Nectar production of pear *(Pyrus communis L.)* cultivars

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Benedek P.[1], Kocsisné Molnár G.[2] and Nyéki, J.[3]

[1]*West Hungarian University, Faculty of Agricultural Sciences, H-9201 Mosonmagyaróvár, Hungary*
[2]*Veszprém University, Georgikon Faculty of Agricultural Sciences, H-8360 Keszthely, Hungary*
[3]*Debrecen University, Centre of Agricultural Sciences, H-4032 Debrecen, Hungary*

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Summary: Detailed studies were made on the nectar production of 44, 16 and 18 pear cultivars, respectively, in a cultivar collection of pear during three consecutive years with highly different weather in the blooming. Results clearly show that pear does not necessarily produce small amount of nectar as stated in the world literature. In fact, pear can produce extremely high amount of nectar sometimes much higher than other temperate zone fruit trees species but its nectar production is highly subjected to weather, first of all to air temperature. Low nectar production seems to be more frequent than high one and cold weather can prevent its nectar production at all. On the other hand, results corroborate to the earlier statements on the low sugar concentration of pear nectar. There is a highly significant negative correlation between the amount of nectar produced by pear flowers and its sugar concentration ($r = -0.52$, $n = 291$, $p < 0.001$ for 1996, $r = -0.34$, $n = 197$, $p < 0.001$ for 1998). Sugar concentration in individual flowers may be up to 40% in exceptional cases but generally it is well below 20%. Very high figures for sugar concentration in pear nectar at the literature seem to be incomprehensible. In contrast of some earlier statement in the literature no real difference could be established in the nectar production of pear cultivars, based on much more measurements than in earlier studies. Very low sugar concentration in pear nectar can explain the fact that the overwhelming majority of honeybees are pollen gatherers at pear trees even in the case of exceptionally high nectar production.

Introduction

Most temperate zone fruit tree species need insect pollination and their bee visitation is highly dependent on the nectar production of their flowers (*Free,* 1970, 1993). Pear flowers are usually considered to produce rather little amount of nectar (*Free,* 1970) and most authors accept the statement of *Vansell,* (1946) that pear nectar is low is sugar content and so it frequently fails to attract honeybees. Other authors, however, report on fairly high mean nectar content of pear flowers (*Glowska,* 1998, *Benedek* and *Nyéki,* 1997) and also on high sugar content of pear nectar (*Péter,* 1972). Some authors point out the definite effect of weather on the nectar production of pear (*Sazykin,* 1999, *Péter,* 1972) and others have found that the nectar production of pear cultivars may be different (*Vansell,* 1946, *Simidchiev,* 1970). Accordingly, nectar production of pear seems not be thoroughly studied and in spite of the general belief on its poor nectar production and the low sugar concentration of its nectar (see in *Free,* 1970, 1993) we decided to re-evaluate the problem because this is highly important from the point of view of bee pollination of pear trees. Re-evaluation has also been found to be reasonable because former studies were made on a limited number of cultivars but the conclusions were related to the pear in general.

Material and method

Studies were made at a 1.5 ha large variety collection of pear including some 250 cultivars at Keszthely (South-west Hungary) at a few hundred metres distance from the lake Balaton. Pear trees were 10–15 years old, except a few cultivars that were not tested.

Strong honeybee colonies were moved to the small orchard at the beginning of the blooming period. The number of colonies varied between 9–18 in the three years of the studies.

Measurements were made in 1996, 1997 and 1998. Nectar production of flowers was carefully measured and weather conditions were registered during the blooming period of pear.

Weather was different in the three years. It was clearly favourable to pear flowering in 1996 *(Table 1).* Air

Table 1 Weather conditions during the blooming period of pear at Keszthely in 1996

Date	Ambient temperature (°C)			Sunny hours	Rainfall (mm)
	minimum	daily mean	maximum		
April 25	12.5	16.0	20.2	7.1	0
April 26	12.5	14.8	19.0	2.3	0
April 27	8.3	13.6	17.45	0	0.5
April 28	11.2	15.6	21.6	8.9	0
April 29	10.3	16.9	23.2	11.4	0.1
April 30	11.4	15.2	19.5	2.6	1.0
May 1	13.2	15.4	20.2	1.4	5.0
May 2	10.5	16.1	22.0	12.4	0
May 3	9.5	14.1	21.0	7.7	5.8
May 4	6.0	14.4	21.7	12.1	0
May 5	7.3	13.7	19.5	12.3	1.1
May 6	12.2	15.2	18.2	2.1	0.1
May 7	9.0	16.2	23.0	12.9	0
May 8	13.8	18.5	22.4	6.7	3.8

Table 2 Weather conditions during the blooming period of pear at Keszthely in 1997

Date	Ambient temperature (°C)			Sunny hours	Rainfall (mm)
	minimum	daily mean	maximum		
April 13	– 1.2	2.2	5.8	10.5	0
April 14	– 6.7	4.3	13.0	10.5	0
April 15	5.4	7.4	11.2	6.1	1.0
April 16	– 3.0	1.7	6.2	6.9	0
April 17	– 0.8	3.7	8.0	3.5	0
April 18	4.3	10.4	17.7	9.9	0
April 19	– 0.7	9.3	18.0	8.0	0
April 20	4.2	4.0	4.2	0	4.9
April 21	0.8	4.4	7.8	0.9	0.4
April 22	1.2	5.4	8.2	0	0
April 23	5.2	8.2	12.8	8.6	0
April 24	– 3.2	6.6	14.0	12.0	0
April 25	– 1.4	9.0	18.3	12.4	0
April 26	2.7	10.8	15.9	0.9	0
April 27	2.1	12.0	21.0	5.5	0.7

Table 3 Weather conditions during the blooming period of pear at Keszthely in 1998

Date	Ambient temperature (°C)			Sunny hours	Rainfall (mm)
	minimum	daily mean	maximum		
April 10	1.7	10.7	18.3	8.0	0
April 11	7.5	13.3	18.6	10.8	1.7
April 12	5.0	9.7	14.9	7.2	1.1
April 13	2.4	8.6	12.8	7.0	5.8
April 14	0.7	6.9	12.9	4.6	0
April 15	- 1.3	7.3	14.3	7.4	0
April 16	5.4	8.8	10.0	0	4.2
April 17	4.5	9.4	14.7	1.6	0.7
April 18	5.3	9.7	14.7	2.6	10.7
April 19	6.5	9.9	14.7	3.1	0
April 20	2.6	9.5	15.3	11.8	0
April 21	1.2	11.3	20.2	11.5	0
April 22	9.0	12.4	16.5	1.2	0

temperature was evenly warm during the blooming period. Daily mean temperatures were well above 10 °C and the maximums were around or above 20 °C . There was no frost during pear flowering. There was some rain on some days but the amount of precipitation was not too much. Weather was usually sunny and the number of sunny hours were usually around 10 or 12 a day.

