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Floral biology of tree fruit rootstocks

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Summary: The modern nursery industry requires seed sources of a high quality and regular quantity year by year. Besides the seed sources of processed cultivars (Bartlett pear, Shipley, Elberta peach) special seed orchards are planted with selected seed trees producing high quality and genetically determined seed (hybrid seed or inbred lines). Seedlings are still the most common commercial source of rootstocks for stone fruits (almond, apricot, peach, plum, prune and walnut). Although clonal rootstocks are spreading, usage of seedlings is still predominant at stone fruits and nuts. For successful seed production and planning of seed orchard the knowledge on floral biology, flower fertility, pollination, blossom time of trees (selected clone or cultivars) used for seed production is essential. In this field very little systematic research was carried out most of the papers were published in the second half of the 20th century.Our mini review gives an overview on the importance of flower fertility in the mating systems applied in seed orchards, and the research results on floral biology of fruit tree rootstocks propagated by seed (*Prunus avium, Prunus mahaleb, Prunus armeniaca, Prunus cerasifera, Prunus insititia, Prunus amygdalus, P. persica, P. amygdalopersica, Pyrus pyraster, Pyrus communis and Pyrus betulifolia*) over the last decades

Key words: fertility, flowering time, fruit set, pollination

Introduction

Seedlings are used as rootstocks for propagation of fruit trees in 50 to 100 percent of fruit trees, depending on species and sites. Although clonal rootstocks are spreading, usage of seedlings is still predominant at stone fruits and nuts. The production of fruit trees by budding or grafting requires the appropriate rootstock plant, thus propagation and production of rootstock liners is an essential part of tree fruit propagation. The use of rootstocks overcomes the common deficiency of scion cultivars of fruit trees, namely the low rooting capacity, which usually was and still is not an important character for breeders in fruit tree cultivar selection.

Historically, the most commonly used rootstock was the seedling of the propagated fruit species, which is still widely used in fruit growing. Seedlings are still the most common commercial source of rootstocks for stone fruits (almond, apricot, peach, plum, prune and walnut). In the modern intensive orchard, where tree size control, precocity and tree uniformity is required, clonal rootstocks are produced and used. The rootstock research and development activity focuses worldwide to produce clonal rootstocks in a wide range of growth vigour for each species. For those species where seedlings fulfil the grower's requirements, the tree uniformity and seedling's characteristics can be improved by seed tree selection. The modern nursery industry requires seed sources of a high quality and regular quantity year by year. Besides the seed sources of processed cultivars (Bartlett pear, Shipley, Elberta peach) special seed orchards are planted with selected seed trees producing high quality and genetically determined seed (hybrid seed or inbred lines).

For successful seed production and planning of seed orchard the knowledge on floral biology, flower fertility, pollination, blossom time of trees (selected clone or cultivars) used for seed production is essential. In this field very few systematic research was carried out most of the papers were published in the second half of the 20th century (*Maurer*, 1939; *Sebőkné*, 1970; *Hrotkó*, 1984; *Erdős*, 1984; *Nyujtó*, 1987; *Hrotkó*, 1999)

Importance of flower fertility in seed orchard planning and planting

In practice for seed production cultivars producing well germinating seeds or selected clone from wild species are planted. In Central- and East-Europe it is typical to plant selected clone from vineyard-seedlings, which are actually sub-spontaneous seedlings of cultivated genotypes of peach, apricot, etc. (*Hrotkó*, 1999).

By flower fertility the seed producing genotypes of fruit species could be classified into three groups (*Table 1*). Self sterility occurs due to pollen incompatibility or pollen sterility. Most of the seed producing genotypes are not self sterile, but for an appropriate fruit set and seed germination need foreign pollinator. Self fertility occurs also but the seed quality and the progeny characteristics should be considered. The flower fertility of these genotypes determines the mating options of genotypes within the orchard and accordingly the genetic composition of the seedling progeny.

Since the flowers in majority of seed producing genotypes are self sterile or in practice for successful seed production need cross pollination, the seedling progeny is

Table 1 Possible flower fertility forms of known rootstock genotypes in different fruit species
(*Sebőkné*, 1968, 1970, *Nyéki*, 1980, *Hrotkó*, 1984, 1986, *Erdős*, 1984)

