

THE EFFECT OF POLLENIZER ON THE FRUIT SET OF
PLUM CULTIVAR ČAČANSKA NAJBOLJA

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Abstract: In this paper, during a 4-year period (2003-2006) effects of six pollenizers (President, Italian Prune, Stanley, Čačanska Rodna, Agen 707, and California Blue) on the degree of fruit set in the plum cultivar Čačanska Najbolja were examined. Besides the controlled pollination of this cultivar, open pollination was investigated. Functional pollen ability in pollenizer-cultivars was established by *in vitro* pollen germination. Degree of fruit set was determined comparing the number of fruit set (10 days after pollination, 21 days after pollination and number of harvested fruits) against the number of pollinated flowers. The results indicated that all pollenizer cultivars, studied in this paper, possessed satisfactory *in vitro* pollen germination (30.1-67.4%). The number of fruit set determined 10 days after pollination was very high and did not differ among pollenizers. Highly significant differences were found between the pollenizers in the number of fruit set 21 days after pollination and significant ones in relation to the number of harvested fruits. Compared to open pollination, higher number of fruit set 21 days after pollination and higher number of harvested fruits were obtained when cultivars Stanley (17.0%; 7.6%) and Italian Prune (14.6%; 6.9%) were used as pollenizers, therefore those cultivars are recommendable as good pollenizers for the cultivar Čačanska Najbolja.

Key words: plum, *Prunus domestica*, cultivar, pollen germination, fruit set.

Introduction

Plum is a very significant stone fruit species. Plum trees are precocious and well cropping, have small requirements for ecological conditions and orchard management practices, and can be grown on higher altitudes. Its best known products are fresh and dried plums and plum brandy “slivovitz” (Mišić, 2006).

Despite the decline of total tree number in last few decades, aggravation of tree age structure, unfavourable assortment, poor health condition caused by sharka (Plum Pox Virus) and smaller income competitiveness compared to other fruit

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species, plum is still, according to its participation in total fruit production, the most important fruit species in Serbia (Vulić et al., 2007).

As for all the other stone-fruits, pollination and fertilization are necessary for plum fruit set. Fruit set depends of pollination, pollen tube growth and ovule longevity (Postweiler et al., 1985). Knowledge of the relationships of fertilization among plum cultivars is important, because if fertilisation is weak or fails, it leads to lower fruit set and poor cropping. Only proper choice of pollenizers in the plantations achieves good cropping and good fruit quality. In an abundant flowering, a normal yield can be achieved if the fruit set is 10-20% (Lučić et al., 1996). Knowledge of the relationship of fertilization is also important in experimental work when performing controlled crossings in order to get optimum quantities of hybrid seeds.

In terms of fertilization, plum cultivars are most commonly divided into three groups: self-fertile or self-compatible, partially self-fertile or partially self-compatible and self-sterile or self-incompatible (Szabó, 2003). Although sexual incompatibility in plums is less significant than in cherries, apples and pears, it is important to take into consideration this phenomenon when designing and planting plum orchards. The selection of an adequate pollenizer is important not only for self-incompatible and partially self-compatible cultivars, but also for the self-compatible cultivars, because better cropping and fruit quality are obtained.

In recent decades, in many breeding programs a lot of efforts is intensively put into breeding of plums and creating high-yielding cultivars that yield fruits of excellent quality and which are resistant to plum pox virus. One of these is the cultivar Čačanska Najbolja created at the Fruit Research Institute in Čačak. It is developed by crossing the cultivar Wangenheims Frühzwetsche x Požegača, and it is recognised as a new cultivar in 1975. Čačanska Najbolja is the cultivar with very large fruits that can be used for fresh consumption as well as for processing. The main disadvantage of this cultivar is self-sterility, so it is necessary to provide adequate pollenizers for achieving optimal yield.

Bearing this in mind, the aim of this study was to investigate the effect of different pollenizers on the degree of fruit set of the plum cultivar Čačanska Najbolja.