Next year (in 1997) the weather was much cooler (*Table 2*). There was a very strong night frost on the 14th of April (–6.7 °C) when most pear cultivars started to bloom or stayed in the white bud stage just prior to the opening of flowers. There was one another strong night frost too on the 16th of April (–3 °C) when all cultivars started to bloom. For this reason pear flowers suffered frost damage that was especially strong at some of the cultivars (*Table 5*). Otherwise, the general tendency of the weather was rather cool on the other days too, first of all during the first half of the flowering, because daily mean temperatures usually were around or below 5 °C only and there was at least a light frost on the night of several days during the blooming period. Air temperature increased gradually in the second half of the blooming but there was one more strong night frost (–3.2 °C) on the 24th of April again. Daytime maximum temperatures were usually also low and rarely exceeded 10 or 15 °C. There was little rain during the blooming period but the number of sunny hours usually was not too much. This year, the weather was extremely unfavourable to pear during the blooming period.

In the third year (in 1998) weather was much better than in the previous year but not as favourable like in the first year of the studies. Daily mean temperatures remained around 10 °C all along the blooming period but daily maximum temperatures were usually around or above 15 °C (*Table 3*). Night minimum temperatures usually were well above zero but there was one light night frost (–1.3 °C) at about at the middle of the blooming period. There was some rain on several days of the blooming but the amount was round 1 or 5 mm except a 10 mm rain in the second half of the flowering period. The number of sunny hours was higher in the first and the last few days than during the rest of blooming.

Nectar production of flowers was measured by the classical capillary tube method on two days (1996, 1997) or on three days during the blooming period (1998). Flowers of several cultivars were tested, much more in 1996 (44 cvs) and less in 1997 (16 cvs) and 1998 (18 cvs). Branches facing to South and North with some 50 flowers were covered by parchment paper bags on two trees per cultivar. *(Figure 1)* Nectar production was measured late morning (10–12 h) and early afternoon (13–15 h). Five flowers were sampled by a single capillary tube at a branch facing to North and facing to South on each of the two trees of the cultivars investigated. The weight of the nectar (mg) and its sugar concentration was measured in the laboratory with a chemical balance and a table refractometer, respectively.

Results

1996: Extremely high nectar production was measured at all the cultivars tested on both days of the measurements (*Table 4*) and the higher extreme values of individual measurements were surprisingly high. The mean nectar content of flowers of cultivars varied between 1.9–30.0 mg and the extreme values of individual measurements were between 0.7–30.2 mg/flower (*Table 4*). The amplitude of the extremes for the individual measurements on the nectar production of flowers were surprisingly wide (highest extremes were 6–11 times higher than the low values) at some instances (April 30: *Pringalle, Egri körte, Clapp's Favourite,* May 1: *Clapp's Favourite, Magyar Kobak, New York, Diel Beurré*) and the same was fairly narrow (highest values were less than 1.5 times higher than low ones) at other cases (April 30: *Alexander Lucius, Magyar Kobak, Miklós, Van Monum,* May 1: *Aromata de Bistrita, Espéren d'Bergamott, Olivier de Serres, Orient, S.2.*). As seen there was a cultivar (*Magyar Kobak*) that was falling to different categories (wide and narrow amplitude of extremes, respectively) in the two days of the measurements. The extremely high amount of nectar was probably the result of the favourable weather prevailing all along the blooming period (*Table 1*). The mean amount of nectar was similar on the two days in about one third (33%) of the cultivars and it was not so much different in some 43 per cent of the cvs. In the case of one fourth of them (24%) the nectar production was highly different on the two days of the investigations because it was high on one and was low on the other day.

The sugar concentration of nectar varied between 2.7–49.5% in individual measurements (*Table 4*) and between 6.4–33.0% for individual cultivars (*Table 7*), respectively. Most cultivars (67%) produced much less sugar than 20%. The amplitude of the extreme values for the individual measurements on the sugar concentration of nectars was very wide (higher values were 9–13 times higher than the low ones) at some instances (April 30: *New York, Clapp's Favourite,* May 1: *Egri körte*) and the same was very narrow (higher values were not more than 1/5–1/4 higher than low ones) at some other cases (April 30: *Lentier doctor, Magyar Kobak, Mercedes,* May 1: *New York, Orient, Pringalle, Worden Sechel*). There was a cultivar again (*New York*) that was falling to different wide and narrow amplitude of extremes, respectively, in the two days of the measurements. Largest mean sugar concentration of cultivars (round or up to 30%) appeared very rarely but no cultivar produced higher sugar concentration in average on both days of the survey. The sugar concentration of nectars was fairly similar on the two days in about 54% of the cultivars and there was not too large difference in some 30% of them. The difference was definitely large in 16% of the cvs. Cultivars with higher amount of nectar in their flowers tended to have smaller sugar concentration in their nectar.

The mean nectar production of all cultivars was fairly similar on both, days because both the amount of nectar and its sugar concentration was very similar (*Table 4*). Mean nectar content was very high (7.9 and 6.0 mg respectively) while mean sugar concentration of nectars was rather low (round 15%).