Species	Self-sterile, needs pollinator	Low self-fertility, for appropriate fruit set and seed germination pollinator is needed	High self-fertility
Malus pumila		X	
Malus silvestris		X	
Malus prunifolia		X	
Malus baccata		X	
Pyrus communis		X	
Pyrus pyraster		X	
Prunus avium	X		
Prunus cerasus	X	X	X
Prunus mahaleb	X	X	X
Prunus cerasifera	X		
Prunus domestica	X	X	X
Prunus insititia	X	X	X
Persica vulgaris		X	X
Armeniaca vulgaris		X	X
Amygdalus comunis	X		

hybrid with all attribute of hybrid vigour and homogeneity in phenotype of F1 population. Such F1 population is produced for rootstock usage e.g. at *Prunus avium* L.(Mönch) (Hüttners-Hochzucht 170x53, Pontavium, Pontaris etc.), *Prunus insititia* St. Julien Hybride Nr. 1 (St. Juliend d'Orleans x Brompton, Nr 2 (St. Julien d'Orlenas x Common Mussel) planted with two clones (*Küppers*, 1964, *Küppers*, 1978, *Gautier*, 1972, *Claverie*, 1996). This hybrid mating system can be created in orchards, where the pollinator represents only 10%, but the overlapping of blossom time is close to 100 %. As an example for *Prunus avium* Hüttners-Hochzucht : the clone Nr. 170 is the seed producer, planted in 90% in the orchard, while the pollinator clone Nr. 53 only 10% (*Küppers*, 1964). Fruits and seeds of pollinator are not harvested at all. When both clone produce high quality seeds and seedlings the ratio of the clone in the seed orchard can be 50–50% (e.g. Pontaris and Pontavium) (*Claverie*, 1996).

Most of seed orchards with cross pollination consist of three to five clones, pollinating well each other (*Funk*, 1969, *Nyujtó*, 1987). This type of hybrid mating system uses the advantages of clone-group pollination system (*Brózik & Nyéki*, 1975): the competition between the germinating pollen grains in the stigma improves the conditions to the fertilization resulting in a higher seed germination capacity too. At crab apple *Popov* (1956, 1962), *Perehodkin* (1962a,b) and *Fetisow & Perehodkin* (1962) reported higher fruit set and larger number of seeds using pollination with mixed pollen. *Baranova* (1965) found larger vigour also in apple and pear seedling progeny produced by mixed pollination. On the other hand in such an orchard a safer overlapping of blossom time of mated clone can be provided. If the fruits and seeds are harvested separated from the different seed producing clone or cultivars, the progeny represents a hybrid family, where the seedlings of different mating combinations (AxB + AxC + AxD etc.) are mixed.

At apple and pear pollinators influence the seed shape, size, weight and the germination capacity (*Popov*, 1956, 1962; *Perehodkin*, 1962a,b). *Sebőkné* (1970) reported smaller seed size as effect of self pollination at *Prunus mahaleb*, although these phenomena could not bee confirmed by *Hrotkó* (1984, 1985). At crab apple and pear the pollinator close related to the seed producing cultivar or the self pollination reduced the germination capacity of seeds (*Popov*, 1956, 1962; *Perehodkin*, 1962a, 1962b).

Since the pollinator may influence the seed (xenia) and seedling characteristics in the phenotype of the progenies from different mating combinations (*Popov*, 1956, 1962, *Perehodkin*, 1962a, 1962b), it is essential to provide the same chance within the orchard for fertilization to each pollinator. Appropriate ordering and tree position within the orchard as well as the considering of blossom time are important tools in this issue.

Contradicting to the rules of genetics it was a common opinion over decades that the seedlings of self fertile genotypes have the advantage to produce homogeneous seedling progeny (*Küppers*, 1978). This can be true only when the required characteristics are by one gene determined and the locus in the seed tree genom is homozygotic. This situation is rather rare in native populations considering the fact that many important growth characteristics are polygenic determined, but the inbreeding may increase the frequency of

Table 2 Mating systems of seed orchards of tree fruit rootstocks

Pollination	Self-fertile, (autogamy + geitonogamy)	Hybrid ; two clone; (allogamy + low percentage autogamy and geitonogamy)	Hybrid; clone-group pollination (allogamy + low percenttage autogamy and geitonogamy)
Mating system	A x A	A x B	A x B x C x D
Pollinators in orchard (%)	–	10-20	66-75-80 (depending on number of clone, 3–5)
Theoretical genetic composition of progeny	A x A	A x B or B x A + few A x A	When four clones are planted: a) AxB + AxC + AxD + AxA b) BxA + BxC + BxD + BxB c) CxA + CxB + CxD + CxC d) DxA + DxB + DxC + DxD

such genotypes. As an example can be mentioned the red-leaf peach seed trees, like 'Rubira', 'Hygama' (*Grassely*, 1985). *Claverie* (1996), *Hrotkó* (1996, 2004), and *Hrotkó & Magyar* (1997) reported on improved uniformity as a result of inbreeding in the seedling progeny of self fertile genotypes. Nevertheless, self fertile genotypes as seed tree may produce diversity in seedlings' characters, segregation in the population (*Hrotkó & Magyar*, 1997; *Hrotkó*, 2004), which is more or less tolerable among the seedlings used for rootstocks. The seedbed practice also may contribute to the seedling uniformity; lethal or low vigour seedlings will be sorted out due to the competition in the seedbed or during sorting by calliper of the seedlings after lifting. Seedlings of self fertile genotype of *Prunus mahaleb* Heimann X was known as uniform progeny (*Heimann*, 1932; *Küppers*, 1978). In contrary, *Hrotkó* (2004) reported on genetic dwarf seedlings in the progeny produced in pots from germinated seeds, which in a seedbed population might have always been eliminated or sorted out.