Materials and Methods

The experiment for this research was set in the collection orchard of plum cultivars at the experimental estate "Radmilovac" of the Faculty of Agriculture in Belgrade. The blossoms of the cultivar Čačanska Najbolja were used as a female parent and the pollen of the cultivars President, Italian Prune, Stanley, Čačanska Rodna, Agen 707 and California Blue was used as a pollenizer. Besides the

controlled pollination, open pollination of the cultivar Čačanska Najbolja was also examined.

Seven pollination combinations were tested during the four-year period of research (2003-2006). For each combination of controlled pollination and open pollination, three fruiting branches of the cultivar Čačanska Najbolja were marked and the number of flowers on them was determined. Just before flowering, at the balloon stage, all fruiting branches, except the control, were isolated using the parchment paper bags. At the same time, branches with flower buds of pollinizers-cultivars were taken, from which in the laboratory conditions pollen was collected and kept by the time of pollination in Petri dishes. Collected pollen was used for the pollination of isolated flowers of the cultivar Čačanska Najbolja in the field conditions and for testing the functional ability in the laboratory.

Functional ability of pollen of pollinizer cultivars was determined using *in vitro* pollen germination. *In vitro* pollen germination was investigated by sowing pollen in Petri dishes with an artificial nutritional medium. Solution of 15% sucrose and 0.7 g agar-agar was poured into Petri dishes in 1-2 mm layer, and then pollen sowing was carried out by means of the brush. For the purpose of germinating pollen grains, Petri dishes were kept for 24 hours at temperature of 22-25°C. Then, germinated and non-germinated pollen grains were counted and the percentage of germinated pollen grains was determined. The experiment was set up in two-factorial design with 3 replications. As for each replication, at least 500 pollen grains were counted. Pollen is considered germinated if the length of pollen tube was greater than the diameter of the pollen grain.

Controlled pollination of isolated blossoms was conducted in full bloom of the cultivar Čačanska Najbolja. Pollen is placed on the stigma by finger touch. Ten days after pollination, the parchment paper bags were removed. At each marked branch, the fruits were counted 10 days after pollination, 21 days after pollination, and just before the harvest. The fruit set was determined by comparing the number of set fruits compared with the number of pollinated blossoms. The experiment was set up in two-factorial design with 3 replications.

The obtained results were analysed by the method of analysis of variance, and regarding the factors for which the F test showed statistical significance, an individual testing was performed using LSD test.

Results and Discussion

Knowledge of pollen functional ability is important not only in terms of genetics and fruit breeding, but also from a practical point of view, for providing high and regular cropping. When growing self-incompatible fruit trees, one of the most important factors for successful production is correct cultivar composition of plantation, that is, the choice of appropriate main cultivars and cultivars-

pollenizers. Pollenizer cultivars should have, in addition to compatibility with the main cultivars and approximate time of flowering, good pollen germination.

If we take into account the statements made by Wertheim (1996), who considers the pollen germination as poor when germinability percentage is lower than 25%, it can be seen from Table 1 that all the examined cultivars of plums had good pollen germination. Averagely highest pollen germination *in vitro* was recorded of the cultivar President (67.4%) and the lowest one of the cultivar California Blue (30.1%). Differences in pollen germination among the tested cultivars were highly significant, indicating that the pollen germination is greatly influenced by the genotype. Low value of pollen germination for the cultivar California Blue (12.2%) was determined by Ogašanović (1985) as well. For the rest of the examined cultivars, interval of variation in pollen germination in his work was from 11.2% to 45.4%, which is slightly lower than the values determined in our study. The low interval of variation of pollen germination (46.2-71.6%) was also found by Sharafi (2011) in 5 examined plum cultivars. Higher interval of variation of pollen germination than in our study was found by Paunović (1971) in 20 plum cultivars (4.8-66.0%), Lee (1980) in 12 plum cultivars (2-64%), Botu et al. (2002) in 14 plum cultivars (12-61%) and Surányi (2006), among 24 plum cultivars (0-64.4%).

