Self-fertility studies of some sweet cherry (*Prunus avium* L.) cultivars and selections

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Summary: Fruit set of two sweet cherry cultivars (*'Alex'* and *'Stella'*) and four Hungarian selections have been studied over two years following open pollination, unassisted self-pollination (autogamy) and artificial self-pollination (geitonogamy). Among accessions 'IV-6/240' proved to be self-sterile, while the other five revealed to be self-fertile. Significant differences have been found in fruit set among years and among pollination treatments but not among self-fertile accessions. Fruit set following unassisted self-pollination was significantly lower than of other pollination treatments. Thus pollen transfer is essential for profitable yield in sweet cherry growing.
There was no significant relationship in the fruit set of open- and self-pollination.

Key words: pollination, self-fertility, autogamy, *P. avium* L.

Introduction

In sweet cherry orchards abundant yield is expected only if pollination and fertilisation is adequate. Flowers of most sweet cherry cultivars are self-sterile: they do not set fruit when self-pollinated and require compatible, viable pollen from other cultivars. This phenomenon is controlled by the so called gametophytic incompatibility that in sweet cherry is attributed to the multi-allelic locus, *S*, by *Crane & Lawrence* (1929).

At the beginning all sweet cherry cultivars were self-sterile and often incompatible with other cultivars (*Crane & Brown*, 1937). A major breakthrough occurred in 1954 when *Lewis & Crowe* produced the first self-fertile seedlings. Three of them were selected and used in further breeding programmes (*Matthews*, 1970). In *JI 2420* and *JI 2434* seedlings self-fertility was obtained by using X-irradiated pollen of their ancestor, *'Napoleon'*. *JI 2538* is a spontaneous mutation coming from selfing *'Merton 42'*(*Lewis & Crowe*, 1954). *JI 2420* is the ancestor of most self-fertile cultivars. It possesses a mutated S_4 allele (i.e. S_4' where prime reveals mutation in the pollen part causing self-fertility) that has lost its pollen activity (*Lewis & Crowe*, 1954; *Matthews*, 1970).

The first self-compatible cultivar, '*Stella*' (*Lapins*, 1971) resulted from a cross between '*Lambert*' and *JI 2420*, released from Summerland, Canada. It has widely been used as the source of self-fertility. Later additional self-compatible cultivars had been released by breeding institutes around the world, the most known are '*Lapins*', '*Sunburst*' (*Lane & Schmidt*, 1984), *'New Star'* (*Lane & Sansavini*, 1988), '*Sweetheart*'. The most relevant self-fertile sweet cherry cultivars are presented in *Table 1*.

Hungarian sweet cherry breeding programme was among the first developing self-fertile cultivars. *Sándor Brózik* obtained self-fertile seedlings by crossing '*Bigarreau Burlat*' and *'Stella'*. From this population he selected several promising ones, some of which applied for registration into the national cultivar list (*Apostol*, 1999a). *'Alex'*, the first self-fertile Hungarian cultivar was developed by using '*Cherry Self Fertile 46*', a seedling from the John Innes Institute (*Brózik & Apostol*, 2000). DNA analysis showed that in '*Alex*' the only type of *S*-alleles presented is S_3 (Sonneveld et al., 2003), thus, carrying self-fertility instead of S_4 that is the case in most self-compatible cultivars. At present, self-fertile registered cultivars in Hungary are '*Alex*' and '*Sunburst*', while '*Stella*' and '*Sweetheart*' are applicants (*Harsányi & Mádi*, 2003).

Growing self-compatible cultivars has several advantages. They can be planted in solid blocks, eliminating pollinator cultivars, thus simplifying spraying and harvesting. For instance, spraying against brown rot blossom blight can be applied more easily and more efficiently in this way (*Holb*, 2003, 2004). Yield is secured by reducing the need of adequate pollen transfer. Moreover, self-fertile sweet cherry cultivars are universal pollen donors (*Thompson*, 1996). However, their disadvantage is that they tend to overset.

