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An investigation on phenological and pomological traits of some almond cultivars grown at Ceylanpinar State farm in Turkey

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SUMMARY – This experiment was carried out at Beyazkule in Ceylanpinar State Farm in Sanliurfa. The phenological and pomological characteristics of 21 almond types or cultivars (8 Turkish, 2 French, 3 American, 4 Russian, 2 Spanish and 2 Italian) planted at CEYTAM are presented. According to the obtained data, nut sizes were small in almost all cultivars. Yields were satisfactory in some cultivars while low in the others. As a result of these, it was assumed that, at least, 'Garrigues', 'Cristomorto' and 'Ferraduel' can be recommended for this region.

Key words: *Amygdalus communis*, almond, phenology, pomology.

RESUME – *"Recherches sur les caractères phénologiques et pomologiques de certains cultivars d'amandier établis à la ferme étatique de Ceylanpinar en Turquie". Cette expérience a été menée à Beyazkule à la Ferme étatique de Ceylanpinar à Sanliurfa. Les caractéristiques phénologiques et pomologiques de 21 types ou cultivars d'amandier (8 turcs, 2 français, 3 américains, 4 russes, 2 espagnols et 2 italiens) plantés à CEYTAM ont été présentées. Selon les données obtenues, les tailles des fruits étaient faibles chez presque tous les cultivars. Les rendements étaient satisfaisants chez certains cultivars mais faibles chez d'autres. Comme conséquence, il apparaît qu'au moins 'Garrigues', 'Cristomorto' et 'Ferraduel' peuvent être recommandés pour cette région.*

Mots-clés : Amygdalus communis*, amandier, phénologie, pomologie.*

Introduction

Almond is a drought resistant plant. It is also spread through all the Anatolia where the climate is suitable. Almond cultivars are classified between fruit species as fruit species that need at least a cold resting period. Having completed cold resting period, almond cultivars start blooming in early spring with warm weather conditions. After first spring frost arising, cold weather conditions cause damage to the flowers. So this unusual cold weather conditions result in loss of significant amount of fruits. This problem has arisen repeatedly and frequently in species that are not suitable for the area. Therefore, determination of fruit species adapted to the area is a vitally important issue, based on spring last frost. The yield is dependent on spring frost.

The wild almond trees such as *Amygdalus communis* and *Amygdalus turcomonica* species are common in the southeast Anatolia region (Ak *et al*., 2001). The first observations are encouraging and suggest that almond can be grown very well at South East Anatolia region of Turkey if spring frost does not occur. These ideas developed to choose late flowering cultivars for this region.

Almond culture is possible at South East Anatolia because: (i) there is enough high temperature and low relative humidity in summer time during maturation and harvesting time; (ii) winters are cold enough to provide chilling requirement; (iii) trees can be grown in soil with high lime content; and (iv) trees are resistant to dry or o reduced water conditions.

South East Anatolia is mainly covered with pistachio trees. But almond is an alternative crop to pistachio (Kuden, 1998). Farmers prefer to grow almond instead of pistachio under irrigated areas (Kaska *et al.* 1999) because: (i) juvenile period is very short; (ii) there is no alternate bearing habit; (iii) harvesting is easy; and (iv) fruits can be stored easily.

All of the above conditions led the farmers to establish almond orchards using late flowering cultivars. This experiment was carried out with late flowering cultivars using early ones as controls. The main aim of this research is the determination of the most suitable almond cultivars for Southern Anatolia region. Phenological and pomological traits were determined for different domestic and foreign almond cultivars.

Materials and methods

The Site: This experiment was conducted at Ceylanpinar State Farm's area between 1997-1998 years in Sanliurfa-Turkey. The spring frost dates of this area were recorded (Table 1).

