

## INCOMPATIBILITY PROBLEMS IN SWEET CHERRY TREES ON DWARFING ROOTSTOCKS SALDO ĶIRŠU NESADERĪBA AR PUNDURPOTCELMIEM

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### Kopsavilkums

Potcelmu un potzaru nesaderība ir sen zināma problēma dārzkopībā. Dažām sugām tā ir nopietna problēma. Parasti lietotajiem *Cerasus mahaleb* potcelmiem nav problēmu ar šķirņu saderību. Savādāk ir, ja potcelms ir *Prunus* ģints hibrīds vai atšķirīgs no *P. avium* sugas, kā tas ir saldo ķiršu pundurpotcelmiem. Šajā gadījumā jāveic potcelma un šķirnes saderības pētījumi pirms to ieviešanas praksē. Pārskats par dažiem pētījumiem šajā jomā ir apkopots rakstā. Te arī minētas hipotēzes, kas skaidro saderības trūkumu.

### Abstract

The problem of incompatibility between rootstock and scion in horticulture has existed ever since grafting and budding were first employed. Some of the fruit tree rootstocks produce a very good junction with top varieties, but with some others the effectiveness of budding is very low. Usually, there are no problems with the growth or cropping of sweet cherry trees on the Mazzard rootstock. In that case, "compatibility" between the two partners is good. However, this may be different when the rootstock is a hybrid of the *Prunus* species or a selection of other than *P. avium* *Prunus* species. Most of the dwarfing rootstocks for sweet cherry trees are hybrids and because of the likelihood of incompatibility, the introduction of them to practice should be preceded by detailed investigations of the compatibility between the two graft components. Otherwise, neither the nurseryman nor the fruit grower will be satisfied. A review of some publications with the results of studies on the physiological incompatibility between scions and the best known cherry dwarfing rootstocks, as well as hypotheses that try to explain the lack of or reduced compatibility between joined components are presented in the article.

**Keywords:** Sweet cherry, rootstock, cultivar, scion-rootstock incompatibility

### Introduction

Rootstocks have been used as a means of propagating fruit trees for at least two thousand years. The history of seedling rootstocks is longer than that of clonal, i.e. vegetatively propagated rootstocks. Among the dwarfing rootstocks the first to be discovered were rootstocks for apple trees. Dwarfing rootstocks for sweet cherry trees have proved much more difficult to breed and it is only in the last years that they have been introduced to commercial orchards (Webster, 2004). At the Fruit Research Station in East Malling, England, the collection of cherry rootstocks started in 1914 with the aim of eliminating the variability through vegetative propagation and to study the effects of clonal rootstocks on scion performance. This work resulted in the release of Mazzard rootstock 'F 12/1' (*P. avium*) that could be propagated vegetatively. 'F 12/1' performed as very vigorous rootstock. According to the Report of East Malling Research Station, 'Colt' (*P. avium* x *P. pseudocerasus*), bred in 1958, had for many years been regarded and marketed commercially as the first rootstock for the sweet cherry, providing some control of tree vigour (Tydeman and Garner, 1966; Webster, 1996). However, numerous experiments, some of them also conducted in Poland, have not confirmed that 'Colt' gives smaller trees in comparison with the clonal or seedling Mazzard rootstocks - trees on 'Colt' were similar in size or even more vigorous (Grzyb *et al.*, 1998; Sitarek *et al.*, 1999). The first results on really dwarfing rootstocks for sweet cherry trees were published in 1970s. At this time breeding programs on new sweet cherry rootstocks were being realized in Europe and the USA (Wertheim, 1998). New dwarfing and semi-dwarfing rootstocks, presently evaluated in many countries and already used in practice, may change sweet cherry production. Fruit trees of small sizes are easier and cheaper to manage, crop more precociously and productively and often bear fruits of higher quality than the traditional large trees. In addition, dwarf trees would also allow the use of plastic roofs

to protect fruits from rain-induced cracking as well as nets covering the trees to protect them from damage caused by birds (Balmer, 1998; Meland and Skjervheim, 1998; Sitarek *et al.*, 1999; Webster, 1998). However, most of the dwarfing rootstocks for sweet cherry trees are hybrids of some *Prunus* species, and *Prunus* is a very large genus that comprises many species (Webster and Schmidt, 1996; Wertheim, 1998). Sweet cherry cultivars grafted on rootstocks of different genetic origins may lead to incompatibility problems (Factea *et al.*, 1996; Stehr, 1998; Sitarek and Grzyb, 1998; Webster and Schmidt, 1996; Wertheim *et al.*, 1998).