Several authors have studied self-fertility of sweet cherry cultivars by test-crosses. In spite of the fact that sweet cherry is described as a basically self-sterile fruit species, some reports had presented self-fertility of certain cultivars. *Stancevic* (1971) found '*Black Tartarian*' and '*Emperor Francis*' to be self-fertile, however, they are not regarded as self-fertile cultivars at present (*Tobutt* et al., 2001). '*Dritte Schwarze*' set some fruits after selfing that was regarded as experimental error (*Stösser*, 1966).

Wolfram (1999) studied self-fertility of a progeny of '*Stella*'. Half of the seedlings proved to be self-fertile as it was expected from the inheritance of self-fertility.

In 1952 Maliga tested self-compatibility of 23 sweet cherry cultivars by unassisted- and artificial self-pollination.

Table 1 Self-fertile sweet cherry cultivars in the world (without completeness)

Cultivar	Country of origin (year where available)	Mother	Father	Source
Black Star	Italy	Lapins	Bigarreau Burlat	8
Blaze Star	Italy	Lapins	no information	8
Cashmere	USA	Stella	Early Burlat	9
Celeste	Canada (1993)	Van	New Star	1
Columbia	USA	Stella	Beaulieu	3
Glacier	USA	Stella	Early Burlat	9
Index	USA	Stella	O.P.	9
Isabella	Italy (1993)	Starking Hardy Giant	Stella	1
Lala Star	Italy	no information	no information	8
Lapins	Canada (1983)	Van	Stella	1
Liberty Bell	USA	Rainier x Bing	Stella	3
Newstar	Canada and Italy (1987)	Van	Stella	1
Sandra Rose	Canada (1996)	2C-61-18	Sunburst	2
Santina	Canada (1996)	Stella	Summit	2
Sir Don	Australia	Stella	Black Douglas	7
Sir Tom	Australia	Stella	Black Douglas	7
Skeena	Canada (1997)	2N60-07 (Bing x Stella)	2N-38-32 (Van x Stella)	2
Sonata	Canada (1996)	Lapins	2N-39-5 (Van x Stella)	2
Staccato	Canada	Sweetheart	unknown	6
Starcrimson	USA (1980)	Garden Bing	Stella	1
Stella	Canada (1970)	Lambert	JI 2420	1
Sunburst	Canada (1983)	Van	Stella	1
Sumesi	Canada (1988)	no information	no information	2
Sweetheart	Canada (1993)	Van	New Star	1
Tehranivee	Canada	no information	no information	–
Vandalay	Canada	no information	no information	–

1. Bargioni (1996)
2. Albertini & Strada (2001)
3. Olmstead et al. (in press)
4. Brózik & Apostol (2000)
5. Apostol, pers. comm.
6. Frank Kappel, pers. comm.
7. Granger, pers. comm.
8. Sansavini, pers. comm.
9. Lang et al. (1998)

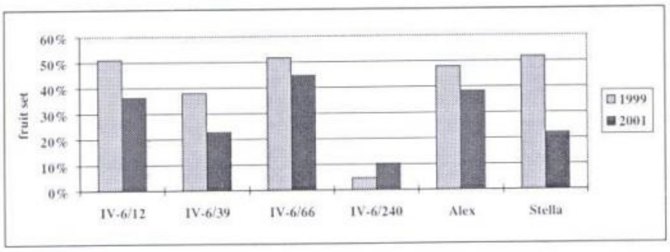

Figure 1a Year effect on fruit set of the accessions

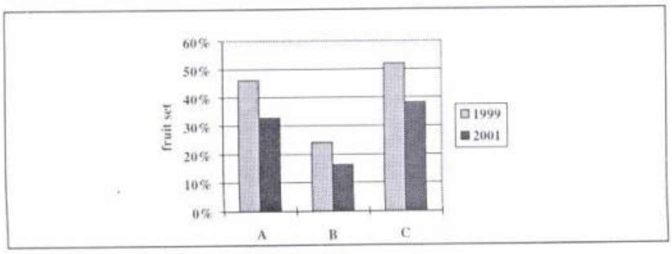

Figure 1b Year effect on fruit set of the treatments (A: open pollination, B: autogamy, C: geitonogamy)

