The Journal of Animal & Plant Sciences, 22(1): 2012, Page: 183-187
ISSN: 1018-7081

DETERMINATION OF PHENOLOGICAL AND POMOLOGICAL CHARACTERISTICS OF SOME APPLE CULTIVARS IN NİĞDE-TURKEY ECOLOGICAL CONDITIONS

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ABSTRACT

The aim of this study was to define phenological and pomological characteristics of some apple varieties grafted on dwarf and semi-dwarf rootstocks. The experiment was conducted at Sazlıca/Niğde on the orchard of private sector during 2006 and 2007. In this experiment, bud swelling, bud breaking, begin of blooming, full blooming, last blooming and harvesting data of Galaxy, Mondial Gala, Red Chief, Super Chief, Oregon Spur, Scarlet Spur, Early Red One, Granny Smith and Fuji (Standard type) apple varieties were observed. The results from our research shown that, full blooming date was 20 April- to 10 May, fruit harvesting was between 20 August and 13 October. Average weight of the fruits was 144.6 g (Galaxy Gala) to 216.3 g (Fuji). The average width of the fruits was 70.1 mm (Galaxy Gala) to 81.7 mm (Fuji). The average height of the fruits was 57.6 mm (Mondial Gala) to 70.3 mm (Granny Smith). The fruit index was 1.13 (Early Redone) to 1.22 (Galaxy Gala, Mondial Gala). The number of seeds was 6.5 (Galaxy Gala) to 9.3 (Granny Smith). The content of soluble solids in the fruits was 12.2 % (Granny Smith) to 16.5 % (Fuji). The starch amount was 1.82 (Early Red One) to 3.00 (Mondial Gala). As a result, according to phenological, pomological properties and yield results of investigated varietes for the conditions of Niğde, the cultivation of Galaxy Gala, Red Chief, Oregon Spur, Granny Smith and Fuji should recommend.

Key words: Apple Varieties, Phenological and Pomological Properties, Niğde Province.

INTRODUCTION

Anatolia, Caucasia, Turkistan, and Europe were centers of origin for the domestic apple (*Malus domestica Borkh*.), now grown in continental climates in the Northern and Southern Hemispheres. Apple cultivation has occurred since ancient times and is one of the most important fruit for human consumption. One reason is great variety in colours, flavours, flesh textures, and other features (Way *et al*., 1990, Mukhtar *et al.*, 2010)). The most important producer countries are China, United States, Turkey, France, Iran, and Italy. Annual apple production in Turkey is 2,547,845 t, is one of the important producers of the word (FAOSTAT, 2011). More than 500 cultivars of apple are known in Turkey. This abundance has resulted from natural hybridization and selection over thousands of years (Özbek, 1978). Niğde is one of the biggest apple producing provinces in Turkey. The number of total apple tree was 5,968,158 and total production was 219,815 t (TUIK, 2011). Apple was produced almost anywhere of Turkey and Niğde is one of the most important regions. Starking Delicious and Golden Delicious are largely produced among apple cultivars in Niğde. But, trade value of these cultivars in international market is very low. In newly planted apple orchards, new cultivars harvesting from July to October were used. By increasing production of mid-season apple cultivars, Mondial Gala and Galaxy Gala would be supply more gains and also prevent to accumulate of crop in the late season. On the other hand, nearly all of apple orchards in Niğde were old and on seedlings. Trees on seedling have long non-flowering period and low marketable fruit ratio, and cultural practices such as harvest, pruning, thinning and pest management are difficult to be made and expensive. With become widespread orchards on cloned rootstocks, early fruiting and cultural treatments such as pruning, harvest, thinning and pest management can be easily and cheap. But, a consequential part of production from old apple cultivars. In addition, most of the apple orchards in Niğde are old and fulfilled economic life-span. Orchard numbers with new cultivars and on dwarfing rootstocks were also very low. It should be increased the number of orchard with new cultivars and on dwarf and semi-dwarf rootstocks in order to increase yield and quality. Therefore, it is necessary to determine to suitable cultivars in terms of high quality and yield for the region.