The aim of this paper is to describe, briefly, incompatibility problems in sweet cherry trees grafted on dwarfing rootstocks. This short article reviews some publications with the results of studies on physiological incompatibility between scions and the best known cherry dwarfing rootstocks as well as hypotheses that try to explain the lack of or reduced compatibility between joined components. The best known dwarfing rootstocks for sweet cherry trees

#### The GiSelA series

In the period 1965-1971, an elaborate crossing programme was carried out at the University in Giessen, Germany, involving four different *Prunus* species – *P. avium*, *P. fruticosa*, *P. canescens* and *P. cerasus*. After more than 20 years of evaluation in many experiments with numerous GiSelA clones, the most promising among them seems to be ‘GiSelA 3’, ‘GiSelA 5’ and ‘GiSelA 6’ (Azarenko and McCluskey, 1998; Franken-Bembenek, 1998 and 2004).

#### The P-HL series

These are rootstocks that originated at Holovousy in the Czech Republic in 1963 and likely are hybrids of *P. avium* and *P. cerasus*. After a preliminary selection, six P-HL clones were chosen for detailed evaluation. Outside the Czech Republic, P-HL rootstocks have been tested in Poland since 1988. The results of those experiments show that the best in Polish growing conditions is clone ‘P-HL A’. In comparison to ‘F 12/1’, the ‘P-HL A’ rootstock improves tree productivity and enables planting of intensive sweet cherry orchards (Grzyb *et al.*, 1998; Sitarek *et al.*, 1999).

#### The Weiroot selections

Collection of *P. cerasus* clones began in 1960, and selection took place in 1965 at the Institute for Fruitgrowing in Weihenstephan, Munich, Germany. The 18 clones that had been selected had different vigour. Clones 10, 11 and 13 showed good characteristics in orchard trials. However, the latest experiments have revealed big incompatibility problems with the first Weiroot rootstocks. Therefore, a new series was raised from seeds of ‘Weiroot 11’, and the new clones, numbered 53, 72 and 158, seem to be much better than the previous ones (Stehr, 1998).

#### The M x M rootstocks

The M x M series originated in Oregon, USA, from a cross between *P. avium* and *P. mahaleb*. The most known in the M x M series are clones number 2, 14, 39, 60 and 97. Of these, only ‘M x M 14’ and ‘M x M 97’ are semi-dwarfing (Azarenko and McCluskey, 1998).

#### The Gembloux rootstocks

At a research station in Gembloux, Belgium, three rootstocks - ‘Inmil’ (GM 9), ‘Damil’ (GM 61) and ‘Camil’ (GM 79), were selected. ‘Inmil’ (*P. incisa* x *P. serulata*) is considered too weak for commercial use. ‘Damil’ (*P. dawyczensis*) and ‘Camil’ (*P. canescens*) are promising, but incompatibility may be a problem in practice (Wertheim *et al.*, 1998). In recent years new breeding programmes relevant to the dwarfism of sweet cherry trees have been initiated among the progeny of ‘Damil’ (Druart, 1998).

#### Graft incompatibility facts

Many authors (Chang, 1937; Tietierjew, 1964; Webster and Schmidt, 1996) are of the opinion that the rootstock determines the success of budding. Some of the fruit tree rootstocks produce a very good junction with top varieties, but with some others the effectiveness of budding is very low. Usually, there are no problems with the growth or cropping of sweet cherry trees on the Mazzard rootstock. In that case, “compatibility” between the two partners is good. However, this may be different when the rootstock is a hybrid of the *Prunus* species or a selection of other than *P. avium* *Prunus* species. So, we can expect incompatibility problems not only in the case of hybrid rootstocks of a different genetic origin. For example, the combination of sweet cherry cultivars with *P. cerasus* rootstocks (Weiroot series) is not always safe either (Wertheim, 1998). It means that *P. avium* and *P. cerasus* differ very much, both in visible characteristics and in metabolism. The symptoms of incompatibility vary. Incompatibility may manifest itself already in the nursery as a low percentage of