Table 1. The late spring frost and autumn early frost dates at Ceylanpinar State Farm

Years	Late spring frost date	Degree of temperature (°C)	Early autumn frost date	Degree of temperature (°C)
1990	18/3	–4.3	13/11	–0.2
1991	10/3	–2.2	06/12	–0.2
1992	16/3	–2.6	09/11	–0.2
1993	22/3	–2.1	13/11	–1.0
1994	16/3	–2.2	13/11	–0.1
1995	27/3	–3.0	12/11	0.0
1996	03/3	0.0	13/11	–4.0
1997	12/4	–2.4	29/11	0.0
1998	26/3	–2.4	05/12	–2.0

Cultivars: 21 almond types or cultivars: Turkish cvs, French cvs, American cvs, Russian cvs, Spanish cvs, and Italian cvs.

Plantation: The budded seedlings, on the almond rootstock, were planted on 26.02.1993, area 5 m x 5 m, 10 trees for each cultivar.

Phenological observation criteria: The dates were determined on bud swelling, half inch green/ pink, first blooming time (5% blooming), full bloom (60% blooming), end of bloom (petal fall) and fruit set (small fruit).

Pomological traits: Pomological analyses were applied on nut and kernel. The traits analysed were weight (g), length (mm), width (mm), thickness (mm), double kernel rate (%) and shelling percentage (%).

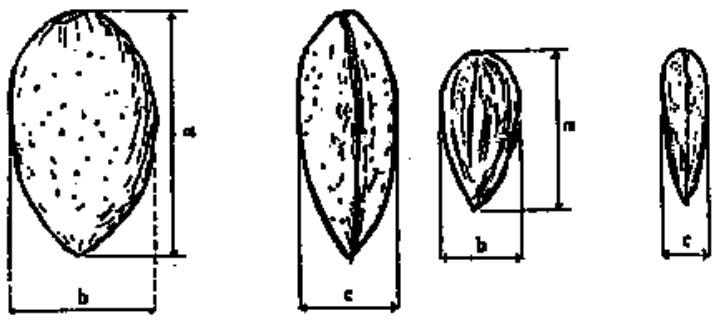

Fig. 1. The measurement of fruit and kernel dimensions (Anonymous, 1981) (a: length, b: width, c: thickness).

Statistical analyses: Harvesting time was measured by sampling 20 fruits per replication. Three replications were used. The data measured was subjected to variance analysis variables and the averages were compared to the TUKEY test (Bek, 1983).

Results and discussion

Phenological observation

Blooming time is a very important trait in almond because this species has been traditionally the one showing the earliest blooming time. The almond orchards should not be established in regions where the spring frost is a risk (Socias i Company, 1997).

In this experiment, blooming dates changed between the years. The cultivars were ordered according to full bloom dates. The dates registered in 1997 are given in Table 2. The first one is cultivar '48-1', which was the earlier cultivar selected by Dokuzoguz and Gulcan (1973). The latest blooming (07.04.1997) cultivar is Ferragnès. The blooming dates between the first and last fully bloomed cultivars differed 34 days in 1997.

Table 2. Phenological observations in 1997

Cultivars	Pink	First bloom	Full bloom	End of bloom	Fruit set	Harvest time
'48-5'	25.02	30.02	03.03	10.03	14.03	–
'D. Largueta'	25.02	29.02	03.03	15.03	01.04	06.09
'48-1'	10.03	11.03	13.03	18.03	21.03	–
'48-2'	10.03	12.03	13.03	04.04	08.04	–
'101-23'	06.03	09.03	13.03	21.03	03.04	25.09
'Tuono'	10.03	14.03	16.03	04.04	07.04	–
'Nikitski'	06.03	12.03	16.03	04.04	07.04	–
'17-4'	10.03	16.03	19.03	22.03	25.03	–
'101-9'	25.03	27.03	31.03	04.04	06.04	–
'Drake'	24.03	27.03	31.03	17.03	19.03	06.09
'Primorskyi'	19.03	27.03	01.04	14.04	16.04	10.09
'101-13'	28.03	30.03	02.04	07.04	18.04	11.09
'300-1'	16.03	19.03	02.04	14.04	17.04	–
'Cristomorto'	16.03	25.03	02.04	14.04	20.04	06.09
'Nonpareil'	24.03	28.03	02.04	14.04	19.04	06.09
'Ferraduel'	28.03	30.03	04.04	07.04	10.04	10.09
'Garrigues'	28.03	30.03	04.04	07.04	10.04	10.09
'Picantili'	31.03	02.04	04.04	09.04	13.04	06.09
'Texas'	28.03	30.03	04.04	17.04	21.04	06.09
'Yaltinski'	28.03	30.03	04.04	08.04	10.04	–
'Ferragnès'	02.04	04.04	07.04	10.04	13.04	–