Studies on flower fertility and blossom time of rootstock genotypes

Prunus avium and Prunus mahaleb

First data on flower fertility of mahaleb cherry are published in botanical papers (*Joley*, 1943). Systematic investigations were carried out in Berlin-Dahlem on the genotypes collected by Heimann, the self-fertility of clone Heimann-X was recognized here (*Maurer*, 1939).

Table 3 Self fertile *Prunus mahaleb* genotypes known in seed production

Name	Fruit set (%)	Author
Heimann X	20-25	*Heimann*, 1932, *Maurer*, 1939, *Küppers*, 1978
Korponay	25	*Sebőkné*, 1968, 1970, *Hrotkó*, 1986
SL 405	–	*Claverie*, 1996

Native *Prunus mahaleb* genotypes are usually self-sterile (*Zylka*, 1971) as well as clone selected for seed production. *Joley* (1943) investigated the flower fertility of genotypes from Germany, France and Dalmatia. Only two genotypes showed low (4–5%) percentage of self fertility. *Funk* (1969) remarked that only 5% of the genotypes showed some self fertility. Sarger's data (*Sarger*, 1972) also confirm the rarity of self fertility at *Prunus mahaleb* (4 self fertile from 106 genotypes). Self fertile genotypes known from seed production are listed in *Table 3*. *Hrotkó & Végvári* (1988) reported on selection of self fertile genotypes from among the I_1 progeny of Korponay.

Within the species *Prunus mahaleb* genotypes pollinate each other well; average fruit set is around 20-30% (*Joley*, 1943, *Funk*, 1969, *Sebőkné*, 1970). *Hrotkó* (1984, 1986) and *Erdős* (1984) reported around 30% fruit set at all tested genotypes in free pollination, while in average of four years 21.5 % for Heimann X and 26.8% fruit set for Korponay after self pollination in isolated bags was achieved.

In contrary to *Erdős* (1984) data of *Hrotkó* (1986) (*Table 6*) showed that the fruit set is significantly influenced by pollinator, which indicates the importance of the appropriate pollinator selection for mahaleb seed trees. In fact the high fruit set results of cross pollination on *Prunus mahaleb* and *Prunus avium* selected in Cegléd show no significant differences (*Erdős*, 1984), which is an evidence for the successful selection of best pollinators.

Pollen sterility at *Prunus mahaleb* may one of the reasons for need on pollinator. One genotype of 'Alpruma' seed orchard produces sterile pollen, but sets fruit and produces well germinating seeds after foreign pollination (*Funk*, 1969). Among the 105 genotypes collected in Bordeaux, Grande Ferrade nine were found as pollen sterile (*Sarger*, 1972). One genotype investigated in Hungary (*Table 7*) showed also pollen sterility (*Hrotkó*, 1984, 1986).

Concerning xenia effects on fruit shape, seed quality there are different opinions in the literature. Except for apple (*Popov*, 1956, 1962, *Perehodkin*, 1962a,b, *Baranova*, 1962) *Sebőkné* (1970) mentioned significant effects of pollinators on seed quality. She found lower stone weight and germination capacity after self pollination at 'Korponay' *Prunus mahaleb* seed tree and significant influence of pollinators on seed weight. Investigations of *Hrotkó* (1984, 1986) on the same plant material could not confirm this (*Tables 8 and 9*).

Table 4 Fruit set of *Prunus mahaleb* genotypes after different pollination (*Hrotkó*, 1983, 1984, 1986)

Year	1979		1980		1981			1982		Average 1979-82	
Pollination	Free	Isol.	Free	Isol.	Free	Isol.	Auto	Free	Isol.	Free	Isol.
Genotypes											
Hemann X	40.3	33.7	30.4	27.5	33.2	9.5	–	30.4	15.3	33.6	21.5
Korponay	33.3	34.4	20.6	24.3	48.9	22.6	–	26.8	25.9	32.4	26.8
Soroksár	–	–	41.2	0.3	25.8	0.2	1.3	24.3	0.0	30.4	0.8
Egervár	–	–	38.8	0.1	33.3	1.1	0.9	25.8	0.0	32.6	0.5
Dunabogdány	17.9	0.0	–	–	–	–	–	–	–	–	–
LSD										NS	