Some cultivars produced 1–5% fruit set after selfing, however, he considered them practically self-incompatible. *Brózik* (1962) studied self-compatibility of '*Germersdorfi Óriás*' and found it completely self-incompatible. *Nyéki* (1989) established groups designated with different fruit sets and so describing the ability of self-fertility in stone fruits. He carried out self-pollination studies in 14 cultivars and proved that all sweet cherry cultivars are entirely self-incompatible. *Apostolné* (1994) found '*Stella*' to be reliably self-fertile. *Wolfram* et al. (1990) studied self-fertility of sour cherry progenies. They considered a cultivar self-comaptible if its fruit set was higher than 20%. In Hungary, *Kerékné* (1981) tested self-fertility of Hungarian sour cherry cultivars.

Relationship between fruit set of self- and open pollination was first reported by *Tóth* (1957) in plum cultivars, confirmed by *Szabó* & *Nyéki* (1987) & *Szabó* (1989). In sour cherry, *Nyéki* (1989) proved that cultivars having higher degree of self-fertility have better fruit set after open pollination than cultivars with less self-fertility. *Szabó* (2002) proved the positive correlation of fruit set following self-fertilisation and open pollination in sour cherry, peach, apricot and plum.

In our study we tested self-compatibility of some Hungarian sweet cherry selections by traditional field test crosses. Since most selections derive from the cross between '*Bigarreau Burlat*' x '*Stella*' therefore they might inherit S_4' allele responsible for self-compatibility *(Table 2.)*. The origin of the selection '*IV-6/240*' is unknown, also whether it had a self-compatible ancestor or not. However, breeders had suspected it to be self-compatible that needed to be tested (*Apostol,* 1999b). In addition, the selfing ability of self-fertile '*Alex*' and '*Stella*' had been checked in contrast to the above mentioned selections. Fruit set of self-fertile accessions following open-pollination, autogamy and geitonogamy and their relationship was examined.

Table 2 The origin of the Hungarian sweet cherry cultivars and selections tested (*Brózik* & *Apostol*, 2000)

Cultivar/selection	Mother	Father
Alex	Van	Cherry Self Fertile 46*
IV-6/12 (Sándor)	Bigarreau Burlat	Stella
IV-6/39 (Pál)	Bigarreau Burlat	Stella
IV-6/66	Bigarreau Burlat	Stella
IV-6/240	Unknown	Unknown

*an accession received from the John Innes Institute, possibly as 1411/46 (Apostol, pers. comm.); 1411/46 is the same as JI 2538 (Matthews & Lapins, 1967)

Material and method

The experiments were carried out in the experimental field of the Research Institute for Fruitgrowing and Ornamentals, Érd, in 1999 and 2001. Pollination was performed on 1–3 trees per accession, budded on *Mazzard* rootstock and planted between 1993-95. The accessions tested are: *IV-6/12* (*'Sándor'*), *IV-6/39* (*'Pál'*), *'IV-6/66'*, *'IV-6/240'* (selections), *'Alex'* and *'Stella'* (cultivars). Their origin is presented in Table 2.

Pollination treatments were performed as follows:

Open pollination: three-four branches were chosen per accession. At full bloom, approx. 100–200 flowers were selected and left for natural pollination.

Unassisted self-pollination (autogamy): approx. 100 flowers per accession were isolated in balloon stage with parchment bags. Open flowers were removed beforehand. When the flowers opened in the bags, they were counted and remained isolated until petal fall.

Artificial self-pollination (geitonogamy): isolation was performed similarly as described at autogamy. When the flowers opened in the bags and the pistils were ready to receive the pollen the artificial pollination took place. Some flowers from each bag were taken and touched to the other flowers in the bag in order to pollinate them. Pollinated flowers were counted and isolated again.

