Bee pollination and association of apricot varieties

INTERNATIONAL JOURNAL OF HORTICULTURAL SCIENCE

AGROINFORM Publishing House, Hungary

Szabó Z.[1], Nyéki, J.[1], Benedek P.[2], Erdős Z.[3] and Soltész M.[4]

[1]*Debrecen University, Centre of Agricultural Sciences, H-4132 Debrecen, Böszörményi út 138, Hungary*
[2]*West Hungarian University Faculty of Agricultural Science, H-920 Mosonmagyaróvár, Vár 4, Hungary*
[3]*Fruit Research Station, Cegléd, Hungary*
[4]*College of Horticulture, College of Kecskemét, H-6001 Kecskemét, Erdei F. tér 1, Hungary*

Key words: apricot, bee pollination, nectar, fertilisation

Summary: Apricot yields are highly variable according to the season. The variation is caused mainly by the adversities during the critical processes of floral biology, i.e. blooming and fertilisation. On the basis of information concerning blooming time and mutual compatibility relations of apricot varieties a system of securing regular and adequate yields has been developed.

Winter frosts of the continental type are well tolerated by most of the apricots, however, after the end of rest period, flower buds are loosing frost tolerance, rapidly.

Being one of the fruit species blooming earliest during the early spring, apricot start to bloom in Hungary around the end of March or early April as a mean of many years, but it also happened, exceptionally that apricot started to bloom at February 20 (at Letenye South Hungary). The early season exposes the floral organs to frost injuries. As a consequence, apricot orchards on the Great Plain produce low yields in 3 years, intermediate yields in other 3 years out of a ten-year-period.

Moreover, weather conditions during the blooming period are often unfavourable for pollination. Cool, windy and rainy weather prevents the flight of insects and on the other hand, warm spells shorten the blooming process, nectaries and stigmata get dry and the female gametes loose viability before effective pollination occurres.

The fertility of individual cultivars are meeting different obstacles. Apricot cultivars differ greatly in the rate of flowers bearing underdeveloped pistils, which may attain even 60% (e.g. *Orangered)*. New commercial cultivars are often self-incompatible. Local varieties of that type in Hungary are the „óriás" varieties (e.g. *Ceglédi óriás, Szegedi mammut)*, and the new hybrid *Ceglédi Piroska*. Many of the cultivars are variable in their self-fertility (partially self-fertile): *Budapest, Harmat, Korai piros, Mandulakajszi.*

Inter-incompatibility is also known in apricots. The „óriás" varieties do not fertilise each other. During the growth of fruits, cool spells (2–4 °C) caused severe fruit shed in *Ceglédi óriás.*

Apricot flowers produce pollen and nectar at average rates related to other fruit species, thus bees are attracted sufficiently. Bee visits are very variable according to growing site and season. Most of the bees are pollen gatherers but sometimes nectar suckers are in majority.

Bee pollination is necessary not only for the self-incompatible varieties but also to enhance the yield of self-fertile varieties.

Taking the blooming and fertility relations of the cultivars into account, plantations should not exceed two rows to a particular self-incompatible varieties, and possibly two different polliniser varieties are suggested to be planted as flanking the block in question.

In commercial plantations 2 to 4 bee colonies per hectare are proposed to move for the whole blooming period.

Introduction

It is generally accepted that apricot is dependent on insect pollination. The size of grains excludes the possible role of wind as for the transfer of pollen.

Some of the apricot varieties are self-incompatible; thus association of varieties and active agents of pollination are needed during the bloom. Apricot blooms during the earliest period of fruit species when the bee colonies start to develop their population after the adversities of the winter pause; i.e. they need much food, pollen and nectar. Information concerning the behaviour of bees and the fertilisation of fruits is surveyed, shortly.

Krause (1968) proved at Long Ashton that apple yield was good as soon as the rate of fruit set attained 5%. A single bee visited 5 flowers per minute. Honeybees proceed along the rows of trees; thus high density of plantation is advantageous. Blooming weeds may divert the bees. The apricot variety *'Trevatt'* produced reduced yield when deprived from the bees, thus fruit set, yield and number of fruits harvested decreased by 43, 32 and 50%, respectively.

The majority (97.6%) of the pollinisers was honeybees according to *Langridge & Goodman* (1981). Also Murneek (1937) recognised honeybees as the main organisms for that purpose in apricots. It may be added that other insect are also able to pollinate the flowers though there importance is clearly secondary (Stark, 1944).