Remarks, Free: free pollination, Isol: self pollination in isolated bags, Auto: artificial self pollination

Table 5 Fruit set (%) on *Prunus mahaleb* and *Prunus avium* genotypes after different pollination (*Erdös*, 1984)

Genotype	Free	Autogamy	Geitono-gamy	Pollinator A	Pollinator B	Fruit set A	Fruit set B
P. mahaleb							
Cema (C 500)	27.4	0.2	0.03	Érdi V.	Cemany	62.5	58.3
Érdi V.	29.3	0.0	0.0	Cemany	Cema	42.8	25.7
Cemany (CT 2753)	33.8	0.1	0.0	Cema	SL 64	59.6	56.7
SL 64	32.3	0.1	0.05	Cema	Cemany	47.2	32.3
P. avium							
AW	50.8	0.0	0.1	C 2493	–	25.8	–
C 2493	50.0	0.2	0.1	AW	–	23.4	–

Table 6 Effect of pollinators on fruit set of 'Egervár1 and 'Soroksár' mahaleb cherry genotypes after artificial pollination (*Hrotkó*, 1986)

Pollinators	Fruit set on Egervár		Fruit set on Soroksár	
	1981	1983	1981	1983
Egervár	0.8	0.1	7.7	7.7
Soroksár	16.0	4.7	0.3	0.6
CT 500	7.5	11.0	11.3	10.6
CT 2753	6.5	16.7	5.7	4.7
Érdi V.	18.8	7.3	10.3	2.3
SL 64	28.8	29.3	6.7	3.3
Korponay	5.5	5.0	4.3	3.7
Hemann X	–	16.3	–	2.0
SM 11/4	–	13.7	–	7.7
Free pollination	32.6	32.7	25.8	23.3
LSD 5%	10.7	8.8	7.0	5.6

Table 7 Germination capacity of pollen grains (% of pollen tubes in 15% sacharose solution) (*Hrotkó*, 1984, 1986)

Genotype	% of pollen tube developed grains
Dunabogdány	0.0
Egervár	47.3
Heimann X.	46.5
Korponay	30.8
Magyar	49.5
Soroksár	45.5
LSD 5%	10.7

Table 8 Effect of pollinators on stone weight at *Prunus mahaleb* genotypes (*Hrotkó*, 1984)

(Weight of 10 stones in g)

Pollinators	Seeds' weight of Egervár	Seeds' weight of Soroksár
Egervár	0.86	0.88
Soroksár	0.86	–
Korponay	0.85	0.89
CT 500	0.9	0.94
CT 2753	0.87	0.91
Érdi V.	0.84	0.91
SL 64	0.83	0.88

Table 9 Effect of pollinators on the germination capacity of *Prunus mahaleb* seeds (*Hrotkó*, 1984)

Genotype	Type of pollination	1981	1982	1983	Average
Korponay	Free pollination	73.8	59.0	96.8	76.5
Korponay	Self pollination	89.8	67.2	86.6	81.2
Heimann X.	Free pollination	53.4	62.2	–	58.0
Heimann X.	Self pollination	84.0	59.8	–	79.1
Egervár	Free pollination	91.2	53.6	–	72.4
Soroksár	Free pollination	93.8	63.6	84.6	80.7
LSD 5%		8.8	NS	6.18	NS

Flowering process of P. mahaleb and P. avium

First data on blossom time of *Prunus mahaleb* is published by *Tillson* (1947) who studied the blossom because of the low fruit set. He found 21 days difference among the genotypes, the flowers on short spurs opened three days earlier. *Sebőkné* (1970) carried out no systematic investigations, but noted that the flowers of 'Korponay' could not be pollinated by pollen of 'Magyar' because of its late blossom.

Hrotkó (1984, 1985) studied the flowering time of *Prunus mahaleb* genotypes in Hungary. The blossom time of *Prunus mahaleb* was similar to sour cherry cultivars or followed them by few days. There are large differences between the genotypes. The data of flowering start and end from 1980-82 are shown in the *Figure 1*. In the three studied years the blossom start showed 6-22 days differences, the sequence of the genotype was every year the same. There are also significant differences between the genotypes in the accumulated heat unit until the blossom start and the average length of the blossom period (*Table 10*). The range of blossom duration is between 7.3 to 11.7 days. It is conspicuous that late blossom types showed a longer flowering duration.

Erdős (1984) showed the day number in the year until the genotypes start to flower (*Table 11*). Among the *Prunus mahaleb* genotypes selected in Cegléd there are smaller differences in blossom time (3 days). Mazzard types (Altenweddingener and C 2493) showed blossom 3 days following the *P. mahaleb*. The duration of blossom in Cegléd was shorter, 5–6 days.

