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# Compatibility Relations in some Sweet Cherry Cultivars

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**Kompatibilitní poměry u některých kultivarů třešní**

Během sedmi let byly zkoumány vzájemné kompatibilitní poměry 16 kultivarů třešní (*Prunus avium* L.), pěstovaných v Československu. Úspěšná opylení hodnocena podle procenta zralých plodů. Výsledky jsou shrnuty v tabulce 1. Podle plodnosti i opylovací schopnosti sestaveno pak v tabulce 2. pořadí jednotlivých kultivarů.

Bylo zjištěno, že u nás pěstovaný kultivar Chrupka císaře Františka se liší příslušností k inkompatibilitní skupině a tudíž i svou genotypovou konstitucí od stejnojmenného kultivaru, pěstovaného v západní Evropě. Označen proto jako Chrupka císaře Františka B. Je inkompatibilní s kultivarem Winklerova černá chrupka, který patří do II. skupiny (genotyp $S^1S^3$).

Všechny ostatní sledované kultivary jsou vzájemně kompatibilní. Je proto třeba při výsadbách uvedených sort přihlížet pouze k době květení.

Diskutovány příčiny, způsobující opakovanou jednostrannou inkompatibilitu. Pravděpodobnější příčina je v květní biologii (stáří květů mateřské rostliny) nežli v genotypové konstituci.

## Summary

In the course of seven years, mutual compatibility relations in 16 Sweet Cherry cultivars, grown in Czechoslovakia were investigated. Successful pollinations were evaluated according to the percentage of fully ripe fruits. The results obtained are summarized in Table 1. The fertility as well as the pollinating ability of the individual cultivars are recorded in Table 2.

It was found that the cultivar Emperor Francis, cultivated in this country, differs from the variety of the same name grown in Western Europe, belonging to another incompatibility group and thus being also of another genotype. It must therefore be designated as Emperor Francis B. It is incompatible with Bigarreau Noir de Winkler, belonging to incompatibility group II (genotype $S^1S^3$).

All remaining cultivars investigated are mutually compatible. Therefore, when larger plantings of these cultivars are to be established, only the time of flowering should be considered.

Further, the conditions are discussed which may cause repeated incompatibility in one direction only. The probable cause lies in flower biology (i.e. the age of blossoms of maternal plant) not in genotypic constitution.

## Introduction

The unability to obtain successful pollination between different varieties of cultivated plants, as a result of an incompatibility reaction between the style and the pollen, is very important from the practical point of view, apart of its theoretical significance. In plants grown for fruit production it is necessary in plantings to consider the relations of self and cross incompatibility. The most important plants of this type are fruit trees, and among them the situation is well recognized in representatives of the genus *Prunus*, especially in the diploid cultivars of Sweet Cherries, *Prunus avium* L. An allelic series in the locus S is responsible for the incompatibility reaction. At the present time six normal alleles of this series are known in Sweet Cherries (BROWN 1955). The occurrence of the same allele in the gynaecium as in the pollen grain hinders the pollen tube from growing into the style and the successful fertilization of the ovule. Therefore, under normal conditions there can only be heterozygous plants, throughout self-incompatible, thus autosterile. Different varieties of the same heterozygous genotype are cross-incompatible and thus inter-sterile.

In cherries the allele on the S locus acts in fact by its two components, the first governing the pollen activity and the second responsible for the style activity (LEWIS & CROWE 1954). In *Oenothera* too CROWE (1955) has shown that in the S locus actually two allelic series occur, one determining the pollen specificity, the other the specificity of the style. In both components of the allele a mutation is possible, stopping one or the other activity. But such situation represents a break-down of the incompatibility reaction which must result in self-fertility of the plant carrying the mutated allele $S^F$. These mutations very rarely occur spontaneously but may be induced through irradiation of flower buds at meiosis. In this way LEWIS & CROWE (1954) succeeded in obtaining self-fertile plants also in cherries, which are now used in further breeding work in Great Britain (LEWIS 1956, WILLIAMS & BROWN 1960).