buds and grafts taken, weak growth of maidens, maidens breaking in the graft zone during strong winds or yellowish leaves. In many cases, it is a result of a poor junction between scion and rootstock. Three forms of discontinuity of wood and bark are observed, namely: bark continuous, but wood discontinuous; bark discontinuous, but wood continuous; both bark and wood discontinuous (Chang, 1937). Such obvious symptoms of incompatibility were demonstrated in 'Hedelfingen' trees on 'P-HL A' in an experiment conducted in Poland by Sitarek and Grzyb (1998). One-year-old trees of 'Hedelfingen' on 'P-HL A' reached only 52.2% of the height of the trees on Mazzard seedlings, but some other cultivars budded on this rootstock were only 3.5 to 20.0% smaller. 'Hedelfingen' maidens on 'P-HL A' showed typical symptoms of incompatibility, expressed in total growth inhibition in the middle of the growing season and precocious leaf yellowing and abscission. Those trees produced apical buds as early as July and tree growth was arrested. During the first year in the orchard, the mortality rate of the trees was extremely high. In spite of clear symptoms of incompatibility, the bud-take rate of 'Hedelfingen' on 'P-HL A' was similar to other combinations. Microscopic examination of the graft union of 'Hedelfingen' sweet cherry trees with the 'P-HL A' rootstock revealed a weak junction between the two components. An isolating layer that makes proper diffusion of water and nourishing elements difficult was clearly visible. Both bark and wood were discontinuous.

In the second experiment, 'Summit', 'Techlovan', 'Sylvia', 'Regina', 'Lapins' and 'Heidegger' were chip-budded with the dwarfing rootstocks 'P-HL A', 'P-HL B' and 'GiSelA 5'. The same cultivars budded on 'F 12/1' were used as the control. The effectiveness of budding varied from 74 to 97% depending on the rootstock/cultivar combinations. However, the rootstocks had no significant influence on the number of the budded trees produced. All the cultivars tested on 'F 12/1' grew significantly more vigorously than those grafted on 'P-HL A', 'P-HL B' and 'GiSelA 5' rootstocks. One-year-old trees of 'Heidegger' on the dwarfing rootstocks 'P-HL A', 'P-HL B' and 'GiSelA 5' reached only 45 to 59% of the height of the control trees, but other cultivars included in the experiment and grafted on the same rootstocks were only 9 to 28% smaller than the control. In terms of trunk diameter a similar tendency was observed. Only on 'F 12/1' 'Heidegger' grow normally, and on 'P-HL A', 'P-HL B' and 'GiSelA 5' rootstocks it showed typical symptoms of incompatibility, expressed in total growth inhibition in the middle of the growing season and precocious leaf yellowing and abscission. During the first year in the orchard the mortality rate of those trees was extremely high. However, in contrast to the previous trial, microscopic examination of the graft union between 'Heidegger' and the dwarfing rootstocks did not show any clear isolating layer between xylem and phloem tissues of the scions and rootstocks. All the sweet cherry trees budded on 'P-HL A', 'P-HL B' and 'GiSelA 5' were smaller than those on 'F 12/1'. This weak growth does not mean a lack of compatibility between the joined components; the only exception was the cultivar 'Heidegger'. The small size of a grafted tree is an indication of the dwarfing effect of the rootstock, but it does not reveal anything about physiological incompatibility (Sitarek and Grzyb, 2005). Examples of incompatible rootstock/scion combinations cited in the literature are listed in Table 1.

Table 1. Examples of incompatible scion/rootstock combinations

Cultivar	Rootstock
'Sam'	'Colt', 'Weiroot 158'
'Hedelfińska'	'Colt', 'Weiroot 13', 'P-HL A', 'Damil', 'P-HL C'*
'Burlat'	'Colt'*, 'MxM 97',
'Ambrune'	'Colt'
'Van'	'Colt'
'Bianka'	'Damil'
'Techlovicka'	'P-HL A', 'P-HL C'
'Heidegger'	'P-HL A', 'P-HL B', 'GiSelA 5'
'Kordia'	'P-HL C'
'Karesova'	'P-HL C'
'Napoleona'	'P-HL C'
'Büttner's Red'	'GiSelA 5'*
'Summit'	'Camil', 'Colt'*
'Stella'	'Inmil'
'Schneiders'	'Inmil'

Explanation: \*Incompatibility may be caused by virus infection.