Figure 1 Branches were covered for one day prior to the nectar samples were taken

1997: Most cultivars tested suffered frost damage of the strong night frost during the blooming period (*Table 2*). The frost damage was very severe for most of the cvs inspected but slight for some others. Surviving flowers were sampled for nectar but no nectar production was detected at any of the cvs investigated. The lack of nectar production was evenly typical at cvs that suffered very strong and light frost damage. This means that the cold weather prevailing during the blooming period of pear prevented the nectar production of flowers, completely.

1998: Much less nectar was found in the flowers than in 1996 but the sugar concentrations of nectars were somewhat higher (*Table 6*). Namely, the average amount of nectar production of flowers of pear cultivas was not more than 2.6–3.1 mg/flower and the mean sugar concentration was 15.9–18.3%. Individual cultivars, however, produced different amounts of nectar per flower with different sugar concentrations. The extreme values of nectar production and of sugar concentration of nectar were 0.1–9.9 mg/flower and 5.5–39.0%, respectively (*Table 6*). The amplitude between the high and the low extremes was exceptionally wide (higher values were 1–50 times higher than low ones) at some instances (April 14: *Orient,* April 15: *Clapp's Favourite, Bartlett, Szentendrei Császár, Ráckevei, Espéren d'Bergamott,* April 16: *Alexander Lucas*). On the other hand, the amplitude was very narrow (higher figures were less than 1.5 times higher than low ones) at other instances (April 14: *Miklós, Conference, Alexander Lucas, Espéren d'Bergamott,* April 16: *Beeuthal*). The amplitude of the extreme values of the sugar concentration of nectars was also wide (high

Table 4 Nectar production of the flowers of pear cultivars in 1996 (Keszthely)