Hootman (1935) observed already that the yields, even of self-fertile apricot varieties, increased by the activity of bees. *Singh* (1954) claimed that honeybees prefer some fruit species in a mixed plantation, e.g. apple and sweet cherry flowers in relation to apricot and pear flowers. *Free* (1960) compared more fruit species, apple, apricot, peach, pear, plum and sweet cherry, and stated that the rate of nectar versus pollen gatherer bees changed highly depending on the day, moreover, on the period within the same day. Pollen gathering was often preferred when nectar was less available or less attractive.

As for the quality of nectar in apricot, *Vansell & Griggs* (1952) noted that a concentration of 15% of the nectar is considered as being rather diluted. Drought may improve the quality of nectar as well as the attractiveness of flowers by enhanced evaporation.

Observing the activity of bees *Free* (1960) raised data to be considered. The mean number of apricot flowers visited a single bee was 8.2 per minute. However, nectar collecting bees visit 5.6 flowers per minute, on the other hand, pollen gatherers 7.9 flowers p.m.

Péter (1972) found differences, up to 60–80%, in nectar production between *Magyar kajszi* and *Nancy* varieties. The former yielded 1.19 mg/flower of nectar with 26.2% soluble solid content. He claimed that those quantities are enough for the bees to cover their current need of energy. Different fruit species produce nectar on a scale between 0.26 and 3.08 mg/day/flower, raspberry being exceptional with 10.44. The sugar value does not attain 1,0 mg in average, for raspberry it is 5.15 mg. Results concerning bee pollination and requirements raised towards apricot varieties in Hungary are summarised by *Benedek* et al. (1991 and 1995).

Material and methods

Observations and measurements have been performed at different sites in Hungary (Balatonboglár, Siófok, Pomáz, and Kecskemét) starting with 1986.

Daily nectar production was measured on the northern and southern side of the selected trees, parallelly. Branches were selected bearing 20–50 flowers and bagged with parchment paper bags. The nectar samples were taken – each time – from completely open flowers one day after isolation. Glass capillary tubes were inserted to the space between the petals and the circle of stamina in 5 randomly selected flowers. The nectar samples were isolated in the tubes by wax plugs at both extremities and stored. During storage the samples were kept cool (refrigerator, cooled bag). *P. Benedek* at Magyaróvár performed the weighing in laboratory.

The registration of frequency of bee visits and the behaviour of bees was organised according the method developed by P. Benedek. The selected trees were sampled, depending on the weather 3 times in the morning and 3 times in the afternoon. On the northern and southern side, each, one branch of about 50 flowers was observed for a 10-minuteinterval.

Treatments of exploring the crucial time of pollination within the bloom period expressed in the rate of fruit set are listed as A to F:

A) On each tree at the four points of the compass, each 100 flowers were counted from the apex proximally and there tagged.

B) At the four points of the compass, all flower buds have been counted under the paper bag.

C) The 4 selected branches were left open during the first 3 days of the bloom period, then bagged at the 4th day as in point B.

D) The bagging was performed like in C) except at the 6th day, on the four branches of the tree.

E) The bags mounted like in point B) were removed at the 4th day of the bloom period.

F) The bags mounted like in point B) were removed at the 6th day of the bloom period.

About 2–3 days after the end of the bloom period all isolation bags were removed, but fruit set was registered later at three successive time:

– three weeks after bloom, following the purification fall, all fruit primordia were registered on the sample branch (where all flower buds have been counted earlier),
– another three weeks later,
– before the maturity of fruits.

Results

Blooming and fertilisation

The production of apricot fruit is highly variable depending on the year. The unreliable yields are clearly consequences of processes of floral biology, i.e. blooming and fertilisation. Information on the blooming time and fertility relations of varieties enables the grower to develop technologies, which guarantee regular and adequate yields of apricot too.

Winter frosts of the continental type are tolerated by most of the apricots because of being in rest period, but that hardiness of flower buds disappears soon with the mild spring weather. The early bloom is often endangered by the late spring frosts. In the plantations of the Great Plain yields are low in 3 years and intermediate in other 3 years out of a period of 10 years, as proved statistically.

Apricot is an early blooming species. In Hungary, depending on the season, the first flowers open between the end of February and the second part of April. According to

Nyújtó, as a mean of many years, the most likely interval was between April 8 and 13, but during the last 10 years the dates shifted to be earlier by some 7 to 10 days. The bloom of a single variety may vary as much as 40 days over a longer period of years.

