Association of varieties in stone fruit plantations

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Summary: In the majority of Hungarian orchards of stone fruits, the planting distance is 6–7 m x 4–5 m. As many of the current varieties are self-incompatible, planting designs are applied to provide for adequate pollinisers. As long as differences in blooming time are small, i.e. 3–5 days at most, overlaps of blooming of the associated varieties are sufficient for fruit set.
In **sour cherry,** one leading variety, *Pándy*, is self-incompatible and requires two polliniser varieties at least *(Cigánymeggy* or some sweet cherry varieites). *Pándy* is, moreover, cross-incompatible with the varieties *Debreceni bőtermő, Kántorjánosi* and *Újfehértói fürtös* being all of them self-fertile as most of new varieties recommended, by the way, for being planted to monovarietal blocks.
Among **European plums** there are varieties registered as male sterile, self-incompatible, parially self-fertile and self-fertile, respectively. For the purpose of cross pollination, the choice of two varieties, at least, to be associated to any variety belonging to the first three groups, is recommended. The number of rows in blocks planted to self incompatible or male-sterile varieties should not be higher than 2-(4). Inter-incompatibility has been observed within the currently recommended assortment, between the varieties *Čačanska najbolja* and *Stanley*, only.
Chinese-Japanese plums are scarcely represented in Hungarian plantations. Variation of blooming time in varieties is somewhat more pronounced, i.e. 5–8 days. There is but a weak tendency to self-fertility, thus practically, all varieties are considered as self-incompatible, thus the planting of two-row blocks for each of three varieties, at least, are recommended to be associated.
Self-incompatibility and partially self-fertile apricot varieties are recommended to be combined with two polliniser varieties, at least, each planted to two-row blocks. The varieties *Ceglédi órias, Ligeti óriás, Nagykőrösi óriás* and *Szegedi Mamut* are mutually inter-incompatible.
Most of the **peach** varieties grown in Hungary are self-fertile, thus they are planted to large blocks, each. On sites threatened by late spring frost, it is recommended to plant (monovarietal) blocks of 4–6 rows at most. Cross-pollination may increase fruit set even in self-fertile varieties.

Introduction

Fertility relations of stone fruits are various. Most sweet cherry varieties are self-incompatible, moreover, several inter-incompatible combinations are found. Self-fertility was considered to be a very desirable character from the point of view of safe and regular yields, thus recently, new self-fertile cherry varieties are gaining space. The Japanese plums are mainly self-incompatible, whereas among European plums as well as apricots there are self-incompatible, partially self-fertile and self-fertile varieties. Peach varieties are mostly self-fertile. Male sterility was found in European plums and peaches only.
Self-incompatible and partially self-fertile varieties need to be associated to polliniser varieties. In choosing an adequate polliniser, an overlap of blooming times is the most important point of view, moreover, an abundant production of viable and compatible pollen.

The present paper summarises relevant experiences concerning the association of varieties in stone fruit production.

Material and methods

Blooming, fertilisation and association of varieties in stone fruit production has been studied since 1968 on 15 growing sites of Hungary involving about 260 varieties. Commercially important varieties have been preferred and methods described by *Nyéki* (1989) are used.

Beginning and end of blooming time, as well as the time of the main blooming of each variety has been registered. According to the mean of data over several years, varieties have been assigned to blooming date groups as potential associates for planting.

Experimental pollinations have been performed on 1 to 4 trees per variety on flowers situated at 1.5–2 meters above ground and distributed to branches on four cardinal points of the crown.

Free pollination has been checked on 400–500 flowers per variety, self- and cross pollination was attempted on 100–200 flowers.

Fruit set was stated one or two weeks before full maturity.

All varieties if their fertility does not allow economical yields in mono-varietal plantations should be considered as self-incompatible. The grade of self-fertility, however, requires some qualification too as *Nyéki* (1989) proposed:

Entirely self-incompatible	0% fruit set
Self-incompatible	0.1–1%
Partially self-incompatible	1.1–10%
Self-fertile	10.1–20%
Highly self-compatible	more than 20% fruit set.

In experimental cross-pollinations a fruit set above 10 % was considered as successful.