Cultivar	Nectar production of flowers: mean ± standard error (extremes*)							
	April 30				May 1			
♀	n	Nectar content: mg/flower	n	Sugar concentration: per cent	n	Nectar content mg/flower	n	Sugar concentration: per cent
Abate Fétel	4	6.6 ± 1.0 (4.0 – 9.0)	4	5.5 ± 0.7 (4.5 – 7.5)	4	8.7 ± 1.2 (4.4 – 11.6)	4	8.9 ± 0.3 (8.9 – 9.5)
Alexander Lucius	4	14.2 ± 0.9 (11.9 – 15.2)	4	11.9 ± 2.0 (8.0 – 15.5)	3	5.3 ± 1.5 (2.6 – 8.1)	3	10.7 ± 1.2 (9.5 – 13.0)
Aromata de Bistrita	4	5.2 ± 1.5 (2.6 – 9.0)	4	24.4 ± 7.6 (8.0 – 43.0)	4	12.9 ± 0.5 (11.4 – 13.9)	4	8.0 ± 0.5 (7.0 – 9.5)
Bartlett (Williams)	4	8.0 ± 1.6 (4.9 – 12.2)	4	11.6 ± 1.5 (8.5 – 13.0)	4	8.7 ±1.3 (5.1 – 9.8)	4	9.9 ± 1.5 (7.0 – 13.0)
Beeuthal	4	7.1 ± 2.6 (2.3 – 10.8)	4	7.6 ± 2.3 (5.0 – 14.5)	3	3.9 ± 2.3 (3.0 – 5.1)	2	11.0 ± 2.0 (9.0 – 13.0)
Bella di Giugno	4	2.9 ± 0.5 (2.2 – 4.3)	3	28.9 ± 6.2 (20.5 – 41.0)	4	4.5 ± 1.1 (2.2 – 6.6)	4	13.4 ± 1.5 (10.5 – 16.5)
Bouder óriás	4	2.7 ± 0.7 (1.4 – 4.6)	3	21.0 ± 2.4 (17.5 – 25.5)	4	4.3 ± 0.5 (3.1 – 5.4)	4	14.0 ± 0.5 (12.5 – 15.0)
Clapp's Favourite	6	4.9 ± 1.8 (1.9 – 13.6)	4	13.2 ± 4.2 (2.3 – 22.5)	4	5.7 ± 1.2 (1.6 – 10.5)	4	16.7 ± 4.8 (5.0 – 33.0)
Conference	3	5.6 ± 0.2 (4.5 – 8.4)	3	16.7 ± 2.5 (12.5 – 21.0)	4	10.8 ± 1.4 (7.3 – 13.5)	4	9.6 ± 0.7 (8.0 – 11.0)
Császár körte	4	3.5 ± 0.4 (2.3 – 4.0)	3	38.0 ± 2.8 (32.5 – 42.0)	4	7.1 ± 1.7 (4.2 – 11.3)	4	13.9 ± 1.7 (11.0 – 18.5)
Debreceni nagy zöld	4	2.1 ± 0.8 (1.0 – 4.2)	2	25.0 ± 14.0 (11.0 – 39.0)	4	4.7 ± 1.6 (1.6 – 8.8)	2	14.0 ± 2.5 (8.0 – 20.0)
Decaishe Henrik	4	3.9 ± 0.2 (2.5 – 5.1)	4	23.6 ± 3.6 (15.0 – 32.5)	4	3.2 ± 1.0 (1.1 – 5.0)	4	20.0 ± 3.3 (11.0 – 25.5)
Diel Beurré	4	2.4 ± 0.4 (1.4 – 3.4)	2	16.3 ± 1.8 (14.5 – 18.0)	4	6.4 ± 2.0 (1.9 – 10.6)	3	8.7 ±0.3 (8.0 – 9.0)
Drouard President	3	11.7 ± 1.2 (7.2 – 15.1)	3	10.0 ± 1.3 (8.0 – 13.0)	4	4.8 ± 1.2 (2.4 – 7.5)	4	8.3 ± 0.8 (7.0 – 10.5)
Düvals		–		–	4	2.4 ± 0.3 (1.8 – 3.1)	4	27.6 ± 7.0 (17.0 – 47.0)
Egri körte	8	6.1 ± 0.8 (2.7 – 17.8)	7	17.9 ± 2.7 (8.5 – 33.5)	7	8.9 ± 2.3 (2.9 – 17.9)	7	18.2 ± 4.9 (2.9 – 39.0)
Espéren d'Bergamott	3	6.2 ± 0.8 (5.0 – 7.7)	3	18.3 ± 3.6 (14.5 – 25.5)	4	6.2 ± 0.6 (5.1 – 7.3)	4	9.0 ± 1.7 (6.5 – 10.0)
Fehérvári körte	4	2.7 ± 0.7 (1.2 – 4.8)	2	42.3 ± 4.8 (27.5 – 47.0)	4	3.9 ± 0.6 (2.3 – 4.9)	4	28.4 ± 6.2 (12.5 – 36.5)
General Osmawill	4	12.6 ± 0.8 (5.4 – 20.5)	4	15.8 ± 3.5 (6.5 – 26.7)	4	5.1 ± 1.0 (2.7 – 6.9)	4	23.8 ± 9.6 (7.5 – 47.5)
Janne d' Arc		–		–	4	3,0 ± 0.7 (2.1 – 4.9)	4	9,9 ± 1.0 (4.5 – 15.1)
Kieffer	4	6.8 ± 0.7 (4.3 – 7.7)	4	15.3 ± 0.6 (10.5 – 19.5)	4	3.5 ± 0.8 (2.6 – 6.7)	4	32.2 ± 3.7 (21.0 – 38.0)
Kieffer improved	2	5.1 ± 0.6 (3.7 – 6.2)	2	19.8 ± 0.3 (17.5 – 22.5)	2	2.0 ± 1.2 (1.0 – 3.1)	1	17.5
Lentier doctor	4	11.5 ± 1.6 (9.2 – 16.3)	4	10.5 ± 0.5 (10.0 – 12.0)	4	9.0 ± 2.8 (4.1 – 14.5)	4	8.8 ± 1.0 (7.0 – 11.5)
Magyar Kobak	4	30.0 ± 1.8 (27.1 – 30.2)	4	5.4 ± 0.2 (5.0 – 6.0)	4	5.1 ± 2.3 (1.3 – 9.1)	1	7.5
Mercedes	4	15.1 ± 2.0 (9.8 – 18.1)	4	5.4 ± 0.2 (5.0 – 6.0)	3	6.3 ± 1.6 (3.1 – 8.4)	3	11.0 ± 5.5 (8.0 – 25.0)
Miklós	4	8.8 ± 0.4 (8.1 – 9.8)	3	8.8 ± 1.0 (7.0 – 10.5)	4	3.1 ± 0.6 (2.0 – 4.6)	2	34.5 ± 8.5 (26.0 – 43.0)
Minister Lucius		–		–	4	6.5 ± 1.2 (2.5 – 11.5)	4	15.1 ± 6.4 (8.0 – 33.5)
Móri császár körte	4	6.9 ± 1.1 (4.8 – 9.0)	4	21.5 ± 13.0 (17.5 – 30,.5)	4	6.2 ± 1.2 (4.0 – 7.2)	4	17.6 ± 4.4 (11.5 – 30.5)
Nagy szegfü körte		–		–	8	2.4 ± 0.3 (0.7 – 3.6)	7	11.0 ± 3.3 (7.0 – 20.5)
Nemes krasszán	4	6.6 ±1.5 (3.0 – 10.4)	4	18.0 ± 2.8 (11.5 – 24.5)	3	8.2 ± 1.2 (4.4 – 9.1)	3	9.0 ± 0.6 (8.5 – 10.5)
New York	4	9.7 ± 2.4 (2.8 – 13.6)	3	18.3 ± 2.5 (4.5 – 45.0)	4	3.5 ± 1.4 (1.0 – 6.3)	2	12.8 ± 1.3 (11.5 – 14.0)
Orient	4	7.6 ± 0.6 (6.2 – 8.9)	4	11.0 ±1.5 (9.5 – 16.0)	4	10.5 ± 0.9 (8.2 – 12.3)	4	9.0 ± 0.5 (7.5 – 10.0)
Õszi császár	4	9.7 ± 3.1 (5.5 – 15.2)	4	18.8 ± 3.6 (7.3 – 22.5)	4	3.5 ± 1.2 (2.7 – 5.7)	4	12.8 ± 3.1 (7.9 – 14.5)
Pantelia	2	19.6 ± 4.4 (14.7 – 27.1)	2	9.5 ± 2.3 (7.5 – 12.0)	4	6.0 ± 1.0 (3.5 – 7.7)	4	12.1 ± 1.4 (7.9 – 14.5)
Pringalle	2	6.7 ± 5.6 (1.1 – 12.3)	1	6.5	4	12.9 ± 1.1 (10.6 – 15.2)	4	7.4 ± 0.2 (7.0 – 8.0)
Ráckevei	4	10.5 ± 1.8 (6.1 – 14.7)	4	8.3 ± 0.5 (7.5 – 9.5)	4	1.9 ± 0.4 (1.4 – 3.2)	2	22.7 ± 1.3 (21.5 – 24.0)
Respublica	8	6.0 ± 2.1 (2.1 – 11.0)	8	18.8 ± 2.2 (12.5 – 28.0)	8	11.8 ± 1.4 (9.2 – 19.2)	8	9.9 ± 1.4 (7.5 – 19.0)
Olivier de Serres	4	12.0 ± 1.9 (6.9 – 15.8)	4	6.9 ± 0.4 (5.0 – 8.0)	2	7.2 ± 0.6 (6.6 – 8.2)	2	10.5 ± 2.5 (8.0 – 13.0)
Szentendrei Császár	4	4.9 ± 0.5 (3.6 – 7.4)	3	11.2 ± 2.9 (6.5 – 16.5)	4	2.8 ± 0.9 (1.7 – 4.4)	2	14.3 ± 3.3 (11.0 – 17.5)
Totleben General	4	12.1 ± 3.5 (3.0 – 19.8)	4	7.9 ± 2.0 (4.5 – 13.0)	4	3.6 ± 1.1 (1.5 – 6.3)	3	20.0 ± 8.5 (7.0 – 36.0)
Van Monum	4	21.2 ± 2.3 (18.0– 22.5)	4	4.5 ± 0.2 (3.5 – 6.5)	4	8.1 ± 2.8 (6.5 – 10.2)	4	16.3 ± 7.0 (12.0 – 21.0)
Worden Seckel	4	5.2 ± 1.2 (1.8 – 6.2)	3	13.7 ± 2.0 (11.0 – 17.5)	3	12.1 ± 2.4 (9.0 – 16.9)	3	7.9 ± 0.6 (8.0 – 9.0)
3-25 TA	3	3.9 ± 2.5 (2.5 – 5.1)	2	13.3 ± 7.3 (6.0 – 20.5)	4	2.3 ± 0.2 (1.9 – 3.0)	4	35.6 ± 7.7 (18.5 – 49.5)
S.2.	4	7.1 ± 1.6 (1.9 –9.6)	4	18.1 ± 8.0 (9.5 – 38.5)	3	5.3 ± 0.6 (4.3 – 6.1)	3	12.5 ± 1.5 (11.5 – 15.0)
Mean of cvs (No. of cvs)	**8.8±0.9 n= 40**		**14.6±1.1 n=40**		**7.1 ± 0.8 n=44**		**14.6±1.1 n=44**	

