

Evaluation of parent combinations fertility in plum breeding (*Prunus domestica* L.)

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Abstract: Plum as a fruit species initiates a large amount of fruit buds but the percentage of fruit set depends on many factors. The number of plants obtained from a certain combination is especially important in the breeding process, due to the fact that not all the seeds germinate after seed stratification by the conventional method in moist sand. Therefore it is very important to evaluate the fertility of the selected parent combinations with the aim of proper plan making. This study presents results of fertility evaluation of 43 parent combinations carried out in the period 2002-2010. A total of 30941 flowers were pollinated and 1406 hybrid seeds were obtained. The percentage of the obtained seeds compared to the pollinated flowers was 6.2% in average for all the combinations. The highest fertility – 46.3% was reported for the ‘Ortenauer’ x ‘Cacanska leptica’ crossing, followed by ‘Stanley’ x ‘Ortenauer’ – 22.8% and ‘Belle de Louvain’ x ‘Cacanska leptica’ – 21.9%. The results obtained suggested that the largest number of hybrid seeds in plum (*P. domestica* L.) breeding were obtained when cvs. ‘Althan’s Gage’, ‘Stanley’ and ‘Ortenauer’ were chosen as a mother parent and ‘Cacanska leptica’, ‘Sineva’ and ‘Cacanska najbolja’ as a father parent (pollinator).

Keywords: *Prunus domestica* L., hybridization, parent combination, evaluation of fertility.

Introduction

One of the most important aims of breeding new plum cultivars in Bulgaria is their resistance to Plum pox virus (PPV). Until now a gene for resistance to the disease has not been found. Due to that, cultivars that are either tolerant, partial

resistant or having the so-called “hypersensitive resistance” have been used as a source.

It was established that the response of plum cultivars to PPV was of two types – quantitative and qualitative. Hartmann (2002) determined that most of the known tolerant cultivars are cultivars of a quantitative-type response. They are infected by PPV but the symptoms of the disease are slightly expressed in fruit and the yield produced is enough in quantity and of acceptable quality. What is more, the infected trees are vital, which enables their use for a long period. The qualitative response was determined by the author as based on hypersensitivity – i.e. necrotic spots in the leaves and young shoots and splitting of the bark, as well as withering of branches, thus the virus was limited and the plants remained virus-free.

The first successful attempts to obtain resistant cultivars were achieved in Germany (Hartmann 1998) by combining in parent combinations cultivars of a quantitative and a qualitative type of response. The cultivar ‘Jojo’, which is practically non-infected by PPV, was obtained in that way. It was a result of crossing the tolerant cultivar ‘Stanley’ and the partial hypersensitive cultivar ‘Ortenauer’. For the last 20 years, plum breeding in Germany has developed in that direction.

Along with PPV resistance, the new cultivars should possess good economic and biological characteristics – good fertility, large sized fruit, good taste qualities, resistance to extreme climatic conditions, etc. All those requirements necessitate the assessment of the desired characteristics when selecting the parent combinations for donors.

Plum as a fruit species initiates a large amount of fruit buds but the percentage of the fruit set depends on the pollinating cultivar, as well as on the climatic conditions at the time of flower pollination and fertilization. In open pollination the percentage varies between 3 and 45% according to some authors (Vitanov 1975; Iliev 1985; Szabo and Nyeki, 2000). The number of plants obtained from a certain combination is especially important in the breeding process. It is known that not all the seeds germinate after seed stratification by the conventional method in moist sand. According to studies of Vitanov (1975) the average percentage of the seeds produced by purposeful crossings for a 13-year period, was 15.04% and the number of plants obtained after stratification was hardly 4.09%. This suggests the importance to evaluate the fertility of the selected parent combinations with the aim of proper planning of the breeding process.

