Effect of the placement of self-incompatible apricot varieties on their yield in commercial plantations

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Summary: Earlier studies concerning self-, free- and cross- fertilization of apricot varieties grown in Hungary, proved the existence of self-sterile as well as self-fertile varieties within the recommended assortment. The self-sterile and partially self-fertile varieties should be planted in association with polliniser varieties, only. The present paper reports about the yields of trees of the widely grown, self-sterile local variety, *Ceglédi óriás (Giant of Cegléd)*, depending on the distance of adequate polliniser trees. In the univarietal, 27 row-wide block of the relevant variety, an efficient polliniser, *Magyar kajszi* was planted to the 10th and 19th row. In the close vicinity, another block of polliniser, *Rózsakajszi C. 320* was located. The number of fruits set per tree has been counted or estimated in two consecutive years. In both seasons, the yield of the *Ceglédi óriás* trees diminished with the growing distance from the nearest polliniser trees. Those trees in the center of the block, between the two (10th and 19th) rows of *Magyar kajszi* bore acceptable yield (40 kg/tree in 1987), however, considerable reduction of the number of the fruits set was stated already in the 4–5th row from the polliniser away. Similar gradient of fruit set was apparent in relation to the neighbouring block of *Rózsakajszi C 320*. The beneficial effect of the vicinity of polliniser varieties was obvious as far as the distance of the 10th row. Taking into consideration the self-sterility, the early blooming time and the poor fertilization of the variety *Ceglédi óriás*, a planting design of associating it with at least two polliniser varieties (e.g. *Gönczi magyar kajszi* and *Ceglédi bíbor*) is highly recommended. On the basis also of earlier results, a proposal has been developed for the association of apricot varieties as recommendations for optimising yields. Blooming time, fertilizing potential, schedule of the picking season and market possibilities have to be considered simultaneously.

Introduction

Apricots grown allegedly for two thousand years in the Carpatian basin, developed very variable populations. Most of the registered varieties in the present production are derived from local varieties selected by Nyújtó and his associates. Some of the most valuable clones are results of purposeful crosses between those local varieties by breeders *(Maliga, Tamássy, Nyújtó, Pedryc)*.

The varieties listed in the state register and recommended for plantation are of Hungarian origin (16 out of 19).

Phenological details of blooming in apricots are explored by *Nyújtó* (1980). New procedures in studying the flowering physiology have been applied by *Máthé, Nyéki* and *Szabó* (1995). The application of insect pollination was assessed by *Benedek, Nyéki* and *Szabó* (1995), fertility relations by *Nyújtó* (1980). Mutual inter-incompatibility of apricot varieties has been reported by *Szabó* and *Nyéki* (1991) the first time in literature. Association of apricot varieties in one plantation was reviewed by *Nyújtó* (1980) and *Nyújtó* et al (1982). Summarizing the Hungarian studies of the last several decennia, it is concluded that the present apricot varieties of the Hungarian assortment are either self-sterile, partially self-fertile or self-fertile. The first two types cannot produce commercially acceptable yields but in combination with adequate polliniser varieties.

The present study stresses the importance of the vicinity of polliniser trees from the point of view of fruit set in a self-incompatible (-sterile) variety. On the basis of the results obtained by earlier studies we will attempt to summarize the principles of associating apricot varieties in Hungarian plantations.

Material and methods

The actual study aimed to measure effects of the spatial distance on the productivity of apricot varieties in a plantation where the late frost did not endanger the crop.

At Pomáz, the plantation was made in 1977 to 6 x 4 m distance on apricot seedling rootstock, and the trees were trained to a combined type crown. The plantation consisted of varieties: *Ceglédi óriás, Szegedi mammut, Ceglédi bíborkajszi, Ligeti óriás,* each in 4 rows, and close to that was a large block of *Magyar kajszi C 235.*

At Viszpuszta the planting started in 1979 and the *Ceglédi óriás* trees stood on *P. cerasifera v. myrabolan* plum rootstock at 8 x 6 m distance, also trained to combined crowns (medium trunks, crown with a leader). In the two-

year old plantation each 9th row was substituted with the *Magyar kajszi variety* claimed to provide pollination for *Ceglédi óriás* being considered to be self-sterile. *Figure 1* presents the planting design of the orchard.