In the second year (1998), the earlier cultivars were '48-5' and 'Desmayo Larguetta' (Table 3). But the latest one was '101-13'. The other cultivars localised between these cultivars. The dates for earliest and latest blooming were 07.03.1998 to 04.04.1998, which means 27 days of difference.

These results cover only two years. According to phenological observations blooming dates changed from one year to another. This is also dependent on different climate factors. One of the climate factors is temperature during springtime. Late blooming is a main factor to prevent spring frost damage. This factor is also one of the important features in the almond breeding program (Kester and Assay, 1975).

Table 3. Phenological observations in 1998

Cultivars	Pink	First bloom	Full bloom	End of bloom	Fruit set	Harvest time
'48-5'	03.03	05.03	07.03	14.03	31.03	–
'D. Largueta'	03.03	05.03	07.03	18.03	03.04	04.09
'48-1'	06.03	08.03	10.03	17.03	02.04	–
'17-4'	07.03	09.03	11.03	18.03	03.04	–
'300-1'	07.03	09.03	11.03	25.03	10.04	04.09
'Tuono'	07.03	09.03	11.03	25.03	10.04	09.09
'48-2'	08.03	10.03	12.03	18.03	03.04	–
'101-23'	09.03	11.03	12.03	25.03	06.04	–
'Nikitski'	08.03	10.03	12.03	27.03	10.04	09.09
'Primorskyi'	12.03	15.03	17.03	31.03	08.04	09.09
'Drake'	13.03	16.03	18.03	31.03	10.04	04.09
'Garrigues'	14.03	16.03	18.03	02.04	08.04	08.09
'Texas'	15.03	17.03	18.03	30.03	14.04	04.09
'Picantili'	15.03	18.03	20.03	06.04	10.04	04.09
'Cristomorto'	16.03	19.03	21.03	03.04	10.04	04.09
'Nonpareil'	14.03	19.03	21.03	03.04	10.04	04.09
'Ferragnès'	17.03	19.03	21.03	06.04	12.04	09.09
'Ferraduel'	18.03	23.03	25.03	06.04	10.04	09.09
'Yaltinski'	19.03	22.03	27.03	07.04	12.04	–
'101-9'	14.03	23.03	28.03	03.04	12.04	–
'101-13'	18.03	25.03	31.03	04.04	15.04	–

According to weather reports taken from meteorology station in Ceylanpinar State Farm, generally spring late frosts have been recorded at the end of March during the last 25 years. Rarely spring late frosts have occurred during the first half of April. So, the date of spring last frost in the area was observed in March 26-27 (Table 1).

Although blooming time of 'Yaltinski' was after the date of spring late frost, 'Yaltinski' had not been harvested during two years of research period. Small amount of raw fruits on the trees have dropped by drying from trees before fruit ripening or fruit maturation period. The problem of fruit formation in 'Yaltinski' cultivar could be explained with late pollination of the cultivar compared to the other selected almond cultivars used in the study.

Even though dates of fruit maturation were different from cultivar to cultivar, harvesting of the cultivars had been done in September 97 (6th and 25th) and September 98 (4th and 9th). Every cultivar in this study was harvested once a year.