In the present study, phenological and pomological features of some new apple cultivars were evaluated in Niğde-Turkey conditions.

MATERIALS AND METHODS

The study was carried out on 14-year old (tree spacing 3.5 m x 1.0 m) Galaxy Gala, Mondial Gala, Granny Smith and Fuji (Standart type) on M9 and

Oregon Spur, Scarlet Spur, Red Chief, Super Chief and Early Red One on MM106 apple trees in the same orchard, in the province of Sazlıca-Niğde in Turkey.

Some phenological properties of cultivars were evaluated by determining bud swell, bud break, beginning of flowering, full bloom, end of flowering, harvest date, number of days from full bloom to harvest. Some pomological features of cultivars were also evaluated by measuring of fruit weight (g), fruit diameter (mm), fruit length (mm), fruit index and seed number . Fruit samples were used to determine total soluble solids (TSS) (%) by refractometer (Atago Pocket Refractometer, PAL-2). Fruit flesh firmness was measured with shoremeter (FT-327) device by penetrating an eleven mm diameter probe into the peeled fruit to a dept of 8 mm. Determination of starch content of fruits was performed by immersing the apple halves for 15 seconds in 1 % iodine solution. After the immersion, the samples were kept under laboratory environment for 3 minutes and the color developed for each sample was compared to a reference color chart. The test results were expressed in a 1-10 scale, where 1 no starch loss, 10 no starch present. Mean yield per tree of each cultivar was calculated as the mean value of all the trees included in this study (Burak *et al*., 1998).

The experiment was based on completely randomized plots with 3 replicates and 10 plants per plots. All data in the present study were subjected to analysis of variance (ANOVA) and means were separated by Duncan's multiple range test at P=0.05 using SPSS (Dowdy and Wearden, 1983).

RESULTS AND DISCUSSION

During 2006, bud swelling, bud burst, beginning of flowering, full flowering and end of flowering in all cultivars were observed 22-28 March, 29 March-3 April, 14-19 April, 19-26 April and 25 April-2 May, respectively. Although flowering dates were almost near in all cultivars, yet significant differences were observed in harvest dates. The cultivars Galaxy Gala/M9 and Granny Smith were harvested on 20 August and 9 October, respectively (Table 2).

During 2007, bud swell, bud break, beginning of flowering, full bloom and end of flowering were observed 8-14 April, 15-21 April, 27April- 4 May, 5-10 May and 11-17 May, respectively. The harvest dates were almost similar to 2006 in all cultivars. The earliest and the latest maturity were observed in Galaxy Gala/M9, Mondial Gala/M9 (31 August), and Granny Smith cultivar (17 October), respectively (Table 3).

In cultivars, bud swell, bud break, beginning of flowering, full bloom and end of flowering were found two weeks later during 2007 than 2006 year. Such divergent result might be due to the differences between the temperatures dominated during early stage of vegetative development. Average temperature in March and April which is flowering period in research area was 7.3 and 11.9^{o}C in 2006 and 6.0 and 7.9^{o}C in 2007, respectively. Flowering date and period may vary according to cultivar aptitude as well as ecological and cultural conditions (Facteau *et al*., 1986).

Number of studies has been published about phonological characteristics of apple cultivars. The bud swell of apple cultivars grafted rootstock MM106 was observed in 16-21 March for Eğirdir province (Öztürk, 2005). Baytekin (2006) stated that dates of bud break in Red Chief/MM106, Fuji/M9, Gala/M9, and Granny Smith/M9 were observed as 12 March, 17 March, 18 March, 30 March, respectively for Tokat region.

The most important criteria in apple cultivars are duration between full bloom and harvest date. This is important factor in determination of harvest date. It is depends upon cultivar, place, year, rootstock and ecological conditions (Karaçalı, 2004). By examine the cultivars, the times between full bloom and harvest date in 2006 and 2007 were found 122–168 and 118–161 days, respectively (Table 2, 3). Ingle and D'souza (1986) reported that such time for Red delicious cultivar varied from 130 to 144 days. Polat (1997) added that it is 143-149 days in Granny Smith cultivar for Tokat province. Similarly, it was found as 142–156 days in other study (Baytekin, 2006).