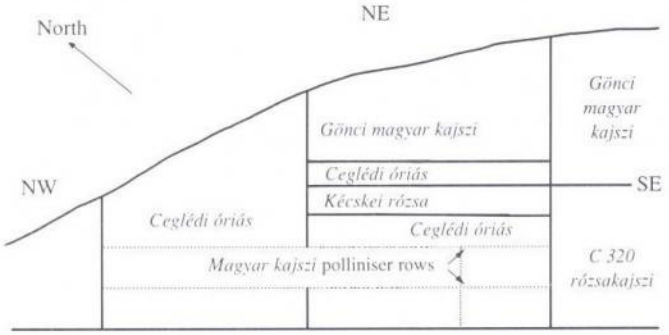

Figure 1 Planting design of the apricot orchard at Viszpuszta
Varieties are in large blocks, excepte in a block of the self-sterile variety, *Ceglédi óriás*, *Magyar kajszi* was interplanted as polliniser. Observations in 1986 and 1987 are limited to the area of 27 rows with 20 trees, each

As for yield, the number of fruits set on *Ceglédi óriás* trees has been counted in 1986 and estimated in 1987.

On the basis of earlier results, recommendations of variety combinations have been developed for the following groups of varieties:

- Local varieties selected in Hungary: *Ceglédi óriás, Mandulakajszi, Magyar kajszi C.235, Gönci magyar kajszi, Szegedi mammut, Borsi-féle kései rózsa, Rózsakajszi C.1406.*
- Seedlings derived from open pollination: *Ceglédi kedves, Harmat, Korai zamatos.*
- Varieties bred by cross pollination: *Ceglédi Piroska, Pannonia, Budapest, Ceglédi arany.*

According to their time of maturity, the varieties are grouped for the purpose of recommending variety associations:

1) very early:	earlier than *Magyar kajszi C.235* by 10–20 days,
2) early:	earlier than *M.k. C.235* by 5–10 days,
3) medium early:	earlier than *M.k. C.235* by 3–4 days,
	or synchronous, or later than *M. k. C.235,*
4) medium late:	later than *M.k. C.235* by 8–12 days,
5) late:	later than *M.k. C.235* by 13–20 days,
6) very late:	later than *M.k. C.235* by 20–40 days
	(there are no varieties of this latter group in the recommendation).

3. Results

The yield of the plantation was highly dependent on the weather conditions. In 1986, the quick warming up with the beginning of April triggered blooming, then cool and rainy days broke the dynamics of flower opening. The cold, windy weather with frequent precipitation impaired the pollination, so the majority of flowers were shed. In 1987, however, the favourable weather during apricot blooming stimulated a busy insect activity, so the excellent pollination resulted in high rates of fruit set in both orchards in question. The varieties produced 1–2 t/ha yields in 1986, whereas at Pomáz mean yields of 20 t/ha (*Ceglédi óriás, Ligeti óriás, Szegedi mammut*), at Viszpuszta 11.5 t/ha (*Ceglédi óriás*) have been harvested in 1987.

Table 1 Fertility and fruiting of apricot trees. (Pomáz 1986)

Variety	Number of the row	Number of fruits/tree	Mean number of fruits/tree
Ceglédi óriás	1	99.6	
	2	187.7	
	3	102.1	
	4	167.8	139.3
Szegedi mammut	5	67.0	
	6	72.5	
	7	61.4	
	8	146.5	86.8
Ceglédi bíbor kajszi	9	159.9	
	10	217.3	
	11	237.4	
	12	89.5	176.0
Ligeti óriás	13	70.3	
	14	59.0	
	15	84.0	
	16	64.0	69.3
Ceglédi óriás	17	67.5	
	18	67.0	
	19	78.5	
	20	58.0	67.7
Szegedi mammut	21	69.5	
	22	84.0	
	23	129.0	
	24	207.0	122.4
Ceglédi bíbor kajszi	25	430.0	
	26	420.0	
	27	340.0	
	28	335.0	381.2
Ligeti óriás	29	260.0	
	30	214.0	
	31	192.0	
	32	121.0	196.8

At *Pomáz*, fruits of 10 individual trees in each row (32) have been counted as shown in *Table 1*. Out of the four varieties involved, the "óriás" (giant) type-varieties (*Ceglédi óriás, Ligeti óriás* and *Szegedi mammut*) are self-incompatible, only *Ceglédi bíborkajszi* is self fertile. The data show clearly that the fruit set on the "óriás" type varieties

flanking the potential polliniser *Ceglédi bíborkajszi* trees was better. With the increasing distance from the polliniser, the trees set less fruits. In the 13–16th rows the effect of distance was not unequivocal, whereas in the 5–8th, the 21–24th and the 29–32 rows the number of fruits set per tree was similar. In the 4th row, however, no beneficial effect of the polliniser was evident. At the same time, there was an overwhelming proof of self- and mutual incompatibility of the "óriás" type of varieties. Their close vicinity did not improve the fruit set of each other as stated by *Nyéki* and *Szabó* (1995).