In western countries where much attention is paid to the growing of cherries, individual cultivars have been thoroughly investigated in regard of their compatibility reactions. In a tabular survey compiled by CRANE & BROWN (1955) 91 varieties are registered. A total of 125 varieties have been tested at the John Innes Institute, and twelve incompatibility groups have been established (WILLIAMS & BROWN 1956). A thirteenth group contains further 20 varieties, all of which are compatible with the other 12 groups and most of which are compatible with one another. It is therefore a group of groups. In nine groups the precise genotypes of S alleles have hitherto been identified

(BROWN, unpublished). The genotypes of the remaining groups have not yet been determined. The highest frequency (32 per cent) is attained by the $S^3$ allele, the second by the $S^1$ allele (25 per cent) and then follows the $S^2$ allele (19 per cent). These three alleles also form the most successful combinations from the breeder's point of view (WILLIAMS & BROWN 1956, WILLIAMS & GALE 1960).

The composition of the West European and particularly British sortiment of cultivars is very different from that in Central European countries. In cherries especially very many local varieties are cultivated in various countries. Thus among 64 cultivars whose genotypes have been precisely determined, there are only six that are also grown in Czechoslovakia. The investigation reported in the present paper had the aim of ascertaining the mutual compatibility relations between some more important varieties grown in Czechoslovakia.

## Material and Methods

A total of 16 Sweet Cherry cultivars were investigated. In the following list the characteristics of each variety are given, its time of ripening (mostly according to FERKL 1958), its origin, and, if known, also the incompatibility group to which it belongs and its genotype.

Bigarreau Dönissen. Mid season ripening, yellow guigne-bigarreau, perhaps of Polish or German origin (Gubin). Compatible with group IV and VI.

Bigarreau Germersdorf. Late ripening black bigarreau; originated at Germersdorf near Gubin (formerly Germany, now Polen).

Bigarreau Napoleon (Lauermanns Kirsche). Mid season or late ripening red bigarreau, most probably originating from Belgium (XVIII century). Incompatibility group III, genotype $S^3S^4$.

Bigarreau Noir de Winkler (Belle Agathe). Mid season till late ripening black guigne-bigarreau. Origin in XIX century in Lower Lausitz (Gubin), now Polen. Incompatibility group II, genotype $S^1S^3$.

Elton Heart. Light guigne produced at the end of XVIII century by T. A. Knight at Elton Hall (Herts.), England; mid season ripening. Incompatibility group VI, genotype $S^3S^6$.

Emperor Francis. Late red bigarreau, perhaps of English origin (1875?). West European type of this variety belongs to incompatibility group III and is of genotype $S^3S^4$. But our material behaved differently.

Hâtive de Molitorov (Vítovka Molitorovská). Early till mid season ripening dark guigne; originated in Central Bohemia in XIX century.

Hedelfingen. Very late ripening black bigarreau of West German origin (Hedelfingen, Württenberg, 1850). Incompatibility group VII, genotype $S^4S^5$.

Karešova. An early red guigne, originating in Eastern Bohemia (around the town Hořice) at the beginning of this century.

Kostelnice. Dark guigne, mid season ripening, origin in Eastern Bohemia (Nové Město n. Met.), early XX century.

Májovka Velichovská. Very early red guigne; a local variety of Eastern Bohemia (Bath Velichovky).

Moreau (Souvenir des Charmes). Mid season ripening black bigarreau of French origin.

Ramon Oliva. Mid season ripening dark red guigne-bigarreau, originated in France. Incompatibility group X. Genotype not yet determined.

Srdcovka přeúrodná. Mid season ripening light guigne of Bohemian origin (Central Bohemia, near Praha, XIX century).

Thurn Taxis. Late dark red bigarreau, originated in Central Bohemia (town Dobrovice) at the beginning of XX century.

Žalanka. Mid season ripening dark guigne, origin in Central Bohemia (near Praha) in XIX century.

