General principles in variety-association for intensive plantations of pomeceous fruits

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INTERNATIONAL JOURNAL OF HORTICULTURAL SCIENCE

AGROINFORM Publishing House, Hungary

Key words: self fertilisation, pollination, association of varieties

Summary: Under conditions of Hungary, more than 400 varieties of apple, pear and quince varieties have been observed for time of blooming and fertility relations in order to check the possibility of their use for intense plantations in different combinations with polliniser varieties. Low (below 3%) rate of self-fertility occurred at 65% of apple varieties. That partial self-fertility, however, is far from being sufficient to produce acceptable yield, thus allogamous pollination is absolutely necessary. The same is true for the rear and quince varieties grown in Hungary, too. The normal development requires the presence of viable seeds in the fruit set, most in quince, therefore, association of the right varieties is most important in that species. Apple and pear varieties are assigned according to their blooming time to 4, quince varieties to 3 groups. The yield of all three pomaceous species declines with the growing distance from the potential pollen source. In the intense plantations, the critical (maximum) distance to be observed is 20 m for apple and 15 m for pear and quince. In combining the placement of varieties, also the principles of a variety-specific cultivation are to be considered carefully. The double objectives are stisfied most by the system of Malus-pollinisers developed for intense plantations.

Introduction

According to Afify (1933) the total auto-sterility is very rare in apple and pear. *Kobel* (1954) considered all apple cultivars to be auto-sterile. *Modlibowska* (1945), *Vondracek* (1962) and *Knight* (1963) stated that triploid apple varieties tend to be self-fertile. A survey of the relevant literature by *Soltész* (1996) proves the extensive seasonal variation of the time of blooming at the same site. *Shitt* et al. (1940) were the first in having presented data about the effect of combining apple cultivars. The effectiveness of the pollination and the variety-specific technology combines well with the use of *Malus* pollinisers as being first introduced by *Williams* (1966).

Great many widespread and local pear cultivars investigated under experimental conditions and compared to each other in a collection of varieties. Their ecological demands, flowering dates and inter-incompatibility were explored. Results were published in previous papers (*Nyéki,* 1973, 1976, *Nyéki & Soltész,* 1996). The flowering time of quince is relatively late, thus late frosts do not but rarely harm at blooming. According to the notes of *Brózik* (1980), the start of blooming in 23 cultivars and mutants of quince varied within the period of 1961 and 1966 between April 20 and May 18. In an attempt to find appropriate pollinisers for given cultivars, very little information has been found.

Materials and methods

Observations of parthenocarpy, floral phenology and inter-fertility of apple cultivars were made on self- and cross-pollinations between 1973 and 1991 on the variety-testing station at Helvécia , and between 1990-1999 at the College Faculty of Horticulture, Kecskemét. There were 325 cultivars involved. The observations were made by the methods described by *Herbst & Rudloff* (1939) and *Rudloff* et al, 1950). According to *Chittenden* (1911), the relative blooming time was related to the *Red Astrachan* cultivar.

The effect of variety and location on fruit set and yield was measured in 20 apple and 6 pear plantations altogether, between 1970 and 1990. The effect of the distance between the pollen source (polliniser variety) and the target cultivar (to be pollinated) was examined in relation to fruit quality and yield in 6 growing sites.

Observations of parthenocarpy, inter-fertility, blooming time and combination of varieties with 70 pear cultivars were performed between 1968-1994 at Érd-Elvira and Kecskemét. The methods are described by *Herbst* et al. (1936). The results are evaluated with the objective of selecting optimal combinations of main and polliniser varieties which will be valid for major regions of the country.

In 1997 and 1999 eight quince cultivars were observed as for blooming time and fertility relations.

The time of bloom ha been determined by estimation of

- Start of blooming means first flowers open
- Main bloom, when the most flowers are open at once
- End of blooming, when all flowers shed petals.

In order to test the effect of autogamy, flowers were isolated by pergamin bag up to the end of blooming, then set free. For manual cross pollination flower buds have been emasculated carefully. Fruit set was registered by counting the fruits set and ripened.

Results and conclusions

The frequency of autogamous sets was low (below 3%) but occurred in 65% of apple cultivars studied. On te average, 0.9% fruit set was due to natural self pollination, whereas 1.9% fruit set resulted by geitonogamy (when pollen of the same variety but taken from another flower was transferred to the stigma). During the relevant period there was not a single cultivar which displayed any considerable self-fertility. Natural autogamy gave 0.9% set in diploid but 1.6% in triploid cultivars. Parthenocarpa was virtually absent. As a mean over all cultivars 0.2% was the frequency of fruits without seeds (i.e. parthenocarpic). No seedless fruit at all has been found in the 78% of cultivars.