At *Viszpuszta,* the number of fruits of each (from the 1st to the 20th) tree was counted along the 27 rows of the orchard in both seasons, 1986 and 1987. The vicinity of the polliniser was expressed close to the 10th and the 19th rows (which are planted to *Magyar kajszi)* and to the flanking block of *C.320 rózsakajszi* in the plantation.

The *Magyar kajszi* trees being planted 2 years later (than the rest of the block *Ceglédi óriás*) were accordingly smaller and started blooming later by 2–3 days, in spite of that, the beneficial effect of the pollination was clearly recognized in both years (1986 and 1987), but even more in 1986 when the conditions of pollination were more critical. The effect of the flanking block of *C 320 rózsakajszi,* as polliniser, on the fruit set of *Ceglédi óriás* is expressed in *Figure 2.* Moreover, the positive effect on yield reached as far as the 10th tree's distance (50 m) from the two single rows of *Magyar kajszi* polliniser trees, as shown in *Figure 3.*

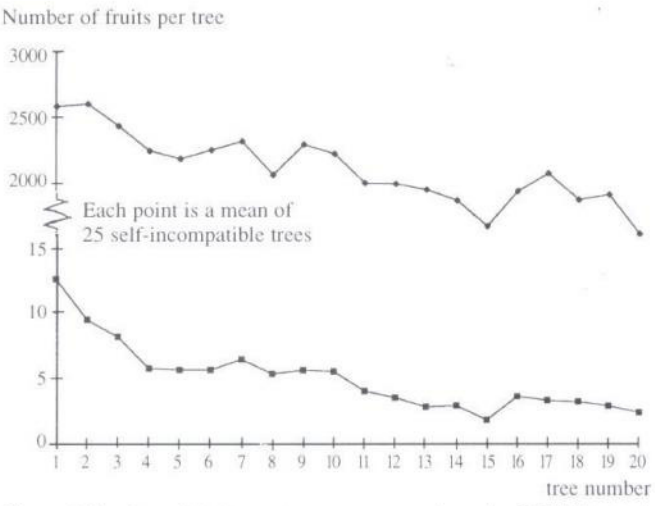

Figure 2 Number of fruits per tree, row means along the SE–NW axis, in 1986 (below) and 1987 (above) (the block of the polliniser variety, *C 320 rózsajakszi*, flanked that of the *Ceglédi rózsa* on the SE end)

The effect of both pollinisers was more expressed in 1986 because of the unfavourable weather conditions as the vicinity of polliniser trees was particularly important.

In order to prove the influence of distance of the pollen source, the data of fruits set in 1986 and 1987 were compaired taking samples of several groups of trees, alternatively. As the fruit set of 1987 may considered to be near to "saturation" on account of optimal conditions for

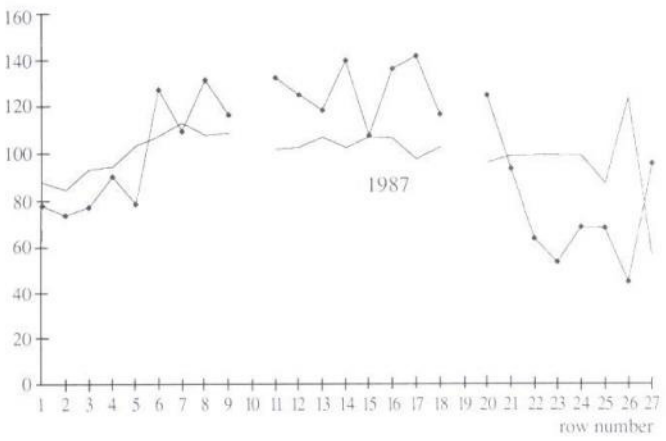

Figure 3 Effect of the vicinity of polliniser (rows 10 and 19) on the relative yield per tree of self incompatible *Ceglédi óriás* expressed in per cent of the mean in 1986 and 1987 (Values of 1986 are adjusted)

insect activity, the data reflect rather the bearing capacity of the individual trees than the distance of pollen source. Therefore, the difference in relative fruit set of the respective groups of trees near to or away from pollinisers proved to be more accentuated in 1986 than in 1987. The significance of differences could be improved substantially in some cases where the pollination was more critical, by adjusting the

