

PLUM GENETIC RESOURCES AND BREEDING

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Abstract

Plum genetic resources were studied in the period 2004-2012. The fruiting type was established and the cultivars were divided into three groups. The major characteristics like fruit and stone weight, dry matter and acid content, fertility, resistance to PPV, frost and drought hardiness were identified and donors were selected for the breeding aims. 43315 flowers were pollinated in 61 parental combinations in the frames of the breeding programme and 459 hybrid plants were obtained and have been studied. Elites of valuable economic and biological characteristics were selected.

Key words: *Prunus domestica*, evaluation, economic and biological characteristics.

INTRODUCTION

Plum is a traditional fruit species in Bulgaria. Although in the period of transition the planted areas decreased significantly (almost twice compared to 1990), it ranks second after sweet cherry with 7489 ha of plum orchards and second after apple in the amount of fruit production. That shows comparative stability of the species development and it enjoys a good demand among the producers. The plum orchards have been renewed at an improved rate, 16% of the newly established fruit tree plantations in 2010 being plum orchards, surpassed only by sweet cherry orchards (21%). The most widely spread in our country is the common plum (*Prunus domestica*). The share of *Prunus cerasifera* and *Prunus salicina* species is limited. The cultivar 'Stanley' is most widely grown in the orchards. According to Agrostistics, in 2006 the cultivar occupied 70.1% of the plantations, followed by 'Gabrovska' with 4.1% and 'Cacanska najbolja' with 0.5%. The prevailing single cultivar is a fact that could be changed in result of the studies on new plum genetic resources and by establishing new cultivars complying with the latest issues of both the producers and the consumers.

Studies on the plum genetic resources influence directly the breeding process for the selection of donors (Bozhkova and Zhivondov, 2004; Blazek, 2007).

At present, about 100 plum cultivars are maintained and studied in the collection plantations of the Fruit-Growing Institute - Plovdiv but in some periods that number was over 180 cultivars.

MATERIALS AND METHODS

Studies were carried out in the period 2004-2012 in the collection and in the breeding plantations of the Fruit-Growing Institute – Plovdiv. The fruiting type of the plum cultivars was studied and the cultivars were grouped. The percentage of the fruit set on wood of different age was determined by counting the fruit in three scaffold branches of each tree, by 3-4 trees from each cultivar.

Fertility and susceptibility to PPV and to droughts were evaluated using IBPGR descriptors, as follow: Yield per unit area: 1 – extremely low, 3 – low, 5 – intermediate, 7 – high, 8 – very high, 9 – extremely high; Plum pox virus susceptibility: 1 – none, 2 – high tolerance, 3 – tolerant, 6 – susceptible, 7 –high susceptibility, 9 – extremely high susceptibility; Drought susceptibility: 1 – extremely low susceptibility, 3 – low susceptibility, 5 – moderate susceptibility, 7 – high susceptibility, 9 – extremely high susceptibility.

Fruit quality potential was assessed by determining the dry matter by refractometer and titratable acidity.

A plum breeding plan was realized and elites grown against natural PPV infection background were selected after conducting initial assessment.

RESULTS AND DISCUSSIONS

Study on Plum Genetic Resources

The observations confirmed that the largest number of fruit buds in plum is set on young short shoots: multiple buds and spurs. As they are structured on scaffold wood of different age, the percentage of the fruit set on each age group was of interest (Bozhkova, 2004). Figure 1 presents the major fruiting types in plum cultivars grown on *Prunus cerasifera* seedling rootstock. The results obtained gave the grounds to distribute the cultivars into three major groups:

First group - cultivars setting fruit mainly on young 2-year old wood, such as ‘Anna Spath’, ‘Blufre’, ‘Pacific’, ‘Kyustendilska sinyá’;

Second group - cultivars setting fruit mainly on 3-and 4-year old wood, such as ‘*Althan's gage*’, ‘Katinka’, ‘Ortenauer’;

Third group – cultivars setting fruit almost evenly on scaffold wood of different age, such as ‘Stanley’, ‘Tuleu timpuriu’, ‘Cacanska leptotica’.