Results

Sweet cherry

Differences in blooming times of varieties are relatively small. In some seasons, even early and late blooming varieties may prove adequate pollinisers for each other because of the sufficient overlap of blooming periods. There is some correlation between the blooming and ripening time over varieties allowing the association of varieties ripening at nearly the same time. There is, however, an exception, the variety *Margit* which is early in ripening, but blooming with the medium late group *(Table 1)*. In inter-fertile combinations fruit set above 25% may be observed. Inter-incompatible combinations are found frequently. Up to now, 14 groups of inter-incompatibility have been established in sweet cherries. The "0" group has been assigned to self fertile varieties which combine well with any other variety of the 14 inter-incompatibility groups (e.g. *Stella* and *Vega*).

Table 1 Blooming and fertilisation of sweet cherry varieties in Hungary

Code	Variety	Intensity of blooming	Polliniser variety recommended
	Internationally known varieties:		
	Early		
1	Bigarreau Burlat	2	2, 4, 6, 8, 7, 3, 9, 12, 13
2	Bigarreau Moreau	2	1, 4, 8
3	Early Rivers	1	May Bigarreau
	Intermediate		
4	Van	2	6, 1, 1, 7, 10, 15
5	Vega	3	4, 7, 10
	Late		
6	Bigarreau Napoleon	4	1, 4, 7
7	Hedelfingeni óriás	4	1, 6, 3, 4, 10, 11, 15
	Varieties grown in Hungary Varieties of foreign origin		
	Early		
8	Jaboulay	2	1, 9, 12, 13
9	Münchebergi korai	1	1, 8, 12, 13
	Intermediate		
10	Germersdorfi óriás	5	4, 7, 15
	Hungarian varieties		
	Early		
11	Margit	4	4, 7, 15, 16
12	Pomázi hosszúszárú	1	1, 8, 9
13	Szomolyai fekete	1	1, 8, 9, 12
	Intermediate		
14	Linda	4	4, 7, 15
15	Solymári gömbölyű	5	4, 7, 10
	Late		
16	Katalin	3	4, 7, 10, 14, 15

Sour cherry

The new Hungarian sour cherry varieties being sufficiently self-fertile. No other varieties are needed to be associated. Earlier, self-incompatible varieties were grown as well (e.g. *Cigánymeggy*), but at present self-fertile varieties are multiplied and planted, only. Additional cross pollination is essentially not desired because the fruit size is reduced by "oversetting". Those few self-incompatible Hungarian varieties commercially admitted (clones of *Pándy* and *Érdi nagygyümölcsű*) should be associated with two polliniser varieties, at least, to cover 70% of the blooming period necessary for reliable yield. In spite of the best combination, those varieties are poor yielders with irregular and low fruit set. The sole justification of their popularity depends just on the exceptionally high price offered on the market.

The self-fertile varieties, *Újfehértói fürtös, Kántorjánosi* and *Debreceni hőtermő* do not need to be planted in association with polliniser varieties. Additional cross fertilisation may increase fruit set beyond the desired optimum causing reduction in fruit size. Those varieties are competititve on the market as long as their fruit diameter kept the standard of 21 mm, at least. Thus they may substitute the famous Pándy variety. Smaller fruits are not desirable in processing either because of their relatively large stones. The three varieties mentioned being genetically related, are virtually inter-incompatible as far as their vicinity does not harm the quality. The effect of a sour cherry polliniser is not valid beyond the distance of 8 to 10 m (*Soltész*, 1996). Suggestions concerning the reasonable combination of sour cherry varieties are presented in *Table 2*.

Plum

Self-incompatible plum varieties should be associated with adequate pollinisers according to their blooming time *(Table 3)*. For most self-sterile European plums there are generally good pollinisers the following varieties: *Bluefree, Čačanska lepotica, Čačanska najbolja, Čačanska rodna* and *Stanley*. For early blooming varieties *President* whereas for the late blooming ones *Besztercei* and *Stanley* are recommended as pollinisers.

Male sterile varieties should be associated with highly self-fertile and regularly yielding varieties. For *Centenar* we recommend *Čačanska rodna*, for *Pescarus* and *Tuleu gras*, in turn, *Čačanska rodna* and *Besztercei*.

Self-incompatible varieties could be associated with each other as far as their blooming time is coincident at 70%, at least, but a mixed planting of 3 or 4 self-incompatible varieties still may increase the security of yield.