In case of autogamy and geitonogamy parchment bags were removed after petal fall. Fruit set was recorded at ripening time of each accession. In each parchment bag percentage of fruit set was calculated.

In the experimental field, mean, maximum and minimum temperature was recorded during flowering (*Figure 2a* & *2b*). Self-fertility of the accessions analysed was determined on a fruit set scale developed by *Nyéki* (1989) for stone fruit species *(Table 3)*.

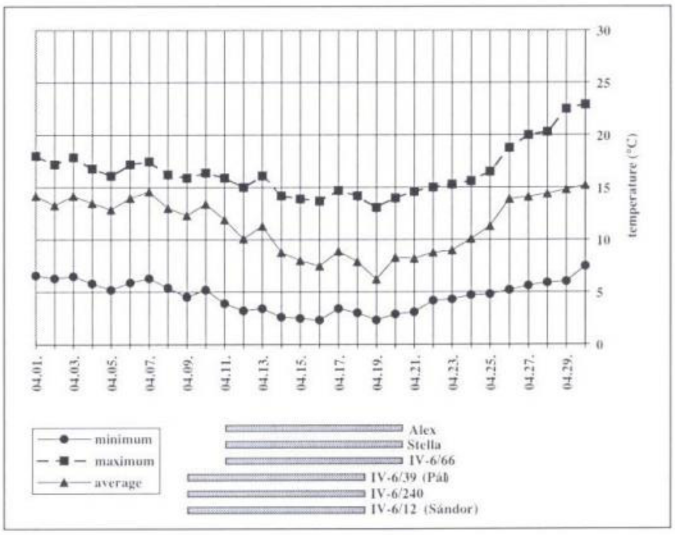

Figure 2a Temperature and blooming time* of sweet cherrz accessions in April, 1999

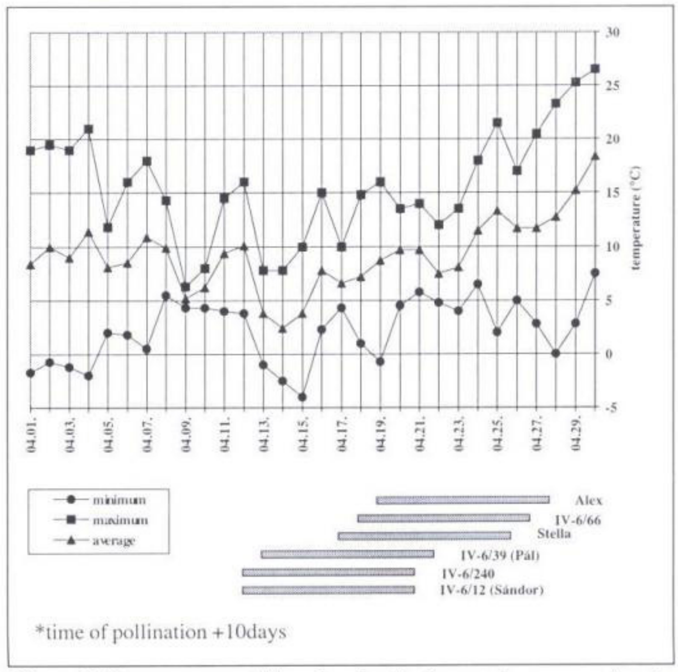

Figure 2b Temperature and blooming time* of sweet cherry accessions in April, 2001

The effect of years, treatments and accessions and their interaction have been analysed statistically by multifactor analysis of variance. Difference among treatments in each accession was evaluated by one way analysis of variance.