During 2006, the minimum and the maximum fruit weights were observed in Galaxy Gala/M9 (150.3 g), and Fuji/M9 (216.3 g), respectively. The fruit index of cultivars was found 1.14 in Scarlet Spur/MM106 and 1.22 in Galaxy Gala/M9 (Table 4). Like the 2006, the minimum and the maximum fruit weight were obtained from Galaxy Gala/M9 (144.6 g), and Fuji/M9 (181.2 g), respectively in 2007. The lowest and the highest fruit index were found as 1.13 in Early Red One/MM106 and as 1.20 in Galaxy Gala/M9, respectively (Table 5).

In study Warmund (2004) conducted a study in United State and observed average fruit weight in Red Fuji grafted on 11 different rootstock cultivars was 177-182 g. In other study Baytekin (2006) in Tokat province, fruit weights were obtained as 186.06 g, 235.80 g, 280.18 g and 283.96 g in Granny Smith/M9, Red Chief/MM106, Gala/M9 and Fuji/M9, respectively. Atay (2007) determined average fruit weight as 150.98 g in Galaxy Gala cultivar for Eğirdir province. Our results are in line with some references but, partly different from others. The difference may be resulted due to cultivar, rootstock, cultural practices as well as variations in fruit formation.

The seed numbers of cultivars were found as 6.7 (Galaxy Gala) to 9.2 (Fuji) in 2006; 6.5 (Galaxy Gala) to 9.3 (Granny Smith) in 2007 (Table 4, 5).

In 2006, total soluble solids of cultivars were determined 12.2 % in Granny Smith and 16.3 % in Fuji. These values were 12.2 % and 16.5 % for Granny Smith and Fuji, respectively during 2007 (Table 4, 5).

Table 1. Meteorological data observed in Niğde province during 2006 and 2007.

	Mean temperature (°C)		Mean of the highest temperature (°C)		Mean of the lowest temperature (°C)		Mean of the sunny period (hour)		Number of rainy day		Maximum temperature (°C)		Minimum temperature (°C)	
	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007
January	-1.8	-0.2	2.8	6.8	-5.4	-5.7	3.7	5.1	10	6	12.8	16.6	-19.0	-13.3
February	2.2	1.2	7.5	6.6.	-2.6	-3.6	4.1	5.4	11	7	18.5	15.8	-16.1	-10.8
March	7.3	6.0	13.2	12.5	2.0	0.4	6.2	6.6	10	10	22.7	20.6	-4.2	-3.5
April	11.9	7.9	18.0	13.7	5.9	2.0	6.6	7.3	11	10	23.5	21.4	-3.1	-2.5
May	16.1	18.6	22.6	24.9	8.8	11.9	10.2	9.0	10	9	31.1	30.0	3.8	4.0
June	22.3	21.5	28.9	27.8	14.0	13.8	12.3	11.2	3	8	33.8	34.0	9.4	9.8
July	22.3	24.2	28.7	31.3	15.3	15.7	11.8	12.5	4	2	32.9	36.6	11.1	11.0
August	26.1	24.6	33.8	31.4	17.2	16.7	11.5	10.8	3	7	37.4	36.8	13.8	13.7
September	18.2	19.2	25.7	27.6	11.1	11.1	9.2	10.6	3	2	29.8	34.4	7.4	7.0
October	13.6	13.7	20.2	21.2	8.3	7.3	6.5	7.3	11	8	28.8	27.2	4.0	0.8
November	4.1	6.2	11.6	12.2	-1.2	5.4	6.3	5.4	7	14	15.8	18.6	-5.8	-5.6
December	-0.9	0.5	6.8	5.2	-6.2	-3.5	6.4	4.2	2	10	17.3	13.0	-14.8	-10.6

Table 2. Some phenologic characteristics of apple cultivars (2006)