Material and methods

The studies were carried out in the period 2002-2010 in plum collection plantations of the Fruit-Growing Institute – Plovdiv. New crosses were made in order to obtain new progenies adapted to different biotic or abiotic conditions, as

well as to satisfy consumer demands for quality. Genitors of Plum pox virus included tolerant or partial resistant genitors 'Althan's gage', 'Stanley', 'Cacanska najbolja', 'Cacanska leptica', 'Pacific' as well as new Bulgarian cultivars 'Sineva', 'Ulpia', and 'Plovdivska renkloda' and partial hypersensitive 'Ortenauer'. Genitors of late blooming included cultivars 'Nectavit', 'Ortenauer' and 'Pacific', for late fruit harvest 'Anna Spath', 'Elena' and 'Ortenauer' and genitors of fruit quality were 'Tuleu timpuriu', 'Cacanska najbolja', 'Cacanska leptica', 'Pacific', 'Malvazinka' and 'Mirabelle de Nancy'. Standard breeding technique such as crossing by emasculation and hand pollination was employed. The pollen of the pollinators was collected at the white button stage and kept in an exicator at a temperature of 20°C – 22°C. The number of the seeds obtained was reported and the percentage of seeds to the number of pollinated flowers was calculated. The results about parent combinations tested for more than one year were summarized for all the years.

Results and Discussion

During 2002-2010 the hybridization programme included 43 parent combinations, with 30941 flowers being pollinated and 1406 hybrid seeds obtained. The percentage of the obtained seeds compared to the pollinated flowers was 6.2% in average for all the combinations (Table 1). In different combinations this percentage varies from 0 to 46.3%. To evaluate the obtained results we used the cluster of Szabo (2000) for fruit set. He assigned 58 European plum according to their fruit set in freely blooming flowers to four groups: low - below 10% fruit set, intermediate between 10 to 20%; high from 20 to 40% and very high more than 40% fruit set. Our results can generally refer to the group that received a low fruit set, suggesting that to get more hybrid seeds it is necessary to increase the number of pollinated flowers. The highest fertility – 46.3% was reported for crossing No. 21 ('Ortenauer' x 'Cacanska leptica'), followed by crossing No. 28 ('Stanley' x 'Ortenauer') – 22.8%, crossing No. 34 ('Belle de Louvain' x 'Cacanska leptica') – 21.9% and crossing No. 1 ('Althan's gage' x 'Stanley') – 17.5%. These results show effectiveness of selected combinations (between groups of intermediate and very high fruit set). No seeds were obtained from the following crossings: No. 4 ('Althan's gage' x 'Ulpia'); No. 12 ('Elena' x 'Ulpia'); No. 40 ('Tuleu timpuriu' x 'Plovdivska renkloda') and No. 41 ('Tuleu timpuriu' x 'Pacific').