*extreme values of individual measurements

Table 5 Nectar production of the flowers of pear cultivars in 1997 (Keszthely)

Cultivar	Frost damage: frozen flowers, per cent	Nectar production of flowers			
		April 24		April 30	
		No. of sampled flowers	Nectar content: mg/flower	No. of sampled flowers	Nectar content: mg/flower
Abate Fétel	12%	60	0	20	0
Alexander Lucius	69%	40	0	30	0
Aromata de Bistrita	13%	45	0	–	–
Beeuthal	52%	40	0	20	0
Clapp' s Favourite	50%	40	0	10	0
Conference	68%	40	0	5	0
Császár körte	75%	30	0	10	0
Decaisne Henrik	31%	40	0	20	0
Espéren d'Bergamott	33%	20	0	–	–
Miklós	64%	35	0	20	0
Nemes krasszán	41%	55	0	10	0
Orient	61%	50	0	15	0
Ráckevei	64%	40	0	20	0
Respublica	63%	40	0	20	0
Olivier de Serres	21%	60	0	15	0
Szentendrei Császár	71%	40	0	20	0

values were at least 3 times larger than low ones) at some cases (April 15: *Pringalle, Nemes Krasszán, Conference,* April 16: *Clapp's Favourite*) but the reverse was true at other instances because the amplitude was narrow (high figures were less than 1.5 times large than low values) at other measurements (April 14: *Decaisne Henrik, Miklós,* April 15: *Császár körte,* April 16: *Espéren d'Bergamott*). Mean nectar production of cultivars and mean sugar concentration was fairly similar on all the three days of measurements. Most cultivars produced at least somewhat different amount of nectar on the three days surveyed (64%), but somewhat more than one third of them produced similar amount on the consecutive days (36%). Sugar concentration of nectars was even more variable because less than one third of the cultivars produced similar sugar concentrations on the three consecutive days (28%) and most of them produced nectar with more or less different sugar concentrations on at least one of the three days (72%). Higher amounts of nectar tended to be connected to smaller sugar concentrations but the tendency was not clearly consequent.

Comparison of individual cultivars: *Table 7* demonstrates that some cultivars seem to produce much higher amount of nectar than others (1996: *Magyar Kobak, Mercedes, Alexander Lucius, Pantelia, Pringalle*, 1998: *Miklós, Nemes Krasszán*) and other ones seem to produce much less (1996: *Duvals, Nagy szegfű körte*, 1998: *Beeuthal, Olivier de Serres*). The same refers to the sugar concentration of the nectars that seems to be higher at some cultivars than at others (1996: *Császár körte, 3–25 TA, Duvals,* 1998: *Orient, Pringalle*) or seems to be much lower (1996: *Magyar Kobak, Abate Fétel, Pringalle*, 1998: *Miklós*). Mean nectar production of flowers and mean sugar concentration of nectars, however clearly differed in consecutive years (*Table 7*). Accordingly, figures for individual cultivars can only be compared to the average figures of the given year. Based on this consideration both the nectar production and the sugar concentration in nectar can be regarded low, medium or high when it is much below, round or much above the mean figure of the year, respectively. Cultivars inspected in consecutive years can be classified accordingly (*Table 8*). Evaluating results in *Table 8,* no consecutive differences can be found between cultivars because large majority of them can be classified into different categories in the years compared. There are no more than 3 of the 18 cultivars that show consequent picture both for the amount and the sugar concentration of nectar (*Bartlett, Espéren d'Bergamott, Respublica*). On the other hand, 8 of the 18 cvs seems to be inconsistent at least at one of the two and 6 of the 18 cvs at both of the two parameters inspected.

Relationship between the amount of the nectar in the flowers and its sugar concentration: In *Tables 4* and *6* larger amount of nectar seems to contain lower sugar concentrations and vice versa. For this reason *Table 7* was used to examine the relationship between the amount of nectars in the flowers of pear cultivars and their sugar concentrations. Coefficient of correlation is highly significant in both years (*Table 9*). The relationship is negative that means: larer amount of pear nectar contains definitely less concentrated sugars.