Table 1. Pollen germination *in vitro* (%) of pollenizer cultivars.

Pollenizer	Year				Average
	2003	2004	2005	2006	
President	66.4	76.5	62.2	64.5	67.4
Italian Prune	63.6	71.9	57.4	61.1	63.5
Stanley	66.1	74.6	60.5	63.6	66.2
Čačanska Rodna	55.4	63.2	51.6	54.2	56.1
Agen 707	54.0	61.1	48.3	50.8	53.5
California Blue	25.1	37.3	28.9	29.3	30.1
Average	55.1	64.1	51.5	53.9	56.1
LSD _{pollenizer}	0.05	5.58	LSD _{year}	0.05	4.56
	0.01	7.72		0.01	6.31

Observing by years of research, the highest pollen germination *in vitro* was recorded in 2004 (64.1%) and the lowest in 2005 (51.5%). Differences between the years of research were significant. Dependence of pollen vitality of some plum clones on the effect of the year was also indicated by Horváth et al. (2000). Variability of pollen germination by years can be explained by the influence of environmental factors before and during flowering of plum. Thus, Keulemans (1984) found a significant correlation between the temperature during flowering period and pollen germination in some plum cultivars. Significant differences in

pollen germination of 11 plum cultivars depending on temperature (12°C and 20.5°C) were determined by Koskela et al. (2010). Beside temperature, pollen germination is also influenced by other environmental factors, such as relative humidity and atmospheric composition (Stanley and Linskens, 1974). Pollen germination is negatively influenced by some fungicides used for treating fruit trees during flowering phase (Cerović et al., 1999).

Data presented in Table 2 show that 10 days after pollination most of the set fruits were found in the variant of open-pollination (91.2%). A high number of set fruits were determined when pollinating the cultivar Čačanska Najbolja with the cultivars Stanley (85.7%) and Italian Prune (74.4%). The lower number of set fruits was found when pollinating with the cultivars Agen 707 (71.1%), President, (68.3%) and California Blue (62.0%). The lowest number of set fruits was recorded when pollinating with the cultivar Čačanska Rodna (58.8%).

As shown in this study, the number of fruits set 10 days after pollination in almost all combinations of pollination was relatively high and did not differ significantly from the applied pollinizers. However, this is not a reliable indicator of the degree of fruit set and usually is not considered, since the differences between the number of set fruits in this period and the number of harvested fruits are high due to false fertilization (Ogašanović, 1985). Differences between the investigated years in the number of fruits set 10 days after pollination also were not significant.

Table 2. The number of fruits set (%) 10 days after pollination of the cultivar Čačanska Najbolja with different pollinizers.

Pollinizer	Year				Average
	2003	2004	2005	2006	
President	63.4	79.5	62.7	67.6	68.3
Italian Prune	70.3	88.6	67.5	71.4	74.4
Stanley	81.2	96.1	80.9	84.6	85.7
Čačanska Rodna	52.6	70.2	51.5	60.9	58.8
Agen 707	68.9	83.4	67.1	65.0	71.1
California Blue	57.1	79.7	58.0	53.2	62.0
Open pollination	88.5	95.3	86.8	94.2	91.2
Average	68.9	84.7	67.8	70.9	73.1

Initially fruit set, determined 21 days after pollination (Table 3) was the highest when pollinating the cultivar Čačanska Najbolja with the cultivar Stanley (17.0%) and the lowest when pollinating with the cultivar President (3.7%). The differences among examined pollinizers for this characteristic are significant, as well as the differences among years. The lowest number of fruits set 21 days after pollination was determined in 2003 (6.7%) and the highest in 2004 (15.1%).

The interval of variation of the number of set fruits in this study (3.7-17.0%) is slightly broader than the interval of variation (4.9-12.9%) found by Botu et al. (2002) while pollinating 19 plum cultivars with different pollenizers. These authors have shown that the cultivar Stanley had the best pollination capacity among 17 examined pollenizers. It took part in the pollination of 16 cultivars in which the average number of set fruits was 14.8%. Broader variation interval of the set fruits of plums was determined by Kellerhals and Rusterholz (1994) in 7 crossing combinations (0-30%), and then by Hjeltnes and Nornes (2007) in 14 crossing combinations (5.4-66.7%) and by Koskela et al. (2010) in 22 crossing combinations (2-50%).