Table 3 Assigning sweet cherry cultivars and selections into fertility groups according to the average fruit sets observed

Cultivar/selection	Self-fertility[1]	Open pollination[2]
IV-6/12 (Sándor)	4-5*	4
IV-6/240	2**	2-3*
IV-6/39 (Pál)	4	3
IV-6/66	5	4
Alex	4	4
Stella	5	3

*the average fruit set was on the limit of two fertility groups
**fruit set was probably due to experimental error

[1]Fertility groups on the basis of fruit set after unassisted self-pollination (Nyéki, 1989):

	Fruit set
1 entirely self-sterile	0%
2 self-sterile	0.1–1%
3 partially self-fertile	1.1–10%
4 self-fertile	10.1–20%
5 highly self-fertile	>20%

[2]Ability of a cultivar to set fruit after open pollination (*Brózik & Nyéki*, 1980):

	Fruit set
1 low	<10%
2 medium	10.1–20%
3 high	20.1–30%
4 extremely high	>30%

Interaction in fruit set after self- and open pollination was studied by regression analysis. All statistical analysis have been performed by Statgraphics 5.1 software.

Results

In both years studied most accessions gave higher than 10% fruit set after unassisted and artificial self-pollination treatments. The only exception, '*IV-6/240*' produced 1.7% average fruit set after autogamy and 0% following geitonogamy. The former fruit set might be attributed to experimental error.

On the basis of their average fruit set the accessions have been assigned to fertility groups according to Nyéki (1989), *Brózik & Nyéki* (1980) *(Table 3)*. All accessions proved to be self-fertile, except '*IV-6/240*'. After unassisted self-pollination the highest average fruit set was produced by '*IV-6/66*' (44.0%), whereas the lowest (12.2%) by *IV-6/39* ('*Pál*'). In case of geitonogamy all self-fertile accessions did well.

For open pollination the lowest average fruit set was observed in '*IV-6/240*' (20.6%), the highest in '*Alex*' (50.5%).

The effect of the years, treatments and accessions was evaluated without the data of the self-sterile '*IV-6/240*' *(Table 4)*. According to the results obtained there was no interaction between variables (accession x treatment, accession x year, treatment x year). There was significant difference between the average fruit set of years (in 1999: 48.1%, in 2001: 32.9%) that appeared in the average set of each accession and treatment (*Figure 1a and 1b*). The reason might be in different weather conditions. Figure 2a and 2b present temperature and blooming time figures of the two flowering seasons studied. In 2001 the blooming period of early flowering cultivars was considerable cold – the minimum temperature dropped even below zero – that made pollen tube growth slower. Due to the stable mild weather in 1999 the accessions got to their full bloom almost at the same day and weather remained favourable after pollination.

Table 4 The effect of accessions, treatments and years on fruit set (analysis of variance)

Source of variation	Sum of squares	d.f.	F-ratio	Probability*
accession	0.115	4	1.202	0.381
treatment	0.469	2	9.793	0.007
year	0.173	1	7.219	0.027
accession x treatment	0.096	8	0.502	0.825
accession x year	0.046	4	0.481	0.749
treatment x year	0.010	2	0.214	0.812
error	0.192	8	0.024	

*significance of the probability at P<0.05

Differences were observed among treatments. Fruit set after unassisted self-pollination was significantly lower than of open- and artificial self-pollination. Geitonogamy showed the highest average fruit set (46.9%), followed by open pollination (39.5%) and autogamy (20.2%).

There were differences among treatments within individual accessions *(Table 5)*. '*Stella*' and '*IV-6/66*' showed similar fruit set regardless of the treatment, whereas in *IV-6/12* ('*Sándor*') all treatments had considerably different effect on the fruit set.

The fruit set of self-fertile accessions did not differ significantly from each other. The highest average fruit set was observed (including the results of all treatments) in 'IV-6/66' (48.3%), while the lowest was 30.4% in IV-6/39 ('Pál').

Figure 3a and 3b present the correlation of open- and unassisted self-pollination. According to our results open pollination is determined 0.74% by autogamy and 38.04% by geitonogamy (P=0.95). Thus strong positive correlation between fruit set following open- and self-pollination was not observed.