CULTIVAR/ROOTSTOCK	B.S.	B.B.	B.F.	F.B.	E.F.	H.D.	DNFFBH
Fuji/M9	27.03	03.04	19.04	26.04	02.05	05.10	162
Galaxy Gala/M9	22.03	29.03	14.04	20.04	25.04	20.08	122
Granny Smith/M9	28.03	02.04	18.04	24.04	01.05	09.10	168
Mondial Gala/M9	23.03	29.03	15.04	19.04	26.04	21.08	124
Early Red One/MM106	26.03	01.04	16.04	22.04	29.04	20.09	151
Oregon Spur/MM106	24.03	30.03	15.04	20.04	27.04	11.09	144
Red Chief/MM106	26.03	31.03	16.04	22.04	29.04	20.09	151
Scarlet Spur/MM106	25.03	31.03	15.04	21.04	27.04	11.09	143
Super Chief/MM106	25.03	31.03	17.04	22.04	28.04	20.09	151

B.S.: Bud swell, B.B.: Bud break, B.F.: Beginnig of flowering, F.B.: Full bloom, E.F.: End of flowering, H.D.: Harvest date, DNFFBH: Number of days from full bloom to harvest

Table 3. Some phenologic characteristics of apple cultivars (2007)

CULTIVAR/ROOTSTOCK	B.S.	B.B.	B.F.	F.B.	E.F.	H.D.	DNFFBH
Fuji/M9	14.04	21.04	04.05	10.05	17.05	13.10	156
Galaxy Gala/M9	08.04	15.04	27.04	05.05	11.05	31.08	118
Granny Smith/M9	13.04	20.04	03.05	09.05	16.05	17.10	161
Mondial Gala/M9	09.04	16.04	29.04	05.05	12.05	31.08	118
Early Red One/MM106	11.04	18.04	02.05	08.05	14.05	28.09	143
Oregon SpurMM106	10.04	17.04	30.04	07.05	13.05	19.09	135
Red Chief/MM106	12.04	19.04	01.05	07.05	15.05	29.09	145
Scarlet Spur/MM106	11.04	18.04	30.04	06.05	14.05	20.09	133
Super Chief/MM106	11.04	18.04	01.05	07.05	14.05	28.09	144

Table 4. Some fruit characteristics of apple cultivar (2006)

CULTIVAR / ROOTSTOCK	Fruit weight (g)	Fruit diameter (mm)	Fruit length (mm)	Fruit index	Seed number	TSS (%)	Fruit flesh firmness (kg/cm²)
Fuji/M9	216.3 a	81.7 a	69.0 a	1.18	9.2	16.3 a	8.3 a
Galaxy Gala/M9	150.3 c	71.6 c	58.3 c	1.22	6.7	12.5 c	7.6 b
Granny Smith/M9	213.3 a	80.9 a	70.3 a	1.15	9.0	12.2 c	8.6 a
Mondial Gala/M9	152.0 c	72.2 b	60.1 c	1.20	6.9	12.5 c	7.4 b
Early Red One/MM106	160.1 c	72.5 b	61.1 b	1.18	8.1	13.4 b	6.4 c
Oregon Spur/MM106	186.8 b	71.2 c	60.9 bc	1.16	8.0	13.9 b	6.0 c
Red Chief/MM106	174.4 bc	73.6 b	62.2 b	1.18	7.2	13.5 b	7.2 b
Scarlet Spur/MM106	153.8 c	70.5 c	61.3 b	1.14	8.4	13.8 b	6.3 b
Super Chief/MM106	152.6 bc	72.6 bc	60.9 bc	1.19	7.5	14.8 b	7.6 ab

The same letter are not significantly different at $p \leq 0.05$

Table 5. Some fruit characteristics of apple cultivar (2007)