Table 3. The number of fruits set (%) 21 days after pollination of the cultivar Čačanska Najbolja with different pollenizers.

Pollenizer	Year				Average
	2003	2004	2005	2006	
President	2.1	7.6	2.8	2.3	3.7
Italian Prune	10.7	20.9	10.5	16.4	14.6
Stanley	11.9	24.5	11.3	20.5	17.0
Čačanska Rodna	3.2	9.8	2.7	8.1	5.9
Agen 707	8.6	17.0	9.0	15.2	12.4
California Blue	3.4	10.2	3.9	3.7	5.3
Open pollination	7.3	16.1	7.6	20.4	12.8
Average	6.7	15.1	6.8	12.4	10.2
LSD _{pollenizer}	0.05	3.34	LSD _{year}	0.05	2.52
	0.01	4.58		0.01	3.45

The number of harvested fruits (Table 4) differed significantly between both applied pollenizers and years of research. As well as in the number of initially set fruits 21 days after pollination, the number of harvested fruits was the highest when pollinating the cultivar Čačanska Najbolja with the cultivar Stanley (7.6%) and the lowest when pollinating with the cultivar President (1.6%). The highest number of harvested fruits was determined in 2004 (7.3%) and the lowest in 2005 (2.8%).

The similar values of harvested fruits when pollinating the cultivar Čačanska Najbolja with eight plum cultivars including the cultivars such as California Blue, Stanley and Čačanska Rodna were determined by Ogašanić (1985). The variation interval of harvested fruits ranged from 1.4-5.2%. This author determined the largest number of harvested fruits also when pollinating the cultivar Čačanska Najbolja with the cultivar Stanley (5.2%). Summarizing the results of international working group on pollination for a large number of crossing combinations of plum, Kemp (1996) states that the number of harvested fruits ranges from 0% to 89%, and Paunović (1971) by studying the choice of the most appropriate pollenizers for

major plum cultivars found that the number of harvested fruits depending on the examined crossing combination varied from 4.39% to 50.80%.

If the obtained results of the number of harvested fruits (final fruit set) are compared with the categories for the degree of fruit set for stone fruit species given by Wertheim (1996) it may be concluded that the poor fruit set specified by the author, which ranges from 0-4%, was manifested when pollinating the cultivar Čačanska Najbolja with the cultivars President (1.6 %), California Blue (2.0%) and Čačanska Rodna (2.6%). Medium fruit set that ranges from 5-9% was found in open pollination (5.6%) and when pollinating the cultivar Čačanska Najbolja with the cultivars Agen 707 (6.8%), Italian Prune (6.9%) and Stanley (7.6%).

Table 4. The number of harvested fruits (%) after pollination of the cultivar Čačanska Najbolja with different pollenizers.

Pollenizer	Year				Average
	2003	2004	2005	2006	
President	1.0	2.9	1.2	1.3	1.6
Italian Prune	4.4	9.8	4.3	9.1	6.9
Stanley	5.0	11.0	4.8	9.5	7.6
Čačanska Rodna	1.5	4.9	1.3	2.6	2.6
Agen 707	4.1	9.6	3.7	9.8	6.8
California Blue	1.2	3.8	1.1	2.1	2.0
Open pollination	3.3	9.0	3.5	6.7	5.6
Average	2.9	7.3	2.8	5.8	4.7
LSD _{pollenizer}	0.05	2.18	LSD _{year}	0.05	1.74
	0.01	2.99		0.01	2.39