Table 5 Average fruit set (%) of cultivars and selections after different treatments*

	IV-6/12 (Sándor)	IV-6/240	IV-6/39 (Pál)	IV-6/66	Alex	Stella
open pollination	49.9 a	20.6 a	33.6 a	44.8 a	50.5 a	38.0 a
autogamy	20.1 b	1.7 b	12.2 a	44.0 a	17.5 b	26.0 a
geitonogamy	71.7 c	0.0 b	45.5 b	56.0 a	61.4 a	46.7 a

*There is no significant difference among treatments marked with the same letter in a column

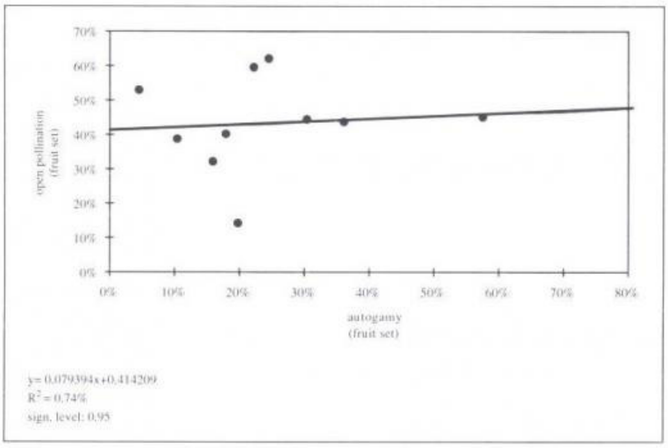

Figure 3a Regression of open pollination and autogamy

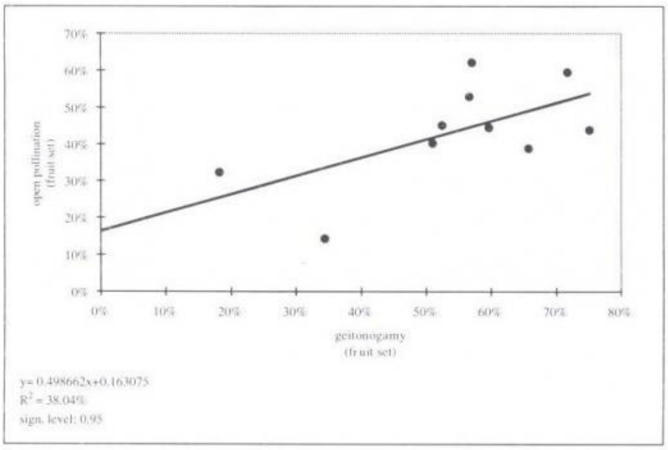

Figure 3b Regression of open pollination and autogamy

Discussion

Fruit sets showed that '*Stella*' and '*Alex*' cultivars along with the selections *IV-6/12* ('*Sándor*'), *IV-6/39* ('*Pál*'), '*IV-6/66*' are self-fertile. As these results were consistent in both years it was unnecessary to repeat the experiments. Self-sterility of '*IV-6/240*' has been proved in contrast to other reports (*Apostol*, 1999b). Pollination experiments described in this paper were followed by molecular analysis of *S*-alleles responsible for cherry incompatibility (*Békefi* et al., 2003). The *S*-genotypes obtained showed that *IV-6/12* ('*Sándor*'), *IV-6/39* ('*Pál*') and '*IV-6/66*' hold S_4 allele that can carry self-fertility – and must come from their parent, '*Stella*' –, whereas '*IV-6/240*' does not.

Year effect was observable in our experiments, it proved again the well-known fact that weather conditions highly affect pollination and fertilisation processes.

Fruit set of '*IV-6/240*' following open pollination was lower than of self-fertile accessions. *Kerékné* (1981) reported lower fruit set after open pollination in self-sterile cultivars than of self-fertile ones. In case of '*IV-6/240*', in addition, its blooming time is extremely early. Thus, another reason for low fruit set might be that there are no other selections that would be able to pollinate it- even not in an experimental orchard with hundreds of selections.

The significant difference of unassisted self-pollination from other pollination treatment suggests that pollen transfer is necessary for abundant fruit set. *Godini* et al. (1998) got to the same conclusion in some self-fertile sweet cherry cultivars as they had much lower fruit set after autogamy than in case of open- or artificial self-pollination. In self-sterile, partially self-fertile and self-fertile sour cherry cultivars *Nyéki* (1989) observed less set by autogamy (11.6% as an average) than by geitonogamy (20.6% as an average). Generally, autogamy was not sufficient to produce enough yield.