Table 10 Accumulated heat unit until the blossom start and the average duration of the blossom of *Prunus mahaleb* genotypes (*Hrotkó*, 1984, 1985)

Genotype	1980		1981		1982		Average	
	heat unit	duration	heat unit	duration	heat unit	duration	heat unit	duration
Korponay	437.0	8	413.8	6	425.0	8	425.3	7.3
Egervár	492.0	8	452.0	11	468.0	7	470.8	8.7
Soroksár	492.5	9	452.0	11	477.6	7	474.0	9.0
SM 11/4	–	–	452.0	13	477.6	9	464.8	11.0
Heimann X	541.7	13	480.9	15	514.8	7	512.5	11.7

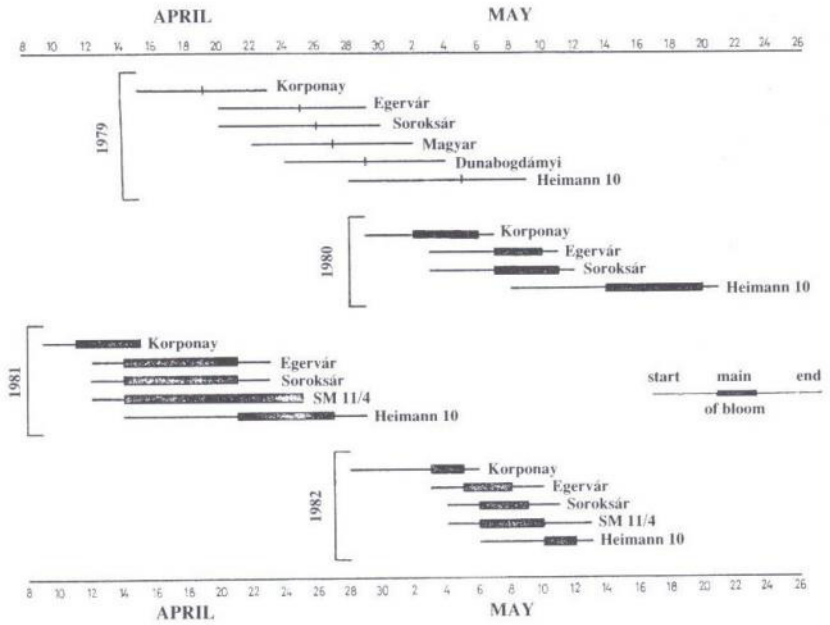

Figure 1 The flowering process (onset, main blossom, end) of *Prunus mahaleb* genotypes in Szigetcsép 1979–1982 (*Hrotkó*, 1984. 1985)

Based on the data of *Hrotkó* (1984, 1986) and *Erdős* (1984) four blossom time groups can be set up for *Prunus mahaleb*:

Early blossom: Korponay

Medium early: Soroksár, Egervár and SM 11/4, Cema, Érdi V.

Medium late: Magyar and Dunabogdány, Cemany, SL 64

Late: Heimann X.

As *Erdős* (1984) noted, the overlapping of blossom among the Cegléd types belonging to a neighbour blossom time group is satisfying for a safe pollination. *Hrotkó* (1984) showed that an appropriate overlapping of blossom curves (50% by *Nyéki*, 1980) is only between the neighbour blossom time groups, the early and late blossom genotypes are not appropriate pollinators for each other because of this blossom time differences (*Table 12*). For a seed orchard these differences can be used for isolation in time of different mating groups.

Table 11 Phenology data of flowering process of *Prunus mahaleb* and *P. avium* seed tree genotypes in days (average of 1979–1991) (*Erdős*, 1984)

Serial Nr of the day in the year

Genotype	Flowering onset	Main flowering	Flowering end	Duration
P. mahaleb				
Érdi V.	105.0	107.2	119.1	14.1
Cema (C 500)	105.2	107.6	119.8	14.6
SL 64	106.5	109.3	120.3	13.8
Cemany (C2753)	106.8	110.4	121.5	14.7
P. avium				
C 2493	102.6	105.5	118.7	16.1
Altenweddingeni	102.7	106.6	118.6	15.8

Table 12 Overlapping of blossom curves of *Prunus mahaleb* genotypes in average of 1980–82

	Egervár		Soroksár		SM 11/4	
Genotype	%	Cv %	%	Cv %	%	Cv %
Korponay	45.4	25.3	44.7	25.6	37.1	22.3
Egervár			91.7	8.1	75.1	16.4
Soroksár	86.5	9.6			73.4	1.0
SM 11/4	85.8	17.2	96.1	0.7		
Heimann X.	37.9	46.6	44.4	49.5	69.3	18.2