Table 1. Plum breeding programme 2002-2010

| № | Cross combination | № pollinate flowers | № obtain seeds | % of fruit set |
|--------------|---|----------------------------|-----------------------|-----------------------|
| 1. | 'Althan's gage' x 'Stanley' | 393 | 69 | 17.5 |
| 2. | 'Althan's gage' x 'Sineva' | 730 | 84 | 11.5 |
| 3. | 'Althan's gage' x 'Plovdivska renkloda' | 1064 | 41 | 3.8 |
| 4. | 'Althan's gage' x 'Ulpia' | 55 | 0 | 0 |
| 5. | 'Anna Spath' x Hybrid 1-9 | 444 | 9 | 2.0 |
| 6. | 'Anna Spath' x Hybrid 1-78 | 447 | 37 | 8,2 |
| 7. | 'Bluefre' x 'Ortenauer' | 667 | 10 | 1,5 |
| 8. | 'Valevka' x 'Cacanska najbolja' | 888 | 60 | 6.7 |
| 9. | 'Debreceni muskotaly' x 'Cacanska najbolja' | 993 | 43 | 4.3 |
| 10. | 'Debreceni muskotaly' x Hybrid 1-9 | 275 | 16 | 5,8 |
| 11. | 'Elena' x 'Sineva' | 595 | 21 | 3.5 |
| 12. | 'Elena' x 'Ulpia' | 248 | 0 | 0 |
| 13. | 'Elena' x 'Cacanska lepotica' | 951 | 22 | 2.3 |
| 14. | 'Imperial' x 'Stanley' | 165 | 15 | 9.0 |
| 15. | 'Imperial' x 'Cacanska najbolja' | 98 | 4 | 4.1 |
| 16. | 'Nectavit' x 'Pacific' | 427 | 16 | 3.7 |
| 17. | 'Ortenauer' x 'Pulpudeva' | 862 | 3 | 0.3 |
| 18. | 'Ortenauer' x 'Ulpia' | 1808 | 49 | 2.7 |
| 19. | 'Ortenauer' x 'Sineva' | 257 | 2 | 0.8 |
| 20. | 'Ortenauer' x 'Stanley' | 1370 | 39 | 2,8 |
| 21. | 'Ortenauer' x 'Cacanska lepotica' | 203 | 94 | 46.3 |
| 22. | 'Pacific' x 'Elena' | 1527 | 9 | 0.6 |
| 23. | 'Pacific' x 'Malvasinka' | 2396 | 14 | 0.6 |
| 24. | 'Pacific' x 'Plovdivska renkloda' | 514 | 10 | 1.9 |
| 25. | 'Pacific'* x 'Sineva' | 543 | 28 | 5.1 |
| 26. | 'Pacific' x 'Stanley'* | 1380 | 6 | 0.4 |
| 27. | 'Pulpudeva' x Hybrid 1-22 | 828 | 117 | 14.1 |
| 28. | 'Stanley' x 'Ortenauer' | 140 | 32 | 22.8 |
| 29. | 'Stanley' x 'Plovdivska renkloda' | 279 | 39 | 13.9 |
| 30. | 'Stanley' x 'Elena' | 537 | 41 | 7.6 |
| 31. | 'Stanley' x 'Pulpudeva' | 208 | 3 | 1.4 |
| 32. | 'Stanley' x 'Sineva' | 172 | 1 | 0.6 |
| 33. | 'Stanley' x 'Cacanska najbolja' | 633 | 1 | 0.2 |
| 34. | 'Belle de Louvain' x 'Cacanska lepotica' | 669 | 147 | 21.9 |
| 35. | 'Tuleu timpuriu' x 'Althan's gage' | 74 | 7 | 9.4 |
| 36. | 'Tuleu timpuriu' x 'Ruth Gersteter' | 1198 | 38 | 8.1 |
| 37. | 'Tuleu timpuriu' x 'Malvazinka' | 1570 | 100 | 6.3 |
| 38. | 'Tuleu timpuriu' x 'Stanley' | 641 | 28 | 4.3 |
| 39. | 'Tuleu timpuriu' x 'Mirabelle de Nancy' | 1667 | 83 | 4 |
| 40. | 'Tuleu timpuriu' x 'Plovdivska renkloda' | 751 | 0 | 0 |
| 41. | 'Tuleu timpuriu' x 'Pacific' | 740 | 0 | 0 |
| 42. | 'Cacanska lepotica' x 'Elena' | 782 | 56 | 7.1 |
| 43. | 'Cacanska lepotica' x 'Stanley' | 752 | 12 | 1.5 |
| Total | | 30941 | 1406 | 6.2 |

The above combinations demonstrate sterility. Since no repetition of the crosses was made, we cannot determine whether the results are induced by incompatible cross or other factors, due to the fact that unsuccessful fertilization is attributed to unfavourable weather conditions, flower morphology etc. But in any case the planning of these crosses in subsequent breeding plans should take into account the fact that they are less effective.

Table 2. Fertility evaluation of cultivars used as mother parents - 2002-2010.

| Cultivar | Total number of pollinated flowers | Number of obtained seeds | Average % of fruit set |
|-----------------|------------------------------------|--------------------------|------------------------|
| 'Althan's gage' | 2242 | 194 | 8.6 |
| 'Stanley' | 1969 | 117 | 5.9 |
| 'Ortenauer' | 4500 | 187 | 4.1 |