Discussion and Conclusions

Result clearly show that pear does not necessarily produce small amount of nectar as stated frequently and accepted widely in world literature (*Free* 1970, 1993, *Benedek* 1996). It is evident that pear can produce significant amount of nectar in favourable weather but its nectar

Table 6 Nectar production of the flowers of pear cultivars in 1998 (Keszthely)

Cultivar	Nectar production of flowers: mean ± standard error (extremes*)								
	April 14			April 15			April 16		
	n	Nectar content: mg/flower	Sugar concentration: per cent	n	Nectar content: mg/flower	Sugar concentration: per cent	n	Nectar content: mg/flower	Sugar concentration: per cent
Abate Fétel	4	3.3 ± 1.5 (0.9 – 7.1)	17.7 ± 5.9 (10.5 – 29.5)	8	1.5 ± 0.4 (0.3 – 3.9)	19.2 ± 4.0 (12.0 – 29.5)	4	4.1 ± 0.7 (2.3 – 5.6)	9.5 ± 1.2 (6.5 – 11.5)
Alexander Lucius	2	1.4 ± 0.1 (1.2 – 1.6)	28.0 ± 11.0 (17.0 – 39.0)	4	3.7 ± 1.4 (0.9 – 7.5)	16.4 ± 3.1 (10.5 – 25.0)	2	3.1 ± 2.8 (0.3 – 5.9)	8.5
Bartlett (Williams)	4	3.1 ± 1.0 (0.5 – 5.4)	19.2 ± 1.7 (16.0 – 22.0)	8	2.1 ± 0.5 (0.2 – 4.3)	17.3 ± 2.9 (10.0 – 24.5)	1	1.1	19.0
Beeuthal	4	0.5 ± 0.2 (0.6 – 0.9)	–	8	1.7 ± 0.2 (1.0 – 2.5)	21.6 ± 2.3 (15.5 – 29.5)	4	2.4 ± 0.6 (1.7 – 2.3)	17.0 ± 2.2 (10.5 – 20.0)
Clapp's Favourite	4	1.2 ± 0.6 (0.3 – 2.4)	20.2 ± 5.3 (9.5 – 21.0)	8	2.1 ± 0.9 (0.1 – 5.6)	19.0 ± 3.1 (9.5 – 27.5)	4	2.1 ± 0.9 (0.6 – 4.8)	16.8 ± 5.7 (6.0 – 19.5)
Conference	4	4.3 ± 0.2 (3.7 – 4.6)	15.2 ± 2.4 (11.0 – 21.5)	8	3.1 ± 0.8 (1.3 – 7.7)	17.5 ± 2.3 (9.5 – 28.5)	4	3.9 ± 1.9 (2.9 – 4.7)	16.1 ± 1.9 (10.5 – 19.5)
Császár körte	4	1.6 ± 0.4 (1.1 – 2.7)	23.1 ± 4.5 (16.5 – 36.5)	8	2.9 ± 1.3 (0.8 – 8.0)	12.8 ± 1.2 (11.0 – 15.0)	4	5.8 ±2.0 (0.7 – 9.6)	7.7 ± 1.2 (6.0 – 10.0)
Decaisne Henrik	4	2.1 ± 0.5 (0.8 – 3.0)	23.8 ± 2.0 (20.0 – 26.5)	8	4.3 ± 0.9 (0.7 – 7.3)	13.5 ± 2.0 (9.5 – 23.5)	4	5.2 ± 1.8 (1.1 – 7.2)	9.6 ± 2.2 (5.5 – 11.5)
Diel Beurré	4	0.5 ± 0.3 (0.2 – 1.5)	18.0	8	2.2 ± 0.8 (0.2 – 7.2)	16.8 ± 2.6 (9.5 – 25.0)	4	5.6 ± 1.2 (3.3 – 8.8)	12.5 ± 2.7 (9.5 – 20.5)
Espéren d'Bergamott	4	1.3 ± 0.1 (1.1 – 1.6)	20.2 ± 1.8 (18.5 – 22.0)	8	2.4 ± 0.7 (0.3 – 5.5)	13.4 ± 1.9 (10.0 – 20.0)	4	4.3 ± 1.5 (1.5 – 8.0)	10.0 ± 0.5 (9.0 – 11.0)
Miklós	4	7.4 ± 0.3 (7.0 – 8.0)	11.5 ± 0.8 (10.0 – 13.5)	8	5.7 ± 1.0 (1.0 – 7.5)	11.5 ± 0.8 (9.5 – 15.0)	4	1.5 ± 0.5 (0.4 – 2.5)	17.0 ± 7.5 (9.5 – 24.5)
Nemes krasszán	4	5.7 ± 0.9 (4.3 – 8.4)	13.9 ± 2.2 (10.5 – 19.5)	8	3.7 ± 0.4 (1.8 – 5.2)	15.1 ± 2.5 (9.5 – 31.0)	4	3.7 ± 1.7 (0.9 – 4.7)	22.0 ± 6.0 (16.0 – 28.0)
Orient	4	2.9 ± 1.6 (0.3 – 5.6)	17.3 ± 2.3 (13.0 – 21.0)	8	1.9 ± 0.5 (0.8 – 5.1)	32.0 ± 1.8 (18.5 – 28.5)	4	1.3 ± 0.3 (0.6 – 2.1)	18.5 ± 4.0 (14.5 – 22.5)
Pringalle	4	2.8 ± 1.0 (0.7 – 5.3)	14.5 ± 2.8 (11.0 – 20.0)	8	2.0 ± 0.5 (0.5 – 5.3)	21.4 ± 3.8 (9.0 – 31.5)	4	1.0± 0.3 (0.7 – 1.8)	29.5
Ráckevei	4	2.9 ± 0.9 (0.9 – 9.4)	16.7± 1.8 (14.0 – 20.0)	8	3.4 ± 1.0 (0.5 – 9.4)	17.4 ± 2.7 (12.0 – 29.0)	4	3.3 ± 0.6 (1.7 – 4.7)	24.6 ± 5.8 (12.0 – 34.5)
Respublica	4	2.7 ± 0.8 (1.0 – 4.9)	17.2 ± 2.6 (12.0 – 20.0)	8	2.0 ± 0.6 (0.3 – 4.7)	16.4 ± 3.2 (10.5 – 28.5)	4	1.7 ± 0.5 (0.9 – 3.2)	15,5 ± 2.4 (9.5 – 20.0)
Olivier de Serres	4	0.3 ± 0.2 (0.4 – 0.7)	–	8	0.7 ± 0.2 (0.3 – 1.5)	19.5	4	3.1 ± 0.9 (1.0 – 5.3)	11.8 ± 1,9 (9.0 – 15.5)
Szentendrei Császár	4	1.9 ± 1.2 (0.6 – 5.3)	16.5 ± 4.5 (12.0 – 21.0)	8	2.0 ± 0.5 (0.2 – 3.9)	16.5 ± 3.8 (10.5 – 27.0)	4	2.6 ± 0.8 (0.7 – 4.0)	20.0 ± 2.8 (15.5 – 25.0)
Mean of cvs (No. of cvs)		**2.6±0.4 (n = 18)**	**18.3±1.0 (n = 18)**		**2.6±0.6 (n = 18)**	**17.6±1.1 (n = 18)**		**3.1±0.6 (n = 18)**	**15.9±1.4 (n = 18)**