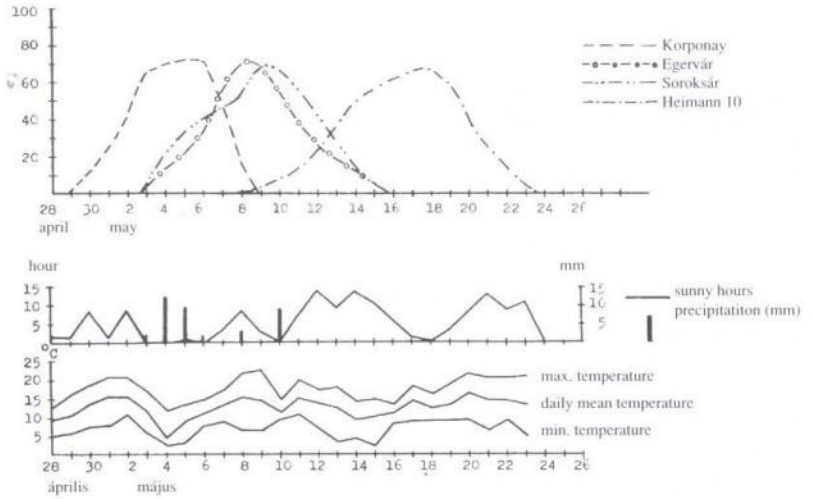

Figure 2 Flowering process of *Prunus mahaleb* genotypes in Szigetcsép 1980

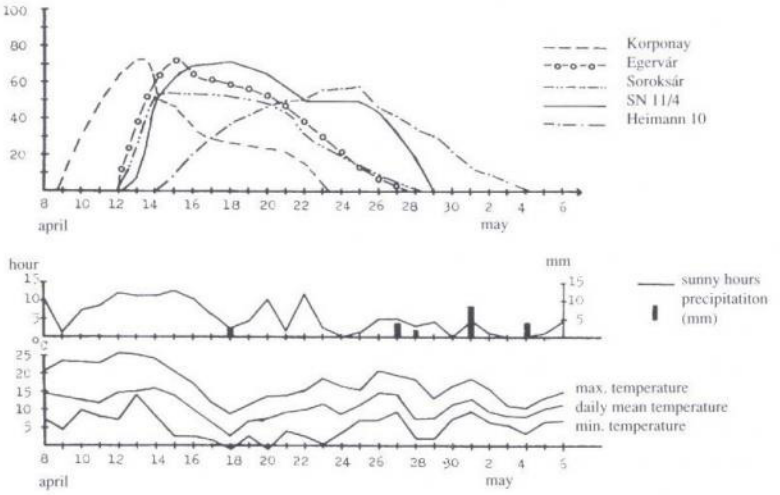

Figure 3 Flowering process of *Prunus mahaleb* genotypes in Szigetcsép 1981

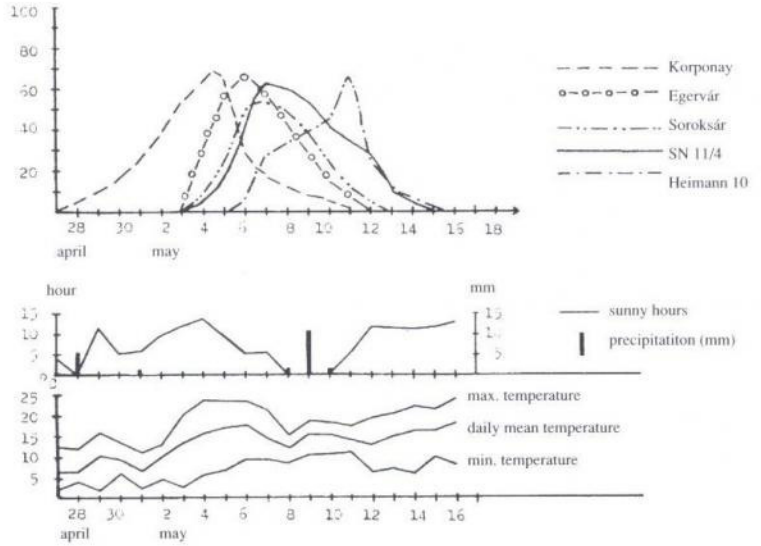

Figure 4 Flowering process of Prunus mahaleb genotypes in Szigetcsép 1982

Prunus armeniaca

Prunus armeniaca seedlings are important rootstocks for apricot in Hungary. From among "vineyard seedlings" seed tree genotypes are selected by *Nyujtó* (1987). Investigation on flower fertility and blossom time were carried out by *Erdős* (1984). After a long-term selection procedure there are five genotypes candidated as seed tree cultivars (*Harsányi* et al., 2004).