Some cultivars tend to be better mother parents in comparison with others. The present results show that the best mother parents were cultivars 'Althan's gage', 'Stanley' and 'Ortenauer' (Table 2). The average percentage of fruit set in all the combinations in which they participated was 8.6, 5.9 and 4.1%, respectively (in a descending order). It should be noted, however, that the same cultivar chosen as mother parent gives diverse results with different pollinators. For example, 'Ortenauer' cross with 'Cacanska leptica' produced very high fruit set- 46.3%, but in combination with 'Stanley' the fruit set was only 2.8%. That means that in order to obtain the same number of hybrid seeds, as in the first combination, at least 5 to 10 times more flowers will have to be pollinated and should be considered in making a breeding plan. Sterility of plums may result also from male sterility, incompatibility and embryo abortion. It has been quite early detected that self- and cross-incompatibility is coupled with slow pollen tube growth (Dorsey, 1919). The results on male sterile cultivar 'Tuleu timpuriu' can be given in association with the above.

Table 3. Fertility evaluation of the test cultivars used as father parent -2002-2010.

| Cultivar | Total number of pollinated flowers | Number of obtained seeds | Average % of fruit set |
|---------------------|------------------------------------|--------------------------|------------------------|
| 'Cacanska leptica' | 1823 | 263 | 14.4 |
| 'Sineva' | 2297 | 136 | 5.9 |
| 'Cacanska najbolja' | 2612 | 108 | 4.1 |

In summary, it produced low fruit set, but in combination with cultivars 'Stanley', 'Malvazinka' and 'Mirabelle de Nancy' it was between 4.3 and 9.4%, while in combination with 'Cacanska najbolja' and 'Plovdivska renkloda' no

fruit set was observed. That confirmed, using male sterile cultivars can be a risk. As regards pollinators, cv. 'Cacanska lepotica' was the best of all – the percentage of the seeds obtained was more than twice higher than that of the other cultivars – 'Sineva' and 'Cacanska najbolja' (Table 3). But in individual combinations very good pollinators occurred, including 'Stanley' (which is known as a good pollinator for a large number of cultivars), 'Ortenauer' and 'Plovdivska renkloda'.

Conclusions

The results of the fertility assessment of 43 parent combinations, carried out in 2002-2010, suggest that the largest number of hybrid seeds in plum (*P. domestica* L.) breeding were obtained when cultivars 'Althan's gage', 'Stanley' and 'Ortenauer' were used as a mother parent and cultivars 'Cacanska lepotica', 'Sineva' and 'Cacanska najbolja' as a father parent (pollinator).

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OCENA PLODNOSTI RODITELJSKIH KOMBINACIJA U OPLEMENJIVANJU ŠLJIVE (*Prunus domestica* L.)

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Rezime

Šljiva kao voćna vrsta inicira razvoj velike količine pupoljaka ali procenat zametanja plodova zavisi od mnogo činilaca. Broj biljaka dobijen iz određene kombinacije od naročitog je značaja u postupku oplemenjivanja zbog toga što svako seme ne proklija nakon stratifikacije semena primenom klasične metode u vlažnom pesku. Iz tog razlika od velikog je značaja ocenjivanje plodnosti odabranih roditeljskih kombinacija u cilju izrade odgovarajućeg plana. Ovo istraživanje predstavlja rezultate utvrđivanja plodnosti 43 roditeljske kombinacije tokom 2002-2010. Oprašen je ukupno 30941 cvet i dobijeno 1406 hibridnih semena. Procenat dobijenog semena u odnosu na oprašene cvetove bio je 6,2% u proseku za sve kombinacije. Najveća plodnost – 46,3% utvrđena je za ukrštanje Ortenauer x Cacanska lepotica, a zatim za Stenli x Ortenauer – 22,8% i Belle de Louvain x Cacanska lepotica – 21,9%. Dobijeni rezultati pokazuju da je najveći broj hibridnih semena u oplemenjivanju šljive (*P. domestica* L.) dobijen kod sorti ‘Althan’s Gage’, ‘Stenli’ i ‘Ortenauer’ odabranih za majčinske biljke i i kod ‘Cacanske lepotice’, ‘Sineve’ i ‘Cacanske najbolje’ kao očinskih biljaka (oprašivača).

Ključne reči: *Prunus domestica* L., hibridizacija, roditeljska kombinacija, ocenjivanje plodnosti.