On the northern border of apricot cultivation, there is but little difference in blooming date of the varieties. Actually, the delay between the earliest and latest blooming varieties was some 4–5 days. Taking a larger sample of varieties, the difference may attain 8–12 days. The delay between the extremes depends on the date of the beginning of bloom. The earlier was the date of start, the longer the delay between bloom times of early and late blooming varieties.

The majority of the European varieties are self-fertile; however, most of the North American, Near-Eastern, Central-Asian and Caucasian varieties are self-incompatible.

Apricots of the Hungarian assortment represent self-incompatible, partially self-fertile and self-fertile varieties *(Table 1)*. However, open pollinated flowers of even highly self-fertile varieties set more fruit than the self-pollinated ones.

The occurrence of inter-incompatibility among stone fruits was stated mainly in sweet cherry and observed also in plum and sour cherry. In apricots, inter-incompatibility was first recognised since the beginning of the 1990-es *(Egea* et al., 1991; *Szabó & Nyéki*, 1991)

Fruit set did not vary according to the four point of the compass; thus honeybees visit all parts of the trees with equally effective frequency.

The fruiting of self-incompatible varieties depends on the pollen transfer by insects, absolutely. However, self-fertile varieties set much more fruit owing to the activity of insects, than without that. Bloom of apricots in the early spring is scarcely supplied by polliniser insects, except honeybees. The activity of most insects starts much later than the bloom of apricots. One cannot rely on wild insects for commercial yields, especially in larger plantations, but in solitary trees. Therefore, relevant literature dealing with insect pollination of apricots is scarce.

Bee activity

The research program comprised several growing sites, different varieties, over many years, and it was focussed on varietal characters related to bee visits and conditions of pollination. Large differences were found in the activity of bees, depending on site, season and weather conditions. Intense bee activity started every day after the temperature rose to 13–14 °C, but declined as soon as the wind rose and stopped almost immediately under the covered sky. Cloudy and cool weather saw bumblebees and solitary bees only. The measurements made during a 6-hour daily period show 0.6 to 17.4 bee-visits per flower per day. In general, the frequency of visits was low (2 to 4 bees per 100 flowers during a sampling period of 10 minutes = 1.2 to 2.4 visits per flower per day). The foraging behaviour of bees was variable on apricot trees. The majority of bees were pollen-gatherers (included the mixed gatherers), but sometimes the honey-gatherers prevailed. It is important that the ratio of „side-workers" (those which approach the nectaries laterally without touching the stigma) was low, unimportant. In *Table 2* some results are presented from the observations made at Kecskemét.

Table 1 Blooming dates of apricot varieties grown as well as potentially important in Hungary and their fertility relations, whereas recommended pollinisers for the self-incompatible varieties

Variety	Blooming time	Self-fertility type	Polliniser recommended
Harmat	early	partially	
Korai piros	early	partially	Magyar kajszi
Korai zamatos	early	self-fertile	
Ceglédi Piroska	medium	self-sterile	Ceglédi biborkajszi, Magyar kajszi, Pannónia
Ceglédi óriás	early	self-sterile	Ceglédi biborkajszi, Magyar kajszi
Szegedi mamut	early	self-sterile	Ceglédi biborkajszi, Magyar kajszi
Harcot	early	self-sterile	
N.J.A.-1	early	self-sterile	
Magyar kajszi C. 235	medium early	self-fertile	
Gönci magyar kajszi		self-fertile	
Ceglédi biborkajszi		self-fertile	
Veecot	medium	self-sterile	
Ligeti óriás	medium	self-sterile	Ceglédi bibor kajszi, Magyar kajszi
Polonais	medium		
Rakovszky	medium early	self-fertile	
Pannónia	medium	self-fertile	
Mandulakajszi	late	partially	Magyar kajszi
Ceglédi arany	late	self-fertile	
Roxana	medium	partielly	Magyar kajszi
Bergeron	late	self-fertile	
Ceglédi kedves	medium late	self-fertile	
Rózsakajszi C. 1406	late	self-fertile	
Budapest	medium	self-fertile	
Borsi-féle kései rózsa	late	self-fertile	
Sirena	late	partially	Mandulakajszi, Selena, Sulmona
Selena	late	partially	Mandulakajszi, Sirena