The apple cultivars were listed into 4 booming-time groups. The appropriate pollinisers were established according to results of controlled cross-pollinations considering also the coincidence of blooming times *(Table 1)*. Only cultivars belonging to the same blooming-time group, or taking into account the phenomenon of protogyny, potential pollinisers blooming earlier have been tested.

The maximum distance to the pollen source still securing sufficient fruit set was estimated to be 25 m for apple. The critical distance decreases, however, in intensive

Table 1 Characteristic figures of the different production systems in the Hungarian fruit industry of apples

Serial number	Cultivars to be pollinated		Suggested pollen donor varieties	
	their names	blooming group*	from the same blooming group	from a neighbouring, earlier blooming group
A. The international cultivars widely grown in Hungary too				
1.	Charden tri	D	27,33	17,20
2.	Close tri	B	7,8,35	19
3.	Champion	C	11,20	7,8,15
4.	Gloster	C	11,25,30	8,22,28
5.	Golden Delicious	C	4,11,18,20,25	7,8,28
6.	Granny Smith	C	5,11,17,18,20,25	
7.	Idared	B	8,9,12,32,35,38	19,21,37
8.	James Grieve	B	7,9,24,32,34,40	19,21,37
9.	Jerseymac	B	7,8,22	21 parthenocarpy
10.	Jonagold tri	C	3,4,5,11,17,18,24,25	7,8,12,22,24,8,32
11.	Jonathan	C	4,18,20,25,30	7,8,23,32
12.	Julyred	B	7,8,22,28,32	21
13.	Mutsu tri	C	4,6,11,20,25,41	7,8,24,38,40
14.	Ozark Gold	D	16,27	6
15.	Prima	B	7,22,40	
16.	Red Rome	D	14,27,33	5,11
17.	Redspur	C	5,6,11,18	7,12,28
18.	Spartan	C	11,20,25,30	7,8,9,12,28
19.	Stark Earliest	A	3,21,37	
20.	Starking	C	5,6,11,18	7,12,28
21.	Summerred	A	37	
22.	Vista Bella	B	7,8,9,12,24,40	21,37
B. The cultivars wide spread abroad and less spread in Hungary				
23.	Akane	C	6,18	7,8,9,37
24.	Alkmene	B	7,8,9,22,32	21
25.	Cox'Orange Pippin	C	4,5,11,18,30	7,8,22,24,32
26.	Delbarestivale	B	7,9	21
27.	Elstar	D	33	4,18,30
28.	Empire	B	7,12,32	
29.	Florina	C		7,15
30.	Gala	C	4,5,11,18,25	7,8
31.	Karmijn de Sonnaville tri	C	4,18,30	7,8,22,24
32.	McIntosh	B	7,8,12,28	19,40
33.	Melrose	D 27	4,5,30	
C. Hungarian cultivars				
34.	Batul	B	7,8,35,38	19,37
35.	Ceglédi piros	B	7,8,9	
36.	Egri piros	C	11,17,18	35,7
37.	Éva	A	19,42	
38.	Fertődi téli	B	7,8,9,12,22,34,35,40	
39.	Husvéti rozmaring	C	6,11	7,8,22
40.	Jonager	B	7,8,9,12,22	19,21
41.	Kovelit	C	3,5,6	7,8
42.	Nyári fontos	A	19,21,37	
43.	Staymared	C	4,6,11,17. 18	7,8,9

A=early
B=medium-early
C=medium-late
D=late

Table 2 Flowering periods of pear cultivars registered in Hungary

Blooming period of cultivars			
Early	Medium early	Medium late	Late
Bella di Giugno Arabitka G* Árpával érő	Aromata de Bistriţa Beurré Giffard Bonne Louise d'Avranches Butirra precoce Morettini Devoe Doyenné d'Hiver Madame Favre Passe Crassane, Bohusné vajkörte* Búzás körte *	Bergamotte d'Esperen Beurré d'Hardenpont Conference Flemish Beauty Général Leclerc Jules Guyot dr Packham's Triumph Olivier de Serres Bartlett (Williams) Kornélia*	Beurré Bosc Beurré Durondeau Clapp's Favourite Napoca Ilonka*

* Hungarian cultivar

Table 3 Favourable combinations of main and polliniser cultivars of pear at Western Hungary with 700-850 mm mean precipitation a year