When spring late frost was investigated for 25 years, spring of the research area in 97 was reported as an extreme year. Therefore flowers of the all cultivars were affected by the spring late frost and the amount of fruits harvested from the cultivars decreased significantly. It was reported that some cultivars did not produced any fruit, probably severely affected by spring late frost.

Pomological traits

Pomological results from 1997 are given in Table 4. All the characters such as length, width, thickness and weight were statistically significant both for nut or kernel. According to the obtained results, for 'Ferraduel' cultivar, the nut weight was 4.44 g, while for 'Texas' it was 1.52 g. The kernel weight in '101-13' cultivar (2.08 g) was very different than in 'Texas' (0.76 g). For nut length, the best cultivars are 'Garrigues' (36.62 mm) and 'Picantili' (36.56 mm). Regarding the shelling percentage, the best cultivar is 'Drake'.

Table 4. Some pomological traits on nuts and kernels of different almond cultivars in 1997

Cultivars	Nut				Kernel				Shelling percentage (%)
	Length (mm)	Width (mm)	Thickness (mm)	Weight (g)	Length (mm)	Width (mm)	Thickness (mm)	Weight (g)	
'101-13'	31.10 f	20.83 e	14.11 e	3.67 cd	21.97 g	13.44 e	6.77 l	2.08 a	56.68
'101-23'	29.71 g	16.23 l	13.84 f	2.21 f	23.30 e	10.48 l	8.15 c	0.92 e	41.63
'Cristomorto'	34.22 d	21.36 c	16.49 b	3.69 c	24.51 d	14.05 c	8.72 b	1.36 b	36.86
'D. Largueta'	33.19 e	21.08 d	14.66d	3.80 b	25.05 c	12.09 f	8.02 cd	1.11 cd	29.21
'Drake'	28.71h	16.71 h	13.38 h	1.63 l	21.15 h	11.33 g	8.78 b	0.99 de	60.74
'Ferraduel'	35.25 b	22.60 b	16.26 c	4.44 a	23.24 f	13.85 d	7.60 f	1.15 c	25.90
'Garrigues'	36.62 a	24.94 a	16.99 a	3.61 d	25.02 c	15.57 a	7.42 g	1.31 b	36.29
'Nonpareil'	27.76 l	17.20 g	14.07 e	1.84 g	21.61 h	11.98 f	9.05 a	1.06 cd	57.61
'Primorskyi'	34.69 c	16.02 l	11.63 l	1.75 h	25.69 b	11.06 h	7.20 h	1.00 de	57.14
'Picantili'	36.56 a	20.85 e	13.68 fg	2.51 e	27.45 a	14.47 b	7.80 e	1.29 b	51.39
'Texas'	25.28 j	17.46 f	13.56 gh	1.52 j	19.81 i	11.06 h	7.92 de	0.76 f	50.00
TUKEY % 5	0.37	0.25	0.18	0.08	0.22	0.13	0.14	0.12	---

Same letters within each column indicate no significant differences at P<0.05.

In 1998 (Table 5), the nut weight also similar to 1997. The nut weight varied between 4.40 g (Ferraduel), and 1.63 g ('Texas'). The kernel also varied from 1.73 g ('Picantili') to 0.82 g ('Texas'). Regarding the kernel length, the best one is 'Picantili' (29.75 mm) and the lowest is 'Texas'. According to shelling percentages the best cultivar is 'Nonpareil' (59.89 %).