In our observation artificial self-pollination gave better results than open pollination. Likewise Miltiadis et al. (1984) in almond cultivars got better fruit set (56.8%) by geitonogamy than by autogamy or open pollination (38.0% and 40.0%, resp.). On the other hand, *Godini* et al. (1998) had lower fruit set in sweet cherry after geitonogamy comparing with open pollination: the insects did it better than the brush.

Experiments on the pollination of '*Stella*' were performed by other authors. Comparing their observations with our results, no considerable differences were found. *Lange* (1979) reported slightly higher fruit set after open pollination than unassisted- or artificial self-pollination. However, *Apostolné* (1994) observed that autogamy of '*Stella*' was more successful than in our experiments.

It was not possible to conclude any interaction of fruit set in sweet cherry following self- and open pollination, it needs to be tested by involving more self-fertile selections.

References

Albertini, A. & Strada, G.D. (2001): Monografia di cultivar di Ciliegio dolce e acido (Sweet and sour cherries monography). Roma, p140–150.

Apostol, J. (1999a): Distribution of some characteristics in the sweet cherry progeny 'Bigarreau Burlat' x 'Stella'. Acta Horticulturae. 484: 245–247.

Apostol, J. (1999b): Results of the sweet cherry breeding programme in Hungary. Acta Horticulturae. 484: 177–178.

Apostolné (1994): Cseresznyefajták és -hibridek értékelése. Thesis. MTA, Budapest

Bargioni, G. (1996): Sweet cherry scions: characteristics of the principal commertial cultivars, breeding objectives and methods. [*In:* **Webster, A.D. & Looney, N.E. (eds.):** Cherries: Crop physiology, production and uses. CAB International.] p73–112.

Békefi Zs., Tobutt, K.R. & Sonneveld, T. (2003): Determination of (in)compatibility genotypes of Hungarian sweet cherry (*Prunus avium* L.) accessions by PCR based methods. Horticultural Science. 9(3-4): 37–42.

Brózik S. (1962): A Germersdorfi óriás cseresznyefajta termékenyülési viszonyai. Kísérletügyi Közlemények. 2: 111–144.

Brózik S .& Apostol J. (2000): Cseresznye. In: *Brózik S. & Kállay Tné* (eds.): Csonthéjas gyümölcsfajták. Mezőgazda Kiadó, Budapest, 187 pp

Brózik S. & Nyéki J. (1980): A cseresznye. In: *Nyéki J.* (ed.): Gyümölcsfajták virágzásbiológiája és termékenyülése. Mezőgazdasági Kiadó, Budapest p195–204.

Crane, M.B. & Lawrence, W.J.C. (1929): Genetical and cytological aspects of incompatibility and sterility in cultivated fruits. Journal of Pomology and Horticultural Science. 7: 276–301.

Crane, M.B. & Brown, A.G. (1937): Incompatibility and sterility in the sweet cherry, *Prunus avium* L. Journal of Pomology and Horticultural Science. 15: 86–116.

Godini, A., Palasciano, M., Cozzi, G. & Petruzzi, G. (1998): Role of self-pollination and horticultural importance of self-compatibility in cherry. Acta Horticulturae. 468: 567–571.

Harsányi J. and Mády Rné (eds.) (2003): Szőlő- és Gyümölcsfajták leíró jegyzéke. 165pp

Holb I. J. (2003): The brown rot fungi of fruit crops (*Monilinia* spp.): Important features of their biology. International Journal of Horticultural Sciences. 9 (3–4): 23–36.

Holb I. J. (2004): The brown rot fungi of fruit crops (*Monilinia* spp.): Important features of their epidemiology. International Journal of Horticultural Sciences. 10 (1): 17–33.

Kerékné (1981): Meggyfajták és fajtajelöltek termékenyülés-biológiája. Thesis. MTA Budapest.