Main cultivar	Polliniser cultivars	
	of completely coinciding blooming period	of partly coinciding earlier blooming period
Bergamotte d'Esperen	Hardenpont, Général Leclerc, Conference, Bartlett (Williams)	Aromata de Bistriţa, Madame Favre
Beurré d'Hardenpont	Bergamotte dEsperen, Conference, Général Leclerc, Bartlett (Williams)	Devoe
Beurré Durondeau	Beurré Bosc, Clapp's Favourite	Conference, Général Leclerc, Hardenpont, Bartlett (Williams)
Bonne Louise	Aromata de Bistriţa Doyenné d'Hiver	Bella di Giugno
Conference	Général Leclerc, Bartlett (Williams), Hardenpont, Jules Guyot dr	Butirra precoce Morettini, Passe Crassane
Doyenné d'Hiver	Aromata de Bistrita, Bonne Louise d'Avranches, Passe Crassane	Butirra precoce Morettini, Passe Crassane
Général Leclerc	Hardenpont, Conference, Jules Guyot dr, Bartlett (Williams)	Passe Crassane
Olivier de Serres	Général Leclerc, Bartlett (Williams), Hardenpont, Packham's Triumph	Doyenné d'Hiver, Passe Crassane
Passe Crassane	Doyenné d'Hiver, Bonne Louise d'Avranches, Aromata de Bistrita	Bella di Giugno

Table 4 Favourable combinations of main and polliniser varieties of pear at lowland areas in Hungary with some 550-700 mm mean precipitation a year

Main cultivar	Polliniser cultivars	
	of completely coinciding blooming period	of partly coinciding earlier blooming period
Aromata de Bistriţa	Devoe, Beurré Giffard	Bella di Giugno
Bella di Giugno	Arabitka G	
Beurré Bosc	Clapp's Favourite, Napoca	Bartlett (Williams), Jules Guyot dr
Beurré Giffard	Aromata de Bistriţa, Devoe, Butirra precoce Morettini	Bella di Giugno
Bohusné vajkörtéje	Beurré Giffard	
Butirra precoce	Morettini Beurré Giffard, Devoe	Bella di Giugno
Clapps's Favourite	Beurré Bosc, Napoca	Bartlett (Williams), Jules Guyot dr
Devoe	Aromata de Bistrita, Butirra precoce Morettini	Bella di Giugno
Flemish Beauty	Jules Guyot dr	Aromata de Bistriţa
Ilonka	Clapp's Favourite, Beurré Bosc, Napoca	Packham's Triumph
Jules Guyot dr	Bartlett (Williams), Kornélia	Devoe, Aromata de Bistriţa
Kornélia	Packham's Triumph, Barlett (Williams)	Aromata de Bistriţa
Madame Favre	Beurré Giffard, Butirra precoce Morettini	
Napoca	Beurré Bosc, Clapp's Favourite	Jules Guyot dr
Paskham's Triumph	Bartlett (Williams), Jules Guyot dr	
Bartlett (Williams)	Jules Guyot dr, Packham's Triumph	Butirra precoce Morettini

Table 5 Flower formation, flower morphology and flowering

Malus domestica	Pyrus communis
Majority of varieties bear many flowers in the buds of long shoots too.	Flowers are (mainly laterally)rarely produced on long shoots too
Blooming is later.	Blooming is earlier.
Blooming period is more prolonged.	Blooming is less prolonged.
The sequence of the relative blooming time of varieties is stable.	The sequence of the relative blooming time of varieties is less stable.
The blooming period of an inflorescence is short.	The blooming period of an inflorescence is very variable depending on variety
Secondary blooming is rare.	Secondary blooming occurs more frequently
Within the inflorescence blooming sequence of the flowers is centrifugal exclusively (cyme type inflorescence)	Blooming sequence within the inflorescence is mainly centripetal but forms of centrifugal and transitional sequence is also found.

Table 6 Fertilisation and fruit set in apple an in pear

Malus domestica	Pyrus communis
Natural and induced parthenocarpy are not found as a rule	Natural and induced parthenocarpy are decisive characters in some cultivars.
The prolonged blooming period has consequences in the phenology of fruit development: fruit set, summer fall, thinning and ripening process.	There is no consequence of that type.
Seed content of the fruit makes little difference in the form of the fruit.	Seeds have visible effect on the form and size of the fruit.
The frost damage does not threat the flowers and fruitlets.	Flowers and fruits are more exposed to be damaged by frost.

Table 7 Insect pollination in apple and pear

Malus domestica	Pyrus communis
Much and sweet nectar is produced in lowers	Less and more diluted nectar is produced in the flowers
Large varietal differences exist between the quantity and concentration of nectar.	Small differences exist between varieties in nectar production.
Flowers are more attractive to honeybees.	Flowers are less attractive to honeybees
The accessibility of nectar in the flowers varies largely according to the variety.	Nectar is easily available, varieties do not differ much although that has little relevance.
Honeybees gather actively nectar and pollen with equal greed.	Honeybees collect pollen, prevalently.
Flowers are visited by honeybees throughout the blooming season.	Flowers are visited mainly during the bursting of anthers
There are chances of repeated pollination on the same flower.	Chances of repeated pollination of the same flower are small.
Timing of bee activity is less critical.	Timing of insect visits is important because the period of receptivity is limited.
There is large difference between varieties in the colour and structure of flowers, which is recognised in insect activity and pollination,	There is similar distance between anthers in different varieties, but this is irrelevant from the point of view of bee activity.
Less bee hives per hectare are needed as located on the seam of the orchard	More bee hives per hectare are needed and located within the blocks of the orchard