The early symptoms of incompatibility are a serious handicap to the nurseryman. However, from the point of view of the commercial fruit grower, it is a disadvantage when big trees, on reaching bearing age, suddenly break off at the union. This is a delayed incompatibility. In that case, trees live longer, looking normal in the beginning and even for up to 8 or 10 years, but after that they show many signs of poor health, such as small or yellowish leaves, stunted growth, premature autumn discolouration and drop of leaves, abundant flower buds formation and suckering. Sometimes, trees with incompatibility symptoms are similar to trees grown in stressful conditions such as too wet or too dry soil. For successful dwarfing rootstocks, it is perhaps necessary to have a sort of 'partial incompatibility', which allows adequate growth control, but also ensures good health and a long life span of the tree (Webster and Schmidt, 1996). 'Burlat' and 'Hedelfingen' cultivars grafted on 'Colt' are good examples of delayed incompatibility in sweet cherry cultivation. In these cases, incompatibility symptoms were not so evident, but little by little the trees declined. In the sixth year after planting in the orchard, there were only 3 out of the 12 'Burlat' trees planted and no 'Hedelfingen' trees left (Grzyb *et al.*, 1998). Problems with early tree losses affecting the variety 'Hedelfingen' have also been experienced with the rootstocks 'Damil' and 'GiSela 10' in Germany (Stehr, 1998).

#### Hypotheses that try to explain the lack of or reduced compatibility

Since the end of the nineteenth century many attempts have been made to explain the problems of incompatibility. Early investigations attributed incompatibility chiefly to structural weakness and abnormal deposits at the union, and the differences in the anatomy of the rootstock and scion as well as the difference in the power of the protoplasmic reaction between the rootstock and scion, resulting in a higher or lower concentration of the cell sap. Older conceptions regarded the botanical relationship as a fair guide to the compatibility of the rootstock and scion. It meant that plants belonging to the same botanical group might be successfully grafted. Later reports have revealed that the cause is of a biochemical origin. Reduced compatibility of heterogenetic grafts in sweet cherry trees is reflected by the varying amounts of polyphenols and sometimes by an accumulation of phenolic compounds above the union (Usenik and Stampar, 2001). The rootstocks 'F 12/1', 'GiSela 4', 'GiSela 5', 'GiSela 12', 'PiKu 4', 'Edabriz', 'Weiroot 13', 'Weiroot 72', 'Weiroot 158' were found to cause different concentrations of polyphenols in the phloem of 'Lapins' sweet cherry trees. Homogenetic grafts often show similar levels of polyphenols along the union (Gebhardt and Feucht, 1982). Therefore, rootstock clones of various cherry species can influence symptoms of incompatibility faster than *P. avium*.

Research work in the USA (Lang *et al.*, 1997) has shown that scions on several of the GiSela rootstocks are very sensitive to infections with plum dwarf virus (PDV) and/or prune necrotic ringspot virus (PNRSV). This was particularly evident with 'Gisela 1' and 'GiSela 10', but was also recorded with 'GiSela 7' and 'GiSela 8'. In these tests 'GiSela 5' and 'GiSela 6', which are currently two of the most promising in the GiSela series, fortunately show tolerance to infection by the two viruses. However, in a Polish trial, 'Büttner's Red' sweet cherry trees grafted on 'GiSela 5' did not grow well after PDV infection. A high number of declining flower buds was observed and a greater reduction in growth from one year to the next resulting in a slow decline of all the trees.

Table 2. Examples of good compatibility between sweet cherry cultivars and two dwarfing rootstocks the basis of the results of Polish trials

Rootstock	Cultivar
'P-HL A'	'Rivan', 'Burlat', 'Merton Premier', 'Karesova', Büttner's Red', 'Kordia', 'Vanda', 'Techlovan', 'Regina', 'Summit', 'Lapins', 'Sylvia'
Gisela 5	'Burlat', 'Vega', 'New York 980.1', 'Kordia', 'Regina', 'Techlovan', 'Summit', 'Lapins', 'Sylvia', 'Karina'

#### Conclusions

The causes of incompatibility show that it is necessary to test as many cultivars on promising new rootstocks as possible to prevent surprises. As new rootstocks and cultivars are regularly being

introduced, such testing requires constant attention. The introduction of dwarfing rootstocks to practice should be preceded by detailed investigations of the compatibility between the two graft components. Otherwise, neither the nurseryman nor the fruit grower will be satisfied.

Incompatibility between the rootstock and scion may be influenced by many factors. Early screening of new sweet cherry rootstocks for compatibility with the main cultivars recommended for cultivation is an important step in characterizing rootstock suitability for commercial production. On the basis of the results of Polish trials, a list of cultivars compatible with two dwarfing rootstocks used in practice has been prepared (Table 2). The growers who will set up intensive sweet cherry orchards with such trees can be assured of success.

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