Table 2 Differences in fruit set (fruit/tree) of the self-sterile apricot variety *"Ceglédi óriás"* according to the distance of the pollen source *"Magyar kajszi"* (at Visz puszta)

Subsequently, differences in fruit set on the margins of the SE-NW and NE–SW axis in 1986 and in 1987, respectively, then the adjusted values (%) of 1986 by the data of 1987, according to Ya=Y6–(100–Y7).

Yield of trees flanking the polliniser rows (9, 11, 18, 20): "Close", compared with trees of more distantly located rows (5, 15, 23, 24): "Distant"
Degree of freedom = 66

	1986 fruit/tree	1987 fruit/tree	1986 adjusted % of mean
Close (C)	62.31	2140	121
Distant (D)	38.82	2135	76
difference C-D	23.49	5	45
test of "t"	3.84 ***	0.69 n.s.	4.76 ***

Yields in the first 8 (South–East) and the last 8 (North–West) rows out of the 20 rows on the SE-NW axis,
D.f. = 166

	1986 fruit/tree	1987 fruit/tree	1986 adj. % of mean
SE	74.35	2342	95
NW	29.56	1869	76
difference SE-NW	44.78	473	19
test of "t"	11.0 ***	8.67 ***	9.51 ***

Yield in the first 7 (North–East) and the last 7 (South–West) rows out of the 27 rows on the NE-SW axis,
D.f. = 119

	1986 fruit/tree	1987 fruit/tree	1986 adj. % of mean
NE	77.51	2111	141
SW	29.68	1997	71
difference NE-SW	47.83	113	70
test of "t"	9.89 ***	1.08 n.s.	8.38 ***

Table 3 The main apricot varieties of Hungary and the recommended association of them

Number of the varieties according to their sequence of ripening	Group of ripening time	Name of the variety	Group of flowering time	Fertilization requirements	Recommended polliniser variety	
					self-sterile	self-fertile
1	very early	*Harmat*	early	self-sterile	4,5,6	
2	early	*Korai zamatos*	medium	self-sterile	3	7, 8
3		*Ceglédi Piroska*	medium	self-sterile	2	7, 8
4		*Ceglédi óriás*	early	self-sterile	1, 6	
5		*Szegedi mammut*	early	self-sterile	1, 6	
6		*Harcot*	early	self-sterile	1,4	
7	medium early	*Magyar kajszi C.235*	medium	self-fertile	–	–
8		*Gönci magyar kajszi*	medium	self-fertile	–	–
9		*Ceglédi bíborkajszi*	medium	self-fertile	–	
10		Veecot	medium	self-fertile	–	–
11		Pannonia	medium	self-fertile	–	–
12		Mandulakajszi	late	self-fertile	19, 20	7, 8
13		Ceglédi arany	late	self-fertile	–	–
14		Bergeron	late	self-fertile	–	–
15	medium late	*Ceglédi kedves*	medium	self-fertile	–	–
16		*Rózsakajszi C1406*	late	self-fertile	–	–
17		*Budapest*	medium	self-fertile	–	–
18		*Borsi féle kései rózsa*	late	self-fertile	–	–
19	late	*Sirene*	late	self-sterile	12, 20	13, 14
20		*Selena*	late	self-sterile	12, 19	13, 14

1986-yield of individual trees according to their 1987-yield. The algorithm of adjustment was:

$$Ya = Y6 - Y7 - (100 - Y7),$$

where deviations of the yearly means are calculated, Ya being the adjusted yield of Y6. Y6 and Y7 are the yields of 1986 and 1987, respectively, expressed in percents of the yearly mean. Values below the mean of 1987 appeared with a negative sign and may express the condition of the tree, consequently, improve the value of Ya, according to the formula. The results are presented in *Table 2.*

As *Ceglédi óriás* has an early blooming time, we recommend, because of its self incompatibility, at least two pollinisers (e.g. *Gönci Magyar kajszi* and *Ceglédi bíborkajszi*).