The selected seedlings are all self fertile with different fruit set capacity in free pollination (*Table 10*) . That is why planting a seed orchard with selected pollinators is reasonable. The fruit set with an appropriate pollinator may range between 19.5 to 50.4%.

As data of *Table 14* show the successful selection considered the flowering time of genotypes too. There is only three days difference in blossom process, which is a guarantee for appropriate overlapping of blossom time of genotypes. The duration of blossom ranged between 7.3 to 8.8 days.

Prunus cerasifera and P. insititia (C 83)

Seedlings of *Prunus cerasifera* and *Prunus insititia* are used as rootstocks for plums and apricots. The long term selection of seed tree genotypes (*Nyujtó*, 1987) resulted in four genotypes of Myrobalan (*P. cerasifera*) and one *P. insititia*.

Erdős (1984) results on flower fertility showed that all of Myrobalan seed tree genotypes are practically self sterile, while the *P. insititia* is self fertile, but using a pollinator significantly improved the ration of fruit set (*Table 15*). For P. myrobalan selected seed tree genotypes using at least one pollinator is essential. Fruit set results with the best two pollinators are shown in *Table 15* too. According to the results except for C 679 all the three other genotypes are very good pollinators. For *P. insititia* by *Erdős* (1984) the plum cultivars 'Debreceni muskotály' and 'Sermina' gave the best fruit set results (*Table 15*).

Considering the flowering process of Myrobalan (*P. cerasifera*) genotypes the selection resulted in appropriate overlapping of blossom, there are only three days differences between the genotypes. The duration of flowering ranged between 8 to 9 days.

Blossom of *Prunus insititia* follows that of Myrobalan by two days, but the duration of blossom is shorter, in average of four years is 5.8 days (*Table 16*).

Table 13 Fruit set after different pollination of *Prunus armeniaca* genotypes in Cegléd (average of years 1979–1982) (*Erdős*, 1984)

Genotype	Free pollination	Autogamy	Geitono-gamy	Pollinator A	Pollinator B	Fruit set A	Fruit set B
C 1300	15.5	2.2	4.8	C 1620	C 1426	19.5	13.3
C 1301	35.6	19.4	32.0	C 2546	C 1652	50.4	49.5
C 1650	22.7	14.9	20.1	C 30235	C 195	44.4	26.6
C 1652	33.2	15.4	30.7	C 1301	C 1426	49.2	40.5
C 1426	27.5	19.6	22.1	C 1650	C 1620	33.3	32.5

Table 14 Phenology data on flowering process of *Prunus armeniaca* seed tree genotypes in days (average of 1979-1991) (*Erdős*, 1984)

Serial Nr of the day in the year

Genotype	Flowering onset	Main flowering	Flowering end	Duration
C 1301	96.4	98.2	110	13.3
C 1650	97.2	99.6	109.2	12.0
C 1652	97.7	99.2	106.2	8.5
C 1426	98.2	100.5	111.0	12.8
C 1300	99.9	102.3	112.2	12.3

Table 15 Fruit set after different pollination of *Prunus cerasifera* and *P. insititia* genotypes in Cegléd (average of years 1979–1982) (*Erdős*, 1984)

Genotype	Free pollination	Autogamy	Geitono-gamy	Pollinator A	Pollinator B	Fruit set A	Fruit set B
P. cersifera							
C 162	12.6	0.0	0.0	C 359	C 174	29.3	18.4
C 174	18.2	0.0	0.5	C 359	C 162	42.1	27.5
C 359	19.7	0.0	0.1	C 174	C 162	32.4	23.7
C 679	12.7	0.05	0.0	C 364	C 767	21.3	12.2
P. insititia							
C 83	37.3	10.1	22.1	Debreceni muskotály	Sermina	63.7	61.0

Table 16 Phenology data of flowering process of *Prunus cerasifera* and *P. insititia* seed tree genotypes in days (average of 1979–1991) (*Erdős*, 1984)

Serial Nr of the day in the year

Genotype	Flowering onset	Main flowering	Flowering end	Duration
P. cerasifera				
C 359	96.6	99.0	109.6	13.1
C 162	97.0	98.8	107.9	10.9
C 174	97.9	99.9	109.0	11.1
C 679	98.5	100.6	109.9	11.4
P. insititia				
C 83	102.8	105.3	112.8	10.0

P. persica, P. amygdalus and P. amygdalopersica

Seedlings of peach (subspontaneous 'vineyard seedlings'), almond and almond-peach seedlings are used as rootstocks for peach and almond cultivars in Hungary. The selection of seed tree genotypes carried out by *Nyujtó* (1987) resulted in two peach, four almond and two almond x peach hybrid genotypes. Their floral biology characters were investigated by *Erdős* (1984).