Table 8 Association of varieties in plantations of apple and pear

Malus domestica	Pyrus communis
There are several current triploid varieties.	Triploid varieties are few at present.
A coincidence of blooming of 50-60 % is sufficient.	Most of the cultivars to be pollinated need an overlap of blooming period of 60–70 %.
Some of the diploid varieties produce little amount and partially sterile pollen.	There was no essential difference revealed in pollen production of diploid varieties
Triploid varieties may be planted in traditional orchards at a low rate, because they attract excessively the honey bees.	Triploid varieties accepted int he orchard at a low rate, because they are less attractive to honey bees.
To provide pollen, pollinisers belonging to neighbouring blooming-time groups are acceptable in the plantation.	Association of varieties should be restricted to members of the same blooming-time group and possibly more than two.
The difference of ecological adaptation between varieties is not large, they are minor criteria in planning of association.	Larger differences in ecological requirements are limiting elements of association in orchards.
The maximum distance of diploid cultivars to the polliniser is 20 metres in the orchard.	The maximum distance of diploid cultivars to the polliniser is 15 metres in the orchard.

Table 9 Varietal characters as for the association of quince varieties in plantations

Variety	Time of ripening	Flowering time group pollination	Self fertility	Fertility at open	Polliniser varieties recommended
Angersi ♀	mid - end Sept.	intermediate	not clear	intermediate	Bereczki bőtermő, Champion, Konstantinápolyi, Mezőtúri
Bereczki	end of Sept.	intermediate	not clear	poor	Angersi, Champion, Konstantinapolyi, Vranja
Bereczki bőtermő	end of Sept.	intermediate	not clear	high	Angersi, Champion, Konstantinapolyi, Mezőtúri
Champion	end of Sept.	intermediate	not clear	intermediate	Angersi, Bereczki, Konstantinapolyi., Mezőtúri Vranja
Konstantinápolyi	first part of Oct.	late	not clear	intermediate	Angersi, Bereczki, Bereczki bőtermő Champion, Mezőtúri
Leskovacka		late	not clear	high	Vranja
Mezőtúri	first part of Oct.	early	not clear	high	Angersi, Bereczki, Champion, Konstantinápolyi
Vranja		intermediate	not clear	intermediate	Leskovacka

production systems. In the case of trees trained to slender spindle, the distance should not be more than 15 to 20 m. Triploid cultivars cannot be planted at a ratio more than 20% and in a block wider than 10 m. The production of nectar in flowers of triploid cultivars is more abundant by 50–60% than of diploids thus preferred by the pollinating insects. A higher ratio of triploids in an orchard – especially at low bee densities – may endanger effective cross pollination.

The more variable the varietal composition of a plantation regarding mutually cross pollinating cultivars – varying row by row or even within one row – the safer the pollen provision. One of the possible solutions of the dilemma is - giving allowance to variety-specific technologies too – the use of *Malus* pollinisers. The ratio of them may attain a maximum of 5–10%.

Based on the results cited above on the detailed studies on the variety collections in the past decades, the blooming periods of pear cultivars are classified also into 4 groups: early, medium early, medium late and late *(Table 2).*

The coupling of pear cultivars depends first of all on their inter-compatibility. Results published by great many authors are dealing with almost all important internationally known cultivars. In accord with the relevant literature, groups of cultivars to be associated are composed as recommended for the major ecological regions of Hungary *(Table 3–4).* Varieties of the late group should be avoided if their coincidence of blooming was not perfect because the lack of proterandry in this case. Hungarian experiences show that two or at most three cultivars should be interplanted in pear orchard as far as blooming of the main cultivar and that of the polliniser(s) is coincident, but the number of inter-planted cultivars must not be less than 4 when the coincidence is partial only.

The results of our own research on the species of apple and pear (*Malus domestica* and *Pyrus communis*) are summarised in *Table 5–8.* The two species are compared from different point of view (flower differentiation, morphology, blooming, fertilisation, fruit set, pollination, association, etc.) and general conclusions may help in making decisions.

In the planning of quince plantations, it is an advisable rule to consider all quince cultivars offered in Hungary as self-incompatible. A mutual overlap in the main bloom periods of the associated cultivars should be observed as a condition of adequate fruit set. The varietal properties to be considered in the association of the cultivars are explored by *Szabó* et al. (1999), moreover, a short summary is given in *Table 9.*

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