Recommended association of apricot varieties for plantations in Hungary are summarized in *Table 3.*

4. Discussion

The self- and inter-incompatibility of the "óriás" type apricot varieties (*Ceglédi óriás, Ligeti óriás, Nagykőrösi óriás, Szegedi mammut*) was definitely confirmed in contradiction with earlier observations of *Nyújtó* (1980) and *Nyújtó* et al (1982). Blooming of those varieties starts as a rule 1-3 days earlier than most of the apricot varieties grown in Hungary. Hence the principles of variety association in apricot plantations are summarized as follows:

Self-fertile varieties should be planted preferably in monovarietal blocks because an efficient polliniser would stimulate unfavourably high rate of fruit set which, in turn, may trigger the onset of alternate bearing. As far as pure stands of individual self-fertile varieties cannot be realized, other self-fertile varieties of thoroughly different blooming time should be chosen as associates in order to prevent super optimal fruit set. There are additional advantages of this solution, as the enhancement of yield security by avoiding the late frost damage of at least in one part of the trees. The critical night minima may affect the varieties of the orchard in different phases of frost sensitivity.

Self-incompatible varieties are to be supplied with pollinisers. Two alternatives are possible. If two self-incompatible varieties belonging to the same group of blooming time are associated, a safe fruit set is expected without the danger of super-optimal fruit set. In case of choosing a self-fertile polliniser for the self-sterile variety, the danger of alternate bearing may become imminent in the self-fertile variety and the pollination of the self-sterile one will be compromitted in the "fallow" years of the former because of its scarce flower formation. To avoid this danger, careful thinning of the fruits set in years favourable for pollination, on the self-fertile variety (which will receive also pollen from the other, self-sterile variety) must be performed.

The region ***Duna-Tisza köze*** (between the Danube and Tisza river) on the Hungarian lowland, is the main, traditional apricot producing part of Hungary, where low winter temperatures and late frosts do occur especially frequently. The latter affect the trees at bud burst and during blooming time. For that reason, varieties of longer winter dormancy and medium late or late flowering time have more chance to bear regularly. Early blooming varieties mean increased risk in the relevant region. For the sake of a

prolonged harvest period varieties of different ripening time should be combined (though preferably in blocks), but the blooming time has to be considered too. There are, fortunately, early ripening varieties available with late or prolonged blooming period (e.g. *Korai zamatos, Ceglédi Piroska*), however, their ratio should not exceed 10% of the plantations.

Harvest and ***utilization*** of the fruit has to be considered in planning of a plantation. The distinction of varieties for fresh consumption and for processing, or those which are suitable for both types of utilization is conditioned by the alternative use of either hand picking or mechanized picking (shaking) techniques. Plantations suitable for only one type of utilization or harvesting technique are particularly difficult to be managed. Hungarian varieties recommended in *Table 3* are mainly of the double-purpose type, only some very early (*Harmat*) and early ripening ones (*Korai zamatos, Ceglédi Piroska*) are exceptions being for fresh consumption and have to be picked by hand, only.

Mechanical harvest requires some grouping of the trees of the same variety which means that mutually polliniser varieties should be planted in alternate blocks of 3 rows at most. The growing distance from the polliniser will impair the fertilization of the self-sterile variety in larger (monovarietal) blocks than that. Self-fertile varieties are not subject to limitations of this type, moreover, it is advantageous to avoid excessive fruit set caused by allogamy, and only the critical row of the plantation flanking the other (self-sterile or self fertile) variety should be thinned if necessary.

In the decision of choosing varieties for combined planting, after considering the time of harvest, the technique of picking, and the conditions of self- and cross-fertilization, the ***flower-insect relations*** of the varieties are to be taken into account. All that system outlined above will be effective at the condition of similar flowering biology of the relevant varieties expressed in the relative bee visitation frequencies. If one of the varieties is preferred and the other neglected by the pollinating insects (mainly honeybees) the ratios of pollinisers and self-steriles are to be adjusted accordingly in favour of an optimal distribution of bees, or more bee hives, i.e. the affluence of bees will overlap the handicaps of poor attractivity of some varieties. As for a combined planting design of self-incompatible varieties with one or more polliniser varieties alternative sketches are recommended by Lichou (1998) and *Szabó Z. & Nyéki J.* (1999).

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