These sixteen varieties were mutually pollinated in both directions making 240 combinations (without autogamies). The investigation was performed in the years 1953—1960. The trees were cultivated in large pots and pollinations made in a greenhouse, to which the entrance of any insect was carefully prevented. At least 20 flowers were pollinated in each combination. Pollination of every flower was repeated once or twice within two or three days of anthesis. The unsuccessful combinations were always repeated in the next year. A total sum of 10359 flowers were pollinated. Successful compatible pollination was considered to be only that in which fruits resulted, attaining full maturity. The number of these ripe fruits is always expressed as a percentage. In the final evaluation of each variety a mean percentage of fruit setting (after pollination with all others) was calculated. Each variety was also classified as a pollinator according to the mean percentage of fruits set in all varieties functioning as maternal plants.

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## Results and Discussion

Results of all 240 pollination combinations are summarized in a tabular survey (Table 1). The numbers in this table represent percentage of ripe fruits from flowers pollinated. The marks – designate repeatedly unsuccessful combinations. The last column and the last row contain mean percentages of individual varieties. The varieties are placed in the table with those belonging to known incompatibility groups with known genotypes first. A peculiar case is that of our variety Emperor Francis. Then follow varieties of wider distribution, but without precise knowledge of the incompatibility groups to which they belong. As last indigenous local varieties are introduced in order of fertility expressed in fruit set percentage.

A true incompatibility reaction manifests itself in cherries by reciprocal failure of pollination. This case occurred only once, i.e. between Big. Winkler and Emperor Francis. The former is a representative of the incompatibility group II, having the genotype $S^1S^3$. As our Emperor Francis was compatible in both directions with Big. Napoleon (incompatibility group III, genotype $S^3S^4$), it cannot be of this genotype and thus differs from plants of the same name grown in western countries. This case is not quite unique, as Crane & Lawrence (1938) already mention various types of one pomological variety, differing among themselves by S genotypes and thus belonging to different incompatibility groups (e.g. Mezel A, Mezel B, Black Tartarian A, D ,E). Therefore our Emperor Francis, belonging to incompatibility group II and consequently having the genotype $S^1S^3$ must be labelled as Emperor Francis B.

From the remaining fourteen cultivars investigated, not even two form a common incompatibility group. This means that they all pollinate each other more or less successfully. This is an important fact since with large plantings of these cherry cultivars it is not necessary select distinct varietal combinations, the only thing which must be respected being the time of