Varieties with inherent low fertility (*Bluefree, Čačanska lepotica, Stanley*) should not be planted in larger blocks than

Table 2 Associations suggested for the sour cherry varieties improved and grown in Hungary

Relative order of harvest times of the varieties*	Groups of earliness	Varieties	Groups of blooming time	Character of fertility	Pollinisers suggested (as self-fertile varieties)
1	Early	Meteor korai	medium early	self-fertile	
2		Csengődi	medium early	self-fertile	
3	Medium	Érdi nagygyümölcs	medium early	self-sterile-----	--------4, 11
4	early	Favorit	medium early	self-fertile	
5		Korai pipacsmeggy	medium early	self-fertile	
6	Medium late	Érdi jubileum	medium late	self-fertile	
7		Cigánymeggy	medium late	self-fertile	
8		Érdi bőtermő	early	self-fertile	
9		Maliga emléke	early	self-fertile	
10		Pándy 48	early	self-sterile-----	--------2, 4, 11
11		Cigánymeggy C404	medium early	self-sterile	
12	Late	Cigánymeggy 59	medium late	self-fertile	
13		Pándy C80	medium late	self-sterile------	----------7, 12
14		Pándy 279	medium late	self-sterile------	----------7, 12
15	Very late	Debreceni bőtermő	late	self-fertile	
16		Kántorjánosi 3	late	self-fertile	
17		Újfehértói fürtös	late	self-fertile	

* Remark: the numbers in column 1 identify the variety in column 6

20 to 40 m in diameter. The self-fertile varieties with very high and regular fruit set are preferably planted into pure stands as the heavy fruit load as a consequence of "oversetting" by cross pollination may lower the fruit size, i.e. quality.

Table 3 European plum varieties and their recommended pollinisers

Variety to be pollinated	Original observations as on good pollinisers	Recommended in the literature as polliniser
Self-sterile varieties		
Altanova ringlota	Čačanska najbolja, Čačanska rodna	Ageni, Besztercei szilva, Stanley
Čačanska najbolja	Bluefre, Čačanska lepotica, Čačanska rodna	Ruth Gerstädter, Stanley
Centenar	Bluefre, Čačanska lepotica, Stanley	Althanova ringlota, Ruth Gerstädter, Silvia, Stanley
Debreceni muskotály		Ageni, President
Pescarus		Stanley
President	Bluefre, Čačanska lepotica, Čačanska najbolja, Čačanska rodna	Althanova ringlota, Bluefre, Debreceni muskotály,Ruth Gerstädter, Stanley
Ruth Gerstädter		Ageni, Althanova ringlota, President, Silvia, Stanley
Silvia	Čačanska lepotica, President	Althanova ringlota, Bluefre, Stanley
Tuleu gras		Ageni, Althanova ringlota, Bluefre, President, Ruth Gerstädter, Stanley
Partially self-fertile varieties		
Bluefre	Besztercei szilva, President, Stanley	President, Ruth Gerstädter, Stanley
Čačanska lepotica		Čačanska najbolja, Čačanska rana
Stanley	Besztercei szilva, Bluefre	Bluefre, President, Ruth Gerstädter

Male sterile and self sterile trees should be provided with pollinisers within a distance of 10 to 15 m. According to our observations, yield reduction on the trees is evident in the second row away from the nearest polliniser trees. At the same time, low fruit set (1 to 2%) was observed in a 12-row block of *Čačanska najbolja* even in the marginal rows close to the pollinisers. That case was interpreted to be caused by the lack of insects as potential pollen vectors.

Apricot

The self- and inter-incompatibility of the "óriás" (giant) type apricot varieties (*Ceglédi óriás, Ligeti óriás, Nagykőrösi óriás, Szegedi mamut*) 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 varieties grown in Hungary.

Recommended association of apricot varieties for plantations in Hungary are summarised in *Table 4*. Hence the principles of variety association in apricot plantations are summarised as follows:

Self-fertile varieties should be planted preferably in monovarietal blocks because an efficient polliniser would stimulate 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 realised 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-

Table 4 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

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 of ***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 blooming 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 utilisation 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 utilisation is conditioned by the alternative use of hand picking or mechanised picking (shaking) techniques. Plantations suitable for only one type of utilisation 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 trees of the same variety which means that mutually polliniser varieties should be planned in alternate blocks of 3 rows at most. The growing distance from the polliniser will impair the fertilisation of the self-sterile variety in larger (monovarietal) blocks than that. Self-fertile varietes 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-incompatible or self-fertile) variety should be thinned if necessary.