The cultivars of the first group need to have good annual shoot length increment as they bear fruit mainly on young wood. Such cultivars start rapidly setting fruit towards the crown margins. The most plastic proved to be the cultivars of the third group, which set fruit evenly all over the scaffold wood and it makes them suitable to be used as donors in the breeding practice. The cultivars ‘Stanley’ and ‘Cacanska leptotica’ were included in our breeding programme.

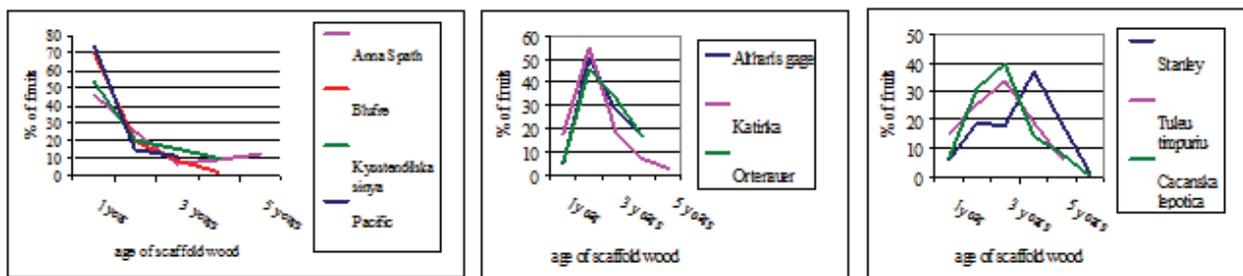


Figure 1. 1st 2nd and 3rd fruiting type of plum cultivars

Fruit of most of the cultivars ripen in August (Table 1). The cultivars ‘Tuleu timpuriu’, ‘Topfirst’, ‘Katinka’, ‘Cacanska ranna’, ‘Malvazinka’ and ‘Opal’ belong to the group of the earlier ripening cultivars, their fruit ripening in July. The cultivars ‘Ortenauer’, ‘Elena’, ‘Jojo’ and ‘Anna Spath’ are of a later ripening period. Those two groups could be used in breeding for extending the fruit ripening season of the plum crop.

Biometric analysis of the fruit showed that the fruit of cultivar ‘Malvazinka’ have the biggest weight and those of ‘Mirabelle de Nancy’ have the lowest weight, which was statistically proved. The cultivars surpassing the standard ‘Stanley’ (34.94 g) in that characteristic, are ‘Anna Spath’, ‘Haganta’, ‘Top Giant Plus’, ‘Cacanska leptotica’, ‘Tuleu timpuriu’, ‘Cacanska ranna’, ‘*Althan's gage*’, ‘Pacific’, ‘Cacanska najbolja’ and ‘Jojo’, which were

used in breeding as donors of large-sized fruit. Large stones (over 2 g) were reported for the cultivars ‘Tuleu timpuriu’, ‘Cacanska ranna’ and ‘Top Giant Plus’, while the stones of the other cultivars have a weight equal or below that of the standard, showing that in most cultivars the fruit flesh to stone ratio is very good.

The dry matter and titratable acid content were established for tentative assessment of fruit quality. Out of the studied cultivars, the highest content of dry matter was reported for ‘Kyustendilska sinyá’ - 22.1% (Table 1). The cultivars ‘Cacanska leptotica’, ‘Mirabelle de Nancy’, ‘Pulpudeva’, ‘Cacanska rodna’, ‘Promis’, ‘Ortenauer’ and ‘Jojo’ also belong to that group. As a whole, the earlier ripening cultivars have a lower dry matter content, which makes them more suitable for fresh consumption than for processing. Acidity of the

studied cultivars is not high and it varies within 0.5 and 1.3%.

Most of the cultivars are high yielding. The highest evaluation grades were awarded to the cultivars 'Katinka', 'Opal', 'Mirabelle de Nancy', 'Top Giant Plus', 'Cacanska najbolja' and 'Stanley'. The cultivars 'Cacanska rodna', 'Promis', 'Kyustendilska sinja' and 'Valevka' showed medium yielding, which might be due to their susceptibility to high summer temperatures and droughts and it would make them unsuitable to be grown in the region of Plovdiv.