Table 1

| ♂ / ♀ | Big. Winkler | Emperor Francis B | Big. Napoleon | Elton Heart | Hedelfingen | Ramon Oliva | Big. Dönissen | Big. Germersdorf | Moreau | Májovka Velichovská | Kostelnice | Hâtive de Molitorov | Žalanka | Srdcovka přeúrodná | Karešova | Thurn Taxis | $\bar{x}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Big. Winkler | — | — | — | 5 | 5 | 55 | 33 | — | 5 | 3 | 50 | — | 10 | 10 | 33 | 20 | 21 |
| Emperor Francis B | — | — | 7 | 45 | — | 10 | 32 | 10 | 18 | 34 | 5 | 25 | 15 | 50 | 15 | 15 | 22 |
| Big. Napoleon | 20 | 16 | — | 24 | 3 | 23 | 38 | 27 | 7 | 35 | 26 | 13 | 25 | 29 | 9 | 40 | 22 |
| Elton Heart | 5 | 9 | 6 | — | 12 | 5 | 14 | 9 | 17 | 5 | 25 | 45 | 50 | 42 | 22 | 3 | 18 |
| Hedelfingen | 33 | 5 | 26 | 40 | — | 20 | 65 | 40 | 26 | 10 | 5 | 25 | 20 | 30 | 25 | 80 | 30 |
| Ramon Oliva | 10 | 35 | 10 | 5 | 25 | — | 37 | 25 | 25 | 35 | 49 | 40 | 45 | 20 | 45 | 20 | 28 |
| Big. Dönissen | 28 | 20 | 20 | 20 | 19 | 35 | — | 27 | 30 | 22 | 26 | 25 | 20 | 29 | 40 | 10 | 25 |
| Big. Germersdorf | 21 | 30 | 10 | 23 | 38 | 5 | 15 | — | 5 | 71 | 50 | 60 | 36 | 7 | 4 | 15 | 26 |
| Moreau | 54 | 9 | 30 | 25 | 25 | 36 | 90 | 40 | — | 7 | 34 | 17 | 30 | 25 | 36 | 75 | 35 |
| Májovka Velichovská | 73 | 40 | 43 | 44 | 27 | 60 | 53 | 100 | 55 | — | 70 | 55 | 65 | 48 | 50 | 85 | 58 |
| Kostelnice | 28 | 10 | 36 | 35 | 40 | 100 | 35 | 25 | 38 | 44 | — | 56 | 70 | 85 | 60 | 46 | 45 |
| Hâtive de Molitorov | 18 | 52 | 17 | 21 | 20 | 45 | 44 | 38 | 39 | 25 | 32 | — | 37 | 83 | 58 | 90 | 41 |
| Žalanka | 50 | 15 | 45 | 45 | 15 | 55 | 40 | 25 | 35 | 5 | 50 | 2 | — | 70 | 17 | 3 | 31 |
| Srdcovka přeúrodná | 28 | 25 | 27 | 50 | 15 | 20 | — | 25 | 19 | 18 | 36 | 30 | 45 | — | 19 | 70 | 30 |
| Karešova | 53 | 25 | 26 | 40 | 5 | 33 | 79 | 50 | 12 | 23 | 32 | 10 | 20 | 10 | — | 20 | 29 |
| Thurn Taxis | 64 | 18 | 23 | 30 | 10 | 14 | 35 | 27 | — | 38 | 21 | 14 | 25 | 16 | 5 | — | 24 |
| $\bar{x}$ | 35 | 22 | 23 | 30 | 18 | 34 | 43 | 33 | 24 | 25 | 32 | 30 | 34 | 37 | 29 | 40 | 30 |

flowering of these varieties. Crane & Brown (1937) state that in compatible pollinations the fruit set percentage varies from 4 to 60. Very rarely in incompatible pollinations, as a result of pseudofertility, single fruits sometimes appear, but their set percentage does not reach 0·3 being as a rule only 0·1 per cent. Mean per cent of fruits set after various compatible pollinations is stated as 26 (Crane & Lawrence 1938). In our material the lowest set of fruits was 2 per cent (in combination Žalanka × Hât. de Molitorov), on the other hand, in two combinations a full hundred per cent of set fruits was reached (Kostelnice × Ramon Oliva and Májovka Velichovská × Big. Germersdorf). The mean percentage of all our successful combinations was 30. If we now consider the fruit setting percentage of individual cultivars, we obtain a different order from that according to pollinating ability. Both these arrangements are given in Table 2. Its left part contains the order in fertility of maternal varieties, the right part that of successful pollinators. It is interesting that especially in fertility the indigenous cultivars occupy the leading location in the table.

In Table 1 there are 6 instances of failure of pollination in one direction only. Attention should be paid to these cases, as these negative results were obtained repeatedly. Such non-reciprocal incompatibility could be due to two reasons. The first is not genetic, only physiological. Eaton (1959) found that in cherries the number of non-functioning egg-cells increases with the time of flowering. Thus, for successful fertilization pollination is necessary