*extreme values of individual measurements

Table 7 Comparison of nectar production of the flowers of pear cultivars in 1996–1998 (Keszthely)

Cultivar	Nectar production of flowers in three consecutive years					
	1996		1997		1998	
	Nectar content: mg/flower	Sugar concentration: per cent	Nectar content: mg/flower	Sugar concentration: per cent	Nectar content: mg/flower	Sugar concentration: per cent
Abate Fétel	7.7 ± 1.8	7.2 ± 0.7	0	x	2.6 ± 1.4	15.3 ± 6.3
Alexander Lucius	10.4 ± 1.8	11.4 ± 2.2	0	x	3.0 ± 2.5	18.6 ± 8.2
Aromatade Bistrita	9.0 ± 1.8	16.2 ± 5.7	0	x	–	–
Bartlett (Williams)	8.4 ± 2.1	10.7 ± 6.0	–	–	2.3 ± 0.9	17.9 ± 2.9
Beeuthal	5.8 ± 1.9	8.6 ± 3.0	0	x	1.6 ± 0.5	19.6 ± 3.2
Bella di Giugno	3.7 ± 1.1	21.1 ± 13.8	–	–	–	–
Bouder óriás	3.5 ± 1.0	17.5 ± 2.0	–	–	–	–
Clapp's Favourite	5.3 ± 3.2	14.1 ± 6.3	0	x	1.9 ± 1.4	18.6 ± 5.6
Conference	8.3 ± 3.3	12.0 ± 2.1	0	x	3.7 ± 0.9	16.6 ± 3.8
Császár körte	5.1 ± 1.5	24.2 ± 3.2	0	x	3.3 ± 2.1	15.4 ± 4.2
Debreceni nagy zöld	3,4 ± 1.7	19.5 ± 14.1	–	–	–	–
Decaisne Henrik	3.6 ± 1.2	21.8 ± 4.8	0	x	3.9 ± 1.8	14.6 ± 3.5
Diel Beurré	4.4 ± 0.7	12.5 ± 1.4	–	–	2.7 ± 1.4	15.2 ± 3.5
Drouard President	3.4 ± 1.0	8.3 ± 0.8	–	–	–	–
Düvals	2.4 ± 0.3	27.6 ± 7.0	–	–	–	–
Egri körte	7.6 ± 2.2	18.0 ± 5.4	–	–	–	–
Espéren d'Bergamott	6.2 ± 1.0	13.0 ± 3.0	0	x	2.6 ± 1.3	13.4 ± 2.3
Fehérvári körte	3.3 ± 1.0	33.0 ± 7.8	–	–	–	–
General Osmawill	5.1 ± 1.0	23.8 ± 9.6	–	–	–	–
Janne d' Arc	3.0 ± 0.7	9.9 ± 1.0	–	–	–	–
Kieffer	5.2 ± 0.6	23.8 ± 3.2	–	–	–	–
Kieffer improved	4.0 ± 1.2	20.0 ± 0.2	–	–	–	–
Lentier doctor	10.3 ± 3.1	11.0 ± 1.2	–	–	–	–
Magyar Kobak	17.5 ± 3.1	6.4 ± 0.2	–	–	–	–
Mercedes	11.9 ± 2.5	8.6 ± 3.9	–	–	–	–
Miklós	6.0 ± 0.6	21.7 ± 6.1	0	x	5.1 ± 1.0	12.4 ± 3.9
Minister Lucius	6.5 ± 1.9	15.1 ± 6.4	–	–	–	–
Móri császár körte	6.5 ± 1.6	19.6 ± 5.3	–	–	–	–
Nagy szegfű körte	2.7 ± 0.3	11.0 ± 3.3	–	–	–	–
Nemes krasszán	6.4 ± 2.1	14.3 ± 2.5	0	x	4.8 ± 1.7	15.7 ± 5.3
New York	6.6 ± 2.6	16.4 ± 10.9	–	–	–	–
Orient	9.1 ± 1.4	10.3 ± 1.4	0	x	2.0 ± 1.1	20.4 ± 4.4
Õszi császár	6.6 ± 1.8	15.8 ± 5.7	–	–	–	–
Pantelia	10.9 ± 4.4	11.3 ± 2.4	–	–	–	–
Pringalle	10.8 ± 4.2	7.2 ± 0.5	–	–	1.9 ± 1.0	20.1 ± 4.5
Rackevei	6.2 ± 1.6	19.8 ± 1.1	0	x	3.2 ± 1.5	19.3 ± 5.9
Respublica	8.9 ± 1.8	14.4 ± 2.5	0	x	2.1 ± 1,3	16.3 ± 4.8
Olivier de Serres	10.3 ± 1.8	8.1 ± 1.8	0	x	1.2 ± 0.7	13.8 ± 1.7
Szentendrei Császár	3.9 ± 1.2	12.7 ± 4.3	0	x	2.1 ± 1.4	14.7 ± 5.4
Totleben General	7.8 ± 3.6	13,9 ± 7.1	–	–	–	–
Van Monum	14.7	10.4 ± 1.8	–	–	–	–
Worden Seehel	8.8 ± 2.5	10.8	–	–	–	–
3-25 TA	2.9 ± 0.7	28.2 ± 10.5	–	–	–	–
S.2.	6.3 ± 1.7	15.3 ± 6.2	–	–	–	–
Mean of cvs	**6.8±0.5 n=44**	**15.2±0.9 n=44**	**0**	**0**	**2.7±0.2 n=18**	**16.5±0.6 n=18**

Table 8 Relative nectar production of pear cultivars compared to the mean figures