Among the studied cultivars grown under natural infection background, 'Mirabelle de Nancy', 'Jojo' and 'Pacific' did not show any symptoms of PPV. ELISA tests showed that the trees of the two latter cultivars were virus-free; however PNRSV was detected in both of the cultivars (Milusheva, unpublished data). It is considered that 'Jojo' cultivar shows hypersensitivity resistance, although there are publications that the resistance is only partial (Poggi Pollini et al., 2008). The cultivar 'Mirabelle de Nancy' is known in literature as a latent carrier of the Plum pox virus and 'Ortenauer' shows partial hypersensitivity.

The cultivars 'Katinka' and 'Kyustendilska sinja' showed susceptibility and the percentage of premature fruit drop off was about 25% (Bozhkova et al., 2006). Most of the cultivars showed a different level of tolerance, the disease symptoms being found in the leaves of all those cultivars and symptoms such as mottling and deformations being found in the fruit of some cultivars, but the fruit retaining on the tree and their quality being acceptable. Based on the results of the studies, the cultivars 'Stanley', 'Jojo', 'Pacific', 'Cacanska najbolja', 'Cacanska leptica' and 'Ortenauer' were used in breeding as donors of resistance or tolerance. The cultivar resistance to stress factors as droughts, frosts and high temperatures in summer acquires greater significance with the observed climate changes. Injuries caused by the high temperatures were established in 2010 and in 2009, expressed as fruit flesh browning in the cultivars, 'Pulpudeva', 'Pacific' and 'Valjevka' and as fruit drying up in the cultivars 'Kyustendilska sinja', '*Althan's gage*' 'Nectavit', 'Tolar' and 'Promis'. Most of the cultivars responded to continuous high

temperatures by leaf rolling. Responses to droughts and high temperatures were not observed in the early ripening cultivars 'Tuleu timpuriu', 'Katinka', 'Cacanska ranna' and 'Malvazinka', which was probably due to the early fruit harvest, before the continuous spells of dry weather. Very good tolerance was shown by 'Stanley', 'Jojo', 'Elena', 'Cacanska najbolja' and 'Cacanska leptica' and that makes the cultivars suitable to be used as donors of drought resistance.

Studies on the effect of low winter temperatures showed that the cultivars of *P. domestica* species demonstrated good winter hardiness. Problems arise at the end of the winter and the beginning of spring, in case the temperatures drop down below -1 °C. Frost injuries were reported in 2004, 2006 and 2012 (Table 2).

In 2004 a minimum temperature of -2.3°C was measured in the period of flowering, which caused about 1% frost damages in 'Stanley' cultivar and up to 97% in 'Elena'. A very high percentage of frost damages was established in 'Pacific' cultivar - 95%. In February 2006, after a comparatively warm period, the temperatures dropped down to -10°C. At that time the cultivars were still in a period of relative dormancy. The highest percentage of damaged buds was reported in 'Elena' cultivar (22%), while in the other cultivars frost damages were not observed or they were insignificant. The low temperatures at the beginning of April 2012 caused frost damages to the flower buds of the plum cultivars at the stage of swelling or white button. The percentage of the damages varied from 5 to 51%.

The damages reported in the cultivars 'Top Giant Plus' and 'Mirabelle de Nancy' were below 10%. For comparison, the frost damages in the standard cultivar 'Stanley' were 11%. The highest percentage of frost damages was reported in 'Toptaste' cultivar - 51%, followed by 'Cacanska leptica' - 28%. The damages in the other studied cultivars varied within 11 – 20%.

The investigations showed that the cultivars 'Elena', 'Pacific' and 'Toptaste' were the most susceptible to winter frosts compared to the rest of the studied cultivars in the collection plantation.

Plum Breeding

In the last 50 years twenty-seven original plum cultivars and several clones of 'Kyustendilska sinya' cultivar were registered. Most of them were obtained as a result of purposeful breeding activities and the rest of them – by open pollination of local plum cultivars or of the cultivars 'Stanley' and 'President'. Nine Bulgarian cultivars resulted from crossing of 'Kyustendilska sinya' x 'Montfort'. 'Kyustendilska sinya' was used as a mother form in establishing twelve cultivars and in 'Pop Hariton' and 'Baleva', which are complex hybrids, it was also used as a mother form in a combination in F1 progeny (Zhivondov et al., 2012). The choice of that cultivar to be used in breeding is not random; it has a number of valuable economic and biological characteristics, such as: high fertility, late flowering period