Table 5. Some pomological traits on nuts and kernels of different almond cultivars in 1998

Cultivars	Nuts				Kernel				Shelling percentage (%)
	Length (mm)	Width (mm)	Thickness (mm)	Weight (g)	Length (mm)	Width (mm)	Thickness (mm)	Weight (g)	
'300-1'	38.23 b	19.29 g	13.55 h	3.15 e	28.53 c	12.06 h	7.69 j	1.23 d	39.05
'Cristomorto'	36.77 d	22.59 a	18.12 a	5.07 a	25.43 f	14.56 b	9.69 b	1.59 b	31.36
'D. Largueta'	33.06 g	20.08 e	15.14 ef	3.49 c	25.11 g	11.99 h	8.77 f	1.15 e	32.95
'Drake'	31.13 h	18.78 h	15.15 ef	2.21 h	22.43 l	12.39 g	9.91 a	1.26 d	57.01
'Ferraduel'	34.15 f	21.74 c	16.29 c	4.40 b	25.08 g	14.02 c	8.97 e	1.56 b	35.45
'Garrigues'	34.53 e	22.69 a	17.21 b	3.16 e	23.79 h	14.15 c	9.19 d	1.34 c	42.41
'Nonpareil'	28.69 l	17.56 j	14.13 g	1.87 l	21.93 j	11.90 l	9.48 c	1.12 ef	59.89
'Primorskyi'	37.73 c	22.22 b	15.06 f	2.86 g	28.08 d	14.63 b	9.15 d	1.54 b	53.85
'Picantili'	40.01 a	22.84 a	15.32 de	2.99 f	29.75 a	15.05 a	9.18 d	1.73 a	57.86
'Texas'	26.94 j	17.99 l	13.54 h	1.63 j	20.32 l	11.23 j	7.95 i	0.82 g	50.31
'Tuono'	26.23 k	19.69 f	16.15 c	2.86 g	21.37 k	13.12 e	8.41 g	1.07 f	37.41
'Nikitski'	38.38 b	17.96 i	13.04 i	2.12 h	28.83 b	12.67 f	9.44 c	1.60 b	57.47
'Ferragnes'	34.08 f	21.09 d	15.48 d	3.27 d	27.06 e	13.61 d	8.30 h	1.36 c	41.59
TUKEY % 5	0.29	0.26	0.19	0.09	0.26	0.14	0.17	0.06	---

Same letters within each column indicate no significant differences at P<0.05.

The other characters of the nuts and kernels are given in Table 6. The separation of hull also changed from easy, medium or hard. Twin kernel habit is also dependent on the cultivar. The highest twin kernel percentage was obtained for 'Cristomorto' (rate was 56.67). These rates may be high because of high summer temperature. The taste of kernel was generally considered of good class.

Conclusions

Early blooming is not desirable because of the spring frost risk. But some times if the area is dry and there is no irrigation possibility, early blooming cultivars especially should be considered. In these conditions, the initial fruit development takes place before the period of severe drought. Moreover, in

these conditions, a short vegetative period may be desirable to complete vegetative growth before summer. Similar growth cycles were observed in wild species growing in the desert areas of Central Asia, where fruit ripening takes place in June (Socias i Company *et al*., 1998).

According to the obtained data, generally nut sizes were a little bit small in almost all cultivars. Yields were satisfactory in some cultivars while low in the others. As a result of these, it was assumed that, at least, 'Garrigues', 'Cristomorto' and 'Ferraduel' can be recommended to this region.

Table 6. Pomological traits of some almond cultivars

Cultivars	Separation of hull	Blank nut rate (%)	Double kernel rate (%)	Taste of kernel
'101-13'	Easy	0	5.00	Good
'101-23'	Medium	0	23.33	Good
'300-1'	Hard	0	8.33	Good
'Cristomorto'	Medium	0	56.67	Good
'D. Largueta'	Hard	0	13.33	Good
'Drake'	Medium	0	25.00	Medium
'Ferraduel'	Easy	0	20.00	Good
'Garrigues'	Medium	0	48.30	Medium
'Nonpareil'	Medium	1.67	25.00	Good
'Primorskyi'	Hard	1.67	26.67	Good
'Picantili'	Hard	1.67	20.00	Medium
'Texas'	Easy	0	8.33	Medium
'Tuono'	Medium	0	6.66	Good
'Nikitski'	Hard	0	31.66	Good
'Ferragnès'	Medium	0	0.00	Good

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