Table 2 Behaviour of honeybees on the blooming apricot trees (Kecskemét, 1989–1990)

Variety	Time of observation in March date and hour	Distribution of bees according to their type of activity				do not gather	Temperature °C
		Pollen gatherers	Nectar suckers Frontally	Nectar suckers Side workers	Mixed gatherers		
Ceglédi óriás 1989	25, 10:10 – 10:10	56	26	8.6	8.6	0	–
	25, 10:15 – 10:25	33	11	33	11	0	–
	28, 14:23 – 14:33	0	100	0	0	0	17
	28, 14:43 – 14:53	0	100	0	0	0	17
	29, 11:23 – 11:33	0	0	0	100	0	20
	29, 15:55 – 16:05	0	100	0	0	0	23
	30, 13:35 – 13:45	0	0	100	0	0	21
1990	18, 14:44 – 14:54	0	100	0	0	0	20
	18, 14:28 – 14:38	0	100	0	0	0	21
	18, 14.40 – 14:50	0	66.6	0	34	0	21
Mandula-kajszi 1989	28, 15:10 – 15:20	0	0	100	0	0	17
	28, 15:10 – 15:20	0	0	0	0	100	17
	29, 10:37 – 10:47	0	50	0	0	50	18
	29, 15:14 – 15:24	40	0	20	20	20	23
	30, 14:05 – 14:15	50	0	0	50	50	22
Gönci magyar kajszi 1989	28, 14:54 – 15:04	0	100	0	0	0	17
	28, 14:53 – 14:03	20	20	20	20	20	17
	29, 10:56 – 11:06	0	100	0	0	0	20
	29, 15:30 – 15:40	20	80	0	0	0	23
	30, 13:50 – 14:00	0	66.6	34	0	0	22
1990	18, 12:20 – 12:30	22	55	0	5.5	16.5	20
	18, 12:55 – 13:05	11	45	22	5.5	16.5	20
	18, 14.50 – 15:00	28.5	42.6	7.1	7.1	14.2	21

The position of the stamina was crucial for the efficiency of pollination. The erect filaments facilitate the activity of side workers in finding the nectar supply. We cannot exclude that as a possible cause of poor and variable fruit set as an alternative of late spring frost.

Nectar production

Nectar production of apricots is also variable. The content was between 0.3 and 4 mg per flower, 2–3 mg being the mean. The differences are sometimes considerable but varieties could not be distinguished unequivocally because different seasons and sites were involved in the measurements.

As sugar content of the nectar is also decisive as a factor of attractiveness for bees, measurements proved that the sugar concentration is intermediate on the scale found in other fruit species. E.g. pear produces more diluted nectar and flowers of other species are superior in sugar concentration of nectar. It is claimed that variation in nectar content and concentration – which may drop to zero in cool weather – cannot be a serious reason of poor bee activity.

Nectar production of apricot varieties is represented in one year in Kecskemét *(Table 3)*. Three varieties were involved: most nectar was found in *Mandulakajszi*, less in *Gönci magyar kajszi*. In sugar content *Ceglédi óriás* excelled (46.1%), *Mandulakajszi* (14.4%) represented the other extreme.

Experimental restrictions of bee pollination

To find what is the most important period for pollination a temporary isolation of different length of periods was applied to the blooming branches excluding the access of bees *(Figure 4)*. On the diagram means of two years are shown.

Table 3 Nectar production of flowers in apricot varieties (Kecskemét, 1989)

Variety	Date of observation	Nectar content (mg/flower)	Soluble solids (%)	Sugar content (mg/flower)
Ceglédi óriás	March 25, 3 p.m.	1.67	46.1	0.77
	March 28, 11:30 a.m.	4.28	32.7	1.40
	March 28, 4 p.m	5.80	32.0	1.86
	March 30, 3:15 p.m	3.65	41.8	1.53
Gönci magyar kajszi	March 25, 3 p.m.	1.57	31.9	0.5.
	March 28, 11:30 a.m.	3.40	41.8	1.42
	March 28, 4 p.m	5.02	27.5	1.38
	March 30, 3:15 p.m	3.46	35.0	1.21
Mandula kajszi	March 28, 12:15 p.m.	5.18	18.5	0.96
	March 28, 4 p.m.	9.40	14.4	1.35
	March 30, 3:15 p.m.	6.67	31.0	1.76

Table 4 Fruit set of apricot trees (Kecskemét, 1989–1990)