Similarly to the fruit producing cultivars peach genotypes are self fertile, as well as *P. amygdalopersica* genotypes, but their fruit set could be significantly improved by foreign pollinators. Almond genotypes are practically self sterile (*Table 17*).

Skola & Erdős (2004) repeated the investigation on flower fertility and cross pollination of the above almond seed tree genotypes involving a new one C 471. The result confirmed the results of *Erdős* (1984). For C 471 the best pollinator is C 431, for C 446 as pollinator C 471 and C 449, for C 449 as pollinator C 431 and 471, for C 431 as pollinator C 446 could be recommended.

Table 17 Fruit set of peach, almond and amygdalopersica genotypes after different pollination (average of 1979–1982) (*Erdös*, 1984)

Genotype	Free	Auto	Geitono-gamy	Pollinator A	Pollinator B	Fruit set A	Fruit set B
P. persica							
C 2629	29.1	19.1	13.5	C 932	–	52.4	–
C 932	18.6	12.2	6.6	C 2629	–	37.8	–
P. amygdalus							
C 431	9.6	0	0.3	C 446	C 410	16.1	14.8
C 446	7.3	0	0	C 449	C 447	11.7	9.7
C 447	7.4	0	0	C 449	C 446	19.6	11.2
C 449	9.0	0	0	C 431	C 446	18.7	12.5
P amygdalopersica							
C 465	23.1	7.7	9.0	C 447	C 449	32.3	25.8
C 410	15.8	9.7	12.5	C 431	C 465	41.4	28.1

Table 18 Cross-pollination results of *Prunus amygdalus* seed tree genotypes in Cegléd from 2000 to 2002. (*Skola & Erdős*, 2004)

Combinations / Years	2000	2001	2002	Total
C.471/C.449	13.8	15.23	0	9.68
C.471/C.431	17.4	19.52	0	12.31
C.471/C.446	15.2	8.62	0	7.94
C.446/C.449	19.7	34.18	0	17.96
C.446/C.471	25.4	43.7	0	23.03
C.446/C.431	10.6	38.12	0	16.24
C.449/C.446	36.2	17.7	0.95	18.28
C.449/C.431	36.1	11.44	0	15.85
C.449/C.471	35.3	8.07	0	14.46
C.431/C.449	10.7	0	3.39	4.70
C.431/C.471	14.3	0	0.99	5.10
C.431/C.446	19.2	0	3.32	7.51
Total	21.16	16.38	0.72	

Since the cross pollinator significantly improved the fruit set at each genotype the selection of appropriate pollinator with large overlapping of blossom time is essential for successful seed production. Considering the data of flowering process among the almond and amygdalopersica genotypes the blossom time overlap is satisfying with 8 days difference. The duration of blossom ranged from 10 to 12 days. The blossom of peach genotypes follows the almond by 7–10 days, but the difference between the two selected types is only 1–2 days, which provides an appropriate opportunity for pollination.

Pyrus communis, Pyrus pyraster and Pyrus betulifolia

Genotypes from all the three *Pyrus* species are selected for seed production based on their seed production and germination capacity. Their flower fertility has never been

Table 19 Phenology data on flowering process of *Prunus persica*, *P. amygdalus* and *P. amygdalopersica* seed tree genotypes in days (average of 1979–1991) (*Erdös*, 1984 and new data)

Serial Nr of the day in the year

Genotype	Flowering onset	Main flowering	Flowering end	Duration
P. persica				
C 932	100.6	103.4	120.7	20.2
C 2629	103.6	105.8	119.1	15.6
P. amygdalus				
C 449	91.5	94.5	108.2	16.7
C 446	91.8	94.6	105.8	14.0
C 447*	92.0	94.6	103.3	11.3
C 431	96.8	98.7	111.0	14.2
P. amygdalopersica				
C 465	90.3	93.3	104.4	14.1
C 410	97.9	99.2	112.8	14.9

Table 20 Phenology data on flowering process of *Pyrus pyraster* and *Pyrus betulifolia* seed tree genotypes in days (average of 1980–1982)

Serial Nr of the day in the year

Genotype	Flowering onset	Main flowering	Flowering end	Duration
P. pyraster				
Egervári II.	111.7	114.0	122.7	11.0
Egervári I.	115.0	116.7	126.3	11.3
P. communis				
Kieffer Dny.279	114.0	115.7	124.3	10.3
P. betulifolia	118.7	122.3	132.0	13.3

systematic investigated but by our experiences all genotypes require pollinator for appropriate fruit set. However the differences in flowering onset are considerable (2 to 7 days), the relative long duration provides an appropriate overlapping of flowering time and results in proper fruit set.

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