CULTIVAR/ROOTSTOCK	Fruit weight (g)	Fruit diameter (mm)	Fruit length (mm)	Fruit index	Seed number	TSS (%)	Fruit flesh firmness (kg/cm²)	Starch content (%)
Fuji/M9	181.2 a	75.3 a	63.1 a	1.19	9.1	16.5 a	8.2 a	2.63 b
Galaxy Gala/M9	144.6 d	70.1 c	58.5 c	1.20	6.5	13.8 c	7.8 a	3.00 a
Granny Smith/M9	180.2 a	75.9 a	66.7 a	1.14	9.3	12.2 d	8.1 a	2.33 b
Mondial Gala/M9	149.6 d	70.5 c	57.6 c	1.22	6.7	13.3 c	7.6 b	2.50 b
Early Red One/MM106	168.9 b	72.4 b	64.0 a	1.13	7.9	14.4 b	5.4 c	1.98 c
Oregon Spur/MM106	178.0 ab	75.1 a	64.4 a	1.16	7.8	12.5 c	7.8 a	2.04 c
Red Chief/MM106	173.2 b	74.3 a	64.2 a	1.16	7.1	14.2 b	6.0 c	2.44 ab
Scarlet Spur/MM106	158.6 c	71.0 b	62.1 b	1.14	8.3	13.9 c	7.9 a	1.97 c
Super Chief/MM106	153.8 c	71.4 b	61.5 b	1.16	7.3	14.4 b	6.4 b	2.36 b

The same letter are not significantly different at $p \leq 0.05$

Table 6. Yields of apple cultivars (kg/tree)

CULTIVAR/ROOTSTOCK	2006	2007
Galaxy Gala/M9	11.27 d	10.84 d
Mondial Gala/M9	11.40 d	11.21 d
Red Chief/MM106	13.07 c	12.99 b
Super Chief/MM106	11.44 d	11.53 d
Oregon Spur/MM106	14.00 b	13.35 b
Scarlet Spur/MM106	11.53 d	11.89 d
Early Red One/MM106	12.80 c	12.66 c
Granny Smith/M9	17.34 a	16.32 a
Fuji/M9	14.50 b	12.68 bc

The same letter are not significantly different at $p \leq 0.05$.

Fruit flesh firmness was obtained 6.01 kg/cm² (Oregon Spur) to 8.64 kg/cm² (Granny Smith) in 2006. These were 5.44 kg/cm² (Early Redone) to 8.18 kg/cm² (Fuji) in 2007 (Table 4, 5). Kaynaş and Karaçalı (1990) determined it as 7.5-8 kg/cm² in Granny Smith cultivar for Yalova region.

In examined apple cultivars, starch contents of Early Red One and Fuji were found 1.82 % and 2.62 %, respectively in 2006; 1.97 % and 3.0 % for Scarlet Spur and Galaxy Gala, respectively in 2007 (Table 4, 5).

In 2006, yield varied 11.27-17.34 kg/plant (Table 6). The highest yields were obtained from Granny Smith and Fuji, whereas the lowest in Galaxy Gala and Mondial Gala. In 2007, the yield varied 10.84-16.32 kg/ plant in cultivars. The highest yields were found in Granny Smith and Oregon Spur whereas yield was the lowest in Mondial Gala and Galaxy, respectively. Baytekin (2006) reported yields of 27.74 kg/plant, 12.02 kg/plant, 12.02 kg/plant and 20.04 kg/plant from Gala, Granny Smith, Red Chief and Fuji cultivars, respectively in Tokat province. Jönsson and Tahir (2004) researched plant yield in 12 different apple cultivars and found as 3.9 kg (Amorosa) to 20.2 kg (Scarlett O' Hara). Our results are in contrast to literature reviews. The apple yield may have great variations in respect to planting places and regions. In addition to cultivar and genetics of rootstock, yield from unit area (ha) is usually affected by some cultural practices such as irrigation, ploughing, pruning, thinning, fertilization, plant protection (Way *et al*., 1990, Antognozzi *et al*., 1993, Rackso *et al*., 2004).

Conclusıons: Adequate lightening and low air humidity stimulate fruit quality such as color, firmness and taste in apple. In terms of lightening period and air humidity, production of Red Chief, Oregon Spur and Scarlet Spur apple cultivars are favorable for Niğde province. Thus, it should be widespread and produced at large scale. According to phenological, pomological and yield results, Galaxy Gala, Red Chief, Oregon Spur, Granny Smith and Fuji were found as most suitable for Niğde province to replace old orchards.

Acknowledgements: We wish to thank to Uni-Tarım Ltd. Şti. This study was supported by a grant from Center of Scientific Research Project of Selcuk University (Project Number: 07201065).

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