in the mid-season have begun to be grown in the higher parts of subtropical regions of Turkey. Our preliminary study showed that ‘Mondial Gala’ cultivar, when grafted onto M9 rootstock, have high economic potential in the higher parts of Subtropical regions. Mid-season maturation of these cultivars increases the economic value of fruits in the market. Despite the subtropical climatic conditions of Mersin district, ‘Mondial Gala’ can be evaluated as a high yield producing cultivar.

### References

1. Ağaoğlu, Y.S., H. Çelik, M. Çelik, Y. Fidan, Y. Gülşen, A. Günay, N. Halloran, I. Köksal and R. Yanmaz, (1995). Common Horticultural Plants, Vol. 4, p: 369. Ankara University, Faculty of Agriculture, Education, Research and Development Foundation Publication
2. Akgül, H., Kaçal, E., Öztürk, F.P., Özongun, Ş., Atasay, A., Öztürk, G., (2011). Apple Culture. Adım Ofset, Konya, (in Turkish), 510p.
3. Atay, E. (2007). Determination of fruit growth and development some apple varieties on MM 106 rootstock. M.Sc. thesis (Unpublished). Dept. of Horticulture, Fac. of Agri., Selçuk Univ., Konya, Turkey.
4. Baytekin, S. (2006). Performance of some apple cultivars on different clonal rootstocks in ecology of Turhal district of Tokat province. M.Sc. thesis (unpublished). Dept. of Horticulture, Fac. of Agri., Gaziosmanpaşa Univ., Tokat, Turkey.
5. Bozbuğa F., Pırlak L. (2012): Determination of phenological and pomological characteristics of some apple cultivars in Niğde-Turkey ecological conditions. Journal of Animal & Plant Sciences, 22(1): 183-187.
6. Deveci, L., (2000). Apple growing, Apple's History and Gene Centre, (in Turkish). p; 7-8.
7. FAO, (2017). Agricultural Statistical Database, available online at:<http://faostat.fao.org> (Accessed: 22 September 2017).
8. Gündüz, M., (1997). World trades of pome fruits and evaluation from point of view of Turkey. Pome Fruit Symposium. Edt. M.Büyükyılmaz, M. Burak. Ataturk Horticultural Central Research Institute, Yalova, 295-304.
9. İkinci, A and Bolat, I. (2013). Determination of phenological, pomological and yield characteristics of low chilling apple cultivars budded on M9 and MM 106 rootstocks. IV International Symposium “Agrosym 2013”; 627-636.
10. Kaşka, N. (1997). Importance of apple growing constraints and solution in Turkey Pome Fruit Symposium. Edt. M.Büyükyılmaz, M. Burak. Ataturk Horticultural Central Research Institute, Yalova, 1-12.
11. Kulina, M., Gacesa, B., Stojanovic, M., Alic-Dzanovic, Z. (2013). Pomological Properties of “Gala” apple clones in the region of Sarajevo. IV International Symposium “Agrosym 2013” 257-262.
12. Ozbek, S. (1978). Special Horticulture. Cukurova University Faculty of Agriculture publications number 128 Ankara University Press Ankara (in Turkish). 488 p.

13. Ozcagiran R., Unalan A., Ozek E., İsfendiyarođlu M. (2005). Apple. Temperate fruit species, Pome Fruits. Volume II., Ege University Faculty of Agriculture, Publication No: 556, Bornova, Izmir, pp. 3-72.
14. Ozongun, Ő., Dolunay, E M., PektaŐ, M., Öztürk, G., Çalhan, Ö., Atay, E. (2016). Yield and Quality Alterations of Some Apple Cultivars on Different Rootstock Ege Üniv. Journal of Agric. Faculty. 53 (1):35-42
15. Way, R. D., Aldwinckle, H. S., Lamb, R. C., Rejman, A., Sansavini, S., Shen, T., Watkins, R., Westwood, M.N., Toshida, Y. (1990). Apples (*Malus*). In: Genetic resources of temperate fruits and nut crops I. Netherlands, ISHS. 488 p.
16. Wertheim, S.J. (1996). Methods for cross pollination and flowering assessment and their interpretation. Acta Horticulturae 423: 237-241.