Lane, W.D. & Sansavini, D. (1988): New Star. Rivista Frutticoltura. 1:19–24.

Lane, W.D. & Schmidt, H. (1984): Lapins and Sunburst sweet cherry. Canadian Journal of Plant Science. 64: 211–214.

Lang, G., Ophardt, D. & Olmstead, J. (1998): Sweet cherry breeding at Washington State University. Acta Horticulturae. 468: 97–104.

Lange, W.D. (1979): Journal of Horticultural Science 34: 87-89.

Lapins, K.O. (1971): '*Stella*', a self-fruitful sweet cherry. Canadian Journal of Plant Science. 51: 252–253.

Lewis, D. & Crowe, L.K. (1954): Structure of the incompatibility gene. IV. Types of mutations in *Prunus avium* L. Heredity. 8: 357–363.

Maliga P. (1952): Badacsonyi és Germersdorfi cseresznye termékenyülési adatai. Agrár Egy. Kert. és Szőlőgazdasági Kar Évkönyve. p27–49.

Matthews, P. & Lapins, K. (1967): Self-fertile sweet cherries. Fruit Varieties and Horticultural Digest. 21: 36–37.

Matthews, P. (1970): Genetics and exploration of self-fertility in the sweet cherry. Proceedings of the Angers Fruit Breeding Symposium, p307–316.

Miltiadis D., Vasilakakis & Porlingis, I.C. (1984): Self-compatibility in 'Truoito' almond and the effect of temperature on selfed and crossed pollen tube growth. HortScience. 19: 659–661.

Nyéki J. (1989): Csonthéjas gyümölcsűek virágzása és termékenyülése. Thesis. MTA, Budapest.

Olmstead, J.W., Whiting, M.D. & Lang, G.A. (in press): New sweet cherry cultivars and selections from Washington State University. Acta Horticultural

Sonneveld, T., Tobutt, K.R. & Robbins, T.P. (2003): Allele-specific PCR detection of sweet cherry incompatibility (S) alleles S1 to S16 using consensus and allele-specific primers. Theoretical and Applied Genetics. 107: 1059–1070.

Stancevic, A.S. (1971): Fertility examinations in some important sweet cherry cultivars (in Serbian). Jugoslovensko Vocarstvo. 17–18: 149–162.

Stösser, R. (1966): Befruchtungsbiologische Untersuchungen bei Süßkirschen. Erwerbsobstbau. 8: 211–214.

Szabó Z. & Nyéki J. (1987): Szilvafajták társítása. Lippay János Tudományos Ülésszak előadásai. Kertészeti és Élelmiszeripari Egyetem Kiadványai. 1: 451–462.

Szabó Z. (1989): Európai és japán szilvafajták virágzása, termékenyülése, társítása. Thesis. MTA, Budapest

Szabó Z. (2002): Csonthéjas gyümölcsűek termésbiztonságának egyes tényezői. Thesis. MTA, Budapest

Thompson, M. (1996): Flowering, pollination and fruit set. [In: Webster, A.D. & Looney, N.E. (eds.): Cherries: Crop physiology, production and uses. CAB International.] p223–242.

Tóth E. (1957): Élet- és alaktani összehasonlító vizsgálatok szilvafajtákon. Kertészeti Kutató Intézet Évkönyve. 2: 11–129.

Tobutt, K.R., Sonneveld, T. & Bošković, R. (2001): Cherry (in)compatibility genotypes – harmonization of recent results from UK, Canada, Germany, Japan and USA. Eucarpia Fruit Breeding Section Newsletter. (5.) 41–46.

Wolfram, B., Ulrich, B. & Richter, C. (1990): Investigations into self-fertility of progenies in cross experiments with sour cherry cultivars and clones and its influence on yield. Advances in Fruit Breeding, Berlin, Academy of Agriculture. p165–171.

Wolfram, B. (1999): Self-fertility as a factor of yield potential in progenies of sweet and sour cherries. Acta Horticulturae. 484: 291–296.