Variety	Time of isolation	Fruit set 1989	Fruit set 1990
Ceglédi óriás	B	0.0	0.0
	C	7.0	1.5
	D	16.3	5.0
	A	18.6	12.8
	LSD 5%	4.3	2.3
Gönci magyar kajszi	B	21.3	18.6
	C	24.6	17.6
	D	34.8	38.0
	A	50.0	47.1
	E	31.4	32.8
	F	26.1	17.2
	LSD 5%	12.6	9.9
Mandulakajszi	B	18.9	9.6
	C	25.9	45.6
	D	35.9	28.0
	A	32.5	37.0
	LSD 5%	9.9	11.9

Legend B isolation at the beginning of bloom
C isolation after the 4th day of bloom
D isolation after the 6th day of bloom
A open pollinated along the whole blooming period
E isolation from the beginning until the 4th day of bloom
F isolation from the beginning until the 6th day of bloom

The variety *Ceglédi óriás* did not set fruit with full time isolation, which means that it is self-incompatible. Different partial time isolations showed significant differences in fruit set depending on the time spent without isolation.

Gönci magyar kajszi set fruit at a rate of 18.7% on isolated flowers, being self-fertile. The same differences appeared between the treatments. It seems that isolation after the 4th day of bloom did not impair fruit set. That indicates, the 3–4-5th days of bloom are the most important ones to pollination.

Association of varieties

The varieties of different geographic regions are inter-compatible with high probability. Self-incompatible varieties should be planted in single rows, only, partially self-fertile ones in 2 or 3 rows, whereas self-fertility allows (monovarietal) blocks of 6-8 rows, furthermore, the rows should not be interrupted by inserted polliniser trees. The final ratio of trees belonging to different varieties should be 1:1, 1:2, 1:3, or 1:1:1.

According to our earlier studies 70% overlap of blooming periods of the respective varieties is considered to be sufficient. For the sake of security, for self-incompatible varieties the use of more than one polliniser variety is recommended.

McGregor (1976) proposed one bee colony per acre (which means 2.5 colonies per hectare) to move into the plantation for the blooming period. Farkas (1982) suggested 3 per ha. Hives should be grouped in a network of 160x160 – 300x300 m distances.

References

Benedek P., Nyéki J. & Szabó Z. (1991): Properties of apricot trees influencing bee pollination. (Hungarian) Kertgazdaság 23 (2), 27–39.

Benedek P., Nyéki J. & Szabó Z. (1995): Bee pollination of apricot: variety features affecting bee activity. Acta Horticulturae 384, 329–332.

Egea, J., Garcia, J.E., Egea, L. & Berenguer, T. (1991): Self-incompatibility in apricot cultivars. Acta Horticulturae 293, 285–293.

Farkas J. (1982): Organisation of the pollination in crops. (Hungarian) Recommendations of the Research Institute of Animal Husbandry.

Free, J.B. (1960): The behaviour of honeybees visiting the flowers of fruit trees. Anim. Ecol. 29, 358–395.

Hootman, H.D. (1935): Importance of pollination and the honeybee in fruit yields. Midwest Fruitman 8/9, 3–4, 9–10.

Krause, W. (1968): We must revise our knowledge of fruit pollination. Grower, London 69/20, 1140.

Langridge, D.F. & Goodman, R.D. (1981): Honeybees pollination of the apricot cv. Trevatt. Aust. I. Exp. Agric. Anim. Husb., Melbourne 21 (109), 241–244.

Murneek, A.E. (1937): Pollination and fruit setting. Midwest Fruitman (5), 8–9.

McGregor, S.E. (1976): Insect pollination of cultivated crop plant. Agriculture Handbook No. 496.

Péter J. (1972): Evaluation of fruit trees according to their nectar production (Hungarian). Agrártud. Egyetem Keszthely, Mosonmagyaróvári Mg. Kar Növénytani és Növényélettani Tsz. Közl. 8, 5–35

Singh, S. (1954): Insect pollinators and the breeding of fruit varieties. Indian J. Hort. 11.

Stark, A.L. (1944): Fruit pollination – A problem in Utah. Farm and Home Sci. 5 (4), 5–6.

Szabó Z. & Nyéki J. (1991): Blooming and combination of apricot varieties. Acta Horticulturae 293, 295–302.

Vansell, G.H. & Griggs, W.H. (1952): Honeybees as agents of pollination. Yb. Agric. U.S.D.A. 88–107.