In the decision of choosing varieties for combined planting, after having considered the time of harvest, the technique of picking, and the conditions of self- and cross-fertilisation, 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 flower 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 polliniser and self-incompatible trees are to be adjusted accordingly in favour of an optimal distribution of bees, or more bee hives, i.e. the affluence of bees will counteract the handicaps of poor attractivness 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) as well as by *Szabó & Nyéki* (1999).

Peach

Peach cultivars commercially grown and registered in Hungary are highly productive and yield regularly in

monovarietial blocks. It was claimed that mixed plantation of varieties may aggravate the grower's trouble caused by thinning of fruit set abundantly, otherwise the size of fruits would be diminished, drastically (*Maliga*, 1961).

Self-sterile and male-sterile peach varieties (e.g. *J.H.Hale*) are not kept any more on the list of recommended and commercially multiplied varieties in Hungary. Different practices are followed in some of the other countries, e.g. in the Crimean area male-sterile peaches are still grown, as *Laureat* and *Uspeh*.

In plantations of self-sterile and male-sterile varieties, association of more, i.e. 2 or 3 normal, polliniser varieties are recommended to be placed in each 3rd to 6th row (*Ryabov & Kancerova*, 1970).

Another form of association of varieties is, when self-sterile varieties are planted in two rows, only, and self-fertile ones, subsequently, in solid blocks as pollinisers.

Nyéki et al. (1998) forwarded the idea that on the northern border of peach cultivation, also the self-fertile varieties need to be cross pollinated by other varieties. After cool periods during winter and spring, moreover, low flower densities suggest that all possible means are to be applied to improve fruit set. In other words, blocks of self-fertile varieties should favour allogamy at a distance less than 40 metres between different varieties. For male-sterile varieties less than 15 to 20 metres from potential pollen producers

Discussion

Many self-incompatible and partially self-fertile varieties are grown in the practice. Their yield is dependent on the presence of adequate polliniser varieties.

At the selection of pollinisers some criteria should be observed as suggested by *Soltész* (1996). The overlap of blooming periods of the respective varieties, i.e. main variety and its pollinisers, should be 70 % at least. The rate of overlap in blooming and the rate recommended for the polliniser trees are inversely correlated. A perfect (100%) overlap may justify a rate of association as 10:1, whereas the less overlap should-be compensated by a higher rate of polliniser trees to be associated or more than one variety should be applied as polliniser.

The use of two pollinisers is encouraged by choosing one with earlier (1 or 2 days) and the other with later blooming date. Thus a continuous availability of compatible pollen will be secured.

Cross pollination increases fruit set even in self-fertile varieties, but the inflence of different pollinisers could not be distinguished (*Mahanoglu* et al., 1995). At reliable growing conditions, however, some limitations of fruit set, or in other words, prevention of "oversetting" may be preferred for self-fertile varieties, thus monovarietal blocks are suggested in large plantations too. On the contrary, poor growing conditions and the risk of adverse weather justify the combination of self-fertile varieties too.

Based on data of the literature, our own experiences on the most important parameters to be considered in plantations of stone fruit species are summarised in *Table 5*. The overlap (coincidence) of blooming periods and the distance of the pollen source are decisive components of conditions necessary for fruit set.

Table 5 The minimal requirements of safe pollination in coincidence of blooming and distance to the pollen source to be observed in planning of stone fruit plantations

Fruit species	Inter-fertility relations of thevariety to be pollinated*	Minimal rate of coincident blooming time (%)	Maximal distance to the pollen sources (m)
Sweet cherry	A	70	6–8
	B–2	40	12–16
Sour cherry	A	70	6–8
	B–2	40	20–30
Plum	A	70	15–20
	B–1	40	30–40
	B–2	40	20–30
Apricot	A	70	20–25
	B–1	40	30–40
Peach	A	70	20–25
	B–1	40	30–40

Comments: A = Self-incompatible, i.e. polliniser is absolutely necessary
B-1 = Self-fertile variety yielding large fruit. At favourable conditions thinning is necessary, subsequently, "oversetting" risked by allogamy is undesirable.
B-2 = Self-fertile variety yielding small fruit. Allogamy may cause further reduction of fruit size endangering quality.

As a third component, the ratio of polliniser trees and those to be pollinated interacts with the former two components. Perfect (100%) coincidence allows a ratio of 1/8 to 1/20, whereas 50–60% coincidence may require even equal ratios (1/1) for securing a safe fertility.

Intense orchards with narrow distances between and within rows at the same time need as well as facilitate further reduction of distances to be covered by the insects as pollen vectors.

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