Cultivar	Nectar production in		Sugar concentration in nectar in	
	1996	1998	1996	1998
Abate Fétel	medium	medium	low	high
Alexander Lucius	high	medium	medium	medium
Bartlett (Williams)	medium	medium	medium	medium
Beeuthal	low	low	low	medium
Clapp's Favourite	low	low	medium	medium
Conference	medium	high	medium	medium
Császár körte	low	high	high	medium
Decaisne Henrik	low	high	high	high
Diel Beurré	low	medium	medium	medium
Espéren d'Bergamott	medium	medium	medium	medium
Miklós	medium	high	high	low
Nemes krasszán	medium	high	medium	medium
Orient	medium	medium	medium	high
Pringalle	high	low	low	medium
Rácкevei	medium	medium	medium	high
Respublica	medium	medium	medium	medium
Olivier d' Serres	high	low	low	medium
Szentendrei császár	low	medium	medium	medium

*See explanation in the text

production is extremely dependent on weather conditions as indicated in some earlier publications (*Sazykin,* 1955, *Péter,* 1972). Large variability is clearly proved by the different mean nectar production of cultivars in the three years of the experiments and also by the highly variable amplitude of the extreme values relating to the same cultivars at different days of the observations (*Tables 4–6*). Namely, the amplitude of the extremes was rather wide on one day but it was very narrow on the other day sometimes for the same cultivars.

Based on present results ambient temperature seems to be the major governing factor since nectar production was extremely high in the warmest year of the studies (1996) but it was much less in the third year (1998) when weather was much cooler. On the other hand, the nectar production was completely prevented in that year when weather was very cold with some serious night frost during the blooming period of pear (1997). In most pear growing countries weather can be rather cool frequently during the blooming period of pear and so it can decrease the nectar production capacity of pear flowers dramatically. This may be the explanation of the fact that nectar production of pear flowers is generally regarded to be very low in the literature.

Recent results show that nectar production of individual pear flowers can be extremely high at some occasions, higher than in the flowers of other temperate-zone fruit trees species (as indicated by *Benedek & Nyéki,* 1997). Highest figures sometimes may be around 30 mg/flower. This figure can be counted as exceptionally high nectar production even among temperate-zone fruit tree species (see *Benedek & Nyéki,* 1997). Mean figures, however, are much lower but those in this study are also much higher (6.8 mg in 1996) than the highest figures mentioned in earlier reports (*Glowska,* 1958: 3.1 mg/flower in 1955; *Péter,* 1972: 0.9 mg/flower in 1971). The high figures, however, seem to be exceptional and so low nectar production of pear can be much more typical than high figures first of all in most Northern, cooler areas where pear production is more common than at Southern latitudes.

Recent study corroborates the earlier statements on low sugar concentration of pear nectars (e.g. *Vansell,* 1946, *Free,* 1970). However, there is a clear and highly significant negative correlation between the amount of nectar in pear flowers and its sugar concentration ($r = -0.52$, $n=291$, $p<0.001$ for 1996, $r = -0.34$, $n=197$, $p<0.001$ for 1998). The sugar concentration can be high at exceptional cages only (see examples in *Tables 4* and *6*) but no doubt typical sugar concentration of pear nectar seems to be around or below 20%. This is well demonstrated by the average figures calculated from all of the measurements that were 15.1% in 1996 (n = 291) and 17.1% in 1998 (n = 197), respectively. Accordingly, the mean sugar concentration of pear nectar can be considered to be very low compared to other temperate-zone fruit tree species (*Benedek & Nyéki,* 1997).

The equations based on the relationship between the nectar content of pear flowers and their sugar concentration are shown in *Table 9*. There are two separate equations in the *Table* based on the data from two different years with highly

Table 9 Relationship between the amount of nectar in pear flowers and its sugar concentration

Year	No. of measurements (n)	Coefficient of correlation	Equation
1996	291	$r = -0.52$ $p < 0.001$	$y = 22.99 - 1.06$
1998	197	$r = -0.34$ $p < 0.001$	$y = 22.08 - 1.33$ x

Note: x = nectar content of the flowers (mg/flower)
y = sugar concentration in the nectar (per cent)

different weather during the blooming period of pear (*Table 1, 3*). In spite of this fact the lines of both equations run closely parallel to each other (the slope values of the two equations are fairly similar, –1.6 and –1.33 respectively) showing that the tendency between the amount of pear nectar and its sugar concentration seems to be fairly stable and seem to be more or less independent of weather. The equations demonstrate that even very small amounts of pear nectar seems not to contain more sugar than some 20%. (the constant values being 22.99 and 22.08). For this reason all high mean sugar concentrations published in earlier reports seem to be incomprehensible (e.g. *Péter,* 1972 stating 46.5–52.8% mean sugar content in pear nectar!)

We have not found any consequent difference between the nectar production of pear cultivars, however, the number of cvs inspected was as high as 44, 16 and 18, respectively. This statement of us is in contradiction with some earlier reports (*Vansell,* 1942, *Simidchiev,* 1970, *Péter,* 1972) that were based on measurements of much smaller number of cultivars usually within a shorter period of time. Comparisons made in a single year can show some differences among cultivars but these differences do ot seem to be consequent during consecutive years (*Table 8*). This in not surprising because it has been proved that some flower characters of fruit tree species can be much more variable during consecutive years than between cvs in given years (*Benedek & Nyéki,* 1994). This refers to the nectar production of a number of the temperate-zone fruit tree species including peach and nectarine as well as apricot (*Benedek & Nyéki, 1994*) and additionally pear (present study).

Our findings contradict to the statement of those authors too who stated that pear can be a good source for honey production to honeybees, early spring (e.g. *Sazykin,* 1955, *Péter,* 1972). Even in 1996 when extremely high nectar production was observed at a number of pear cultivars (*Table 4*) the vast majority of honeybees (95.6%) were pure pollen gatherers in the experimental orchard inspected for nectar production of flowers as reported in a previous paper (*Benedek et al.,* 1997). This means that honeybees fail to gather great amount of nectar at pear flowers for its very low sugar concentration even in the case when nectar production of pear flowers is exceptionally high.

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