Table 2

| Fertility of cultivars | | | Pollinating ability of cultivars | | |
|---|---|---|---|---|---|
| Order | Name | per cent of fruit set | Order | Name | per cent of fruit set |
| 1 | Májovka Velichovská | 58 | 1 | Big. Dönissen | 43 |
| 2 | Kostelnice | 45 | 2 | Thurn Taxis | 40 |
| 3 | Hâtive de Molitorov | 41 | 3 | Srdcovka přeúrodná | 37 |
| 4 | Moreau | 35 | 4 | Big. Winkler | 35 |
| 5 | Žalanka | 31 | 5 | Žalanka | 34 |
| 6 | Srdcovka přeúrodná | 30 | 6 | Ramon Oliva | 34 |
| 7 | Hedelfingen | 30 | 7 | Big. Germersdorf | 33 |
| 8 | Karešova | 29 | 8 | Kostelnice | 32 |
| 9 | Ramon Oliva | 28 | 9 | Hâtive de Molitorov | 30 |
| 10 | Big. Germersdorf | 26 | 10 | Elton Heart | 30 |
| 11 | Big. Dönissen | 25 | 11 | Karešova | 29 |
| 12 | Thurn Taxis | 24 | 12 | Májovka Velichovská | 25 |
| 13 | Big. Napoleon | 22 | 13 | Moreau | 24 |
| 14 | Emperor Francis B | 22 | 14 | Big. Napoleon | 23 |
| 15 | Big. Winkler | 21 | 15 | Emperor Francis B | 22 |
| 16 | Elton Heart | 18 | 16 | Hedelfingen | 18 |

immediately after the opening of the flower. When a large number of different combinations are simultaneously performed in the same year, it is quite possible that, since all varieties do not bloom at exactly same time, some pollinations are effected on flowers one or two days old, merely because the pollen of the respective paternal variety was not available when they first opened. This situation might be repeated even in subsequent years. I consider this explanation as much more probable than the second possible cause.

The second cause could be the homozygous constitution of the unsuccessfully pollinating variety. A homozygous constitution may be attained in two ways. Either through a mutation of one S allele, or as a result of pseudofertility at autogamy. It is known that quite exceptionally successful self-fertilization may be realized even in an absolutely auto-incompatible plant. This is possible if pollination takes place in a not yet opened flower bud. This was called pseudofertility by East & Park (1917). Another cause of pseudofertility is temperature conditions at the time of flowering (Tomková 1962). These two possibilities cannot be excluded, though no instances of homozygous constitution in cultivars of cherries are known.

Let us pay attention now to our individual cases. In the case of an unsuccessful pollination Big. Winkler × Big. Napoleon the homozygosity of the variety Big. Napoleon is excluded. It could be merely $S^3S^3$, but in this case it could not pollinate successfully the variety Elton Heart from incompatibility group VI, genotype $S^3S^6$. In the second instance there was a failure in pollination Big. Winkler × Big. Germersdorf (reciprocal cross 21 per cent of fruits set). The pollinating variety Big. Germersdorf cannot be homozygous ($S^1S^1$ or $S^3S^3$) as then it ought be an incompatible pollinator of our variety Emperor Francis B; in fact it pollinates all other varieties successfully, except Big. Winkler. There is an analogous situation also in further instances (Big. Winkler × Hâtive de Molitorov, Emperor Francis B × Hedelfingen). In the remaining cases the situation is not quite clear. As already stated, the age of pollinated flowers is a much more probable cause of nonreciprocal failure of fertilization than a homozygous condition of the pollinator. This question will be further followed.

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### Способность к взаимному опылению у некоторых сортов черешни

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В течение семи лет была исследована взаимная способность к опылению у 16 сортов черешни (*Prunus avium* L.), разводимых в Чехословакии. Успешное опыление оценивалось по проценту созревших плодов. Результаты приведены в таблице 1. В таблице 2 помещены отдельные культурные сорта в порядке соответственно их плодовитости и способности опылять.

Было обнаружено, что разводимый в Чехословакии сорт Хрупка цисарже Франтишка отличается своей принадлежностью к инкомпатибильной группе и, следовательно, также и своим генотипом отличается от культурного сорта, разводимого под таким же названием в Западной Европе. Поэтому он обозначен автором как Хрупка цисарже Франтишка В. Этот сорт инкомпатибилен по отношению к сорту Черная хрупка Винклера, принадлежащему к группе II (генотип $S^1S^3$).

Все остальные исследованные сорта компатибильны, так что при их посадке необходимо учитывать лишь их время цветения.

Автор рассматривает причины, вызывающие повторную одностороннюю несовместимость. Вероятной причиной является скорее биология цветения (возраст цветов материнского растения), чем генотипический состав.