Comparing the results of initial and final fruit set of open and controlled pollination (Tables 3 and 4) it can be seen as follows. The number of fruits set 21 days after pollination of the cultivar Čačanska Najbolja from open pollination was 12.8%. Only two pollenizers from the group of controlled pollination showed better results than those from open pollination. These are Stanley (17.0%) and Italian Prune (14.6%). Rozpara and Grzyb (1994) found similar values for the number of fruits set by open pollination of the cultivar Čačanska Najbolja. Depending on the rootstocks for grafting (Myrobalan seedling or Wagenheim seedling) the number of set fruits of this cultivar by open pollination ranged from 9.2% to 14.7%. Comparing the number of set fruits of the two plum cultivars and the two years of research of open and controlled pollination, Keulemans (1994) found that a significantly higher number of set fruits is also obtained from controlled (artificial) pollination. The situation is similar to the number of harvested fruits in our study. The number of harvested fruits of the cultivar Čačanska Najbolja by open pollination was 5.6%. Better results for the number of harvested fruits were obtained by three pollenizers such as: Stanley (7.6%), Italian

Prune (6.9%) and Agen 707 (6.8%). Since the number of harvested fruits obtained in our study is less than 10%, other pollenizers, which could eventually affect better fruit set and yield increase in cultivar Čačanska Najbolja, should be studied. Similarly, choosing pollenizers should be careful in the production orchards, because depending on the hereditary basis and the weather conditions during flowering time, they can give better or worse results.

Conclusion

All pollenizer cultivars had a satisfactory *in vitro* pollen germination (30.1-67.4%).

The number of fruits set 10 days after pollination was very high and did not differ depending on the applied pollenizers.

Very significant differences were determined among pollenizers for the number of fruits set 21 days after pollination, and they are significant in relation to the number of harvested fruits.

The years of research showed a very significant effect on the number of fruits set 21 days after pollination, as well as the significant effects on pollen germination and the number of harvested fruits.

Comparing with open pollination, a higher number of fruits set 21 days after pollination, as well as a higher number of harvested fruits was obtained when as pollenizers the cultivars Stanley (17.0%; 7.6%) and Italian Prune (14.6%; 6.9%) were used and these cultivars can be recommended as good pollenizers for the cultivar Čačanska Najbolja.

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UTICAJ OPRAŠIVAČA NA ZAMETANJE PLODOVA
SORTE ŠLJIVE ČAČANSKA NAJBOLJA

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R e z i m e

U radu je tokom četvorogodišnjeg perioda istraživanja (2003-2006) ispitivan uticaj šest oprašivača (Prezident, Italijanka, Stenli, Čačanska rodna, Aženka 707 i Kalifornijska plava) na stepen zametanja plodova sorte šljive Čačanska najbolja. Pored kontrolisanog pračeno je i slobodno oprašivanje ove sorte. Funkcionalna sposobnost polena sorti oprašivača ustanovljena je na osnovu *in vitro* klijavosti polena. Stepenn zametanja plodova utvrđen je poređenjem broja zametnutih plodova (10 dana posle oprašivanja, 21 dan posle oprašivanja i broja ubranih plodova) u odnosu na broj oprašanih cvetova. Rezultati istraživanja pokazali su da su sve sorte oprašivači, proučavane u ovom radu, imale zadovoljavajuću *in vitro* klijavost polena (30,1-67,4%). Broj zametnutih plodova 10 dana nakon oprašivanja bio je veoma visok i nije se razlikovao u zavisnosti od primenjenog oprašivača. Između primenjenih oprašivača utvrđene su veoma značajane razlike u broju zametnutih plodova 21 dan nakon oprašivanja, a značajne u odnosu na broj ubranih plodova. U poređenju sa slobodnim oprašivanjem, veći broj zametnutih plodova 21 dan nakon oprašivanja i veći broj ubranih plodova dobijen je kada su kao oprašivači korišćene sorte Stenli (17,0%; 7,6%) i Italijanka (14,6%; 6,9%) pa se ove sorte mogu preporučiti kao dobri oprašivači za sortu Čačanska najbolja.

Ključne reči: šljiva, *Prunus domestica*, sorta, klijavost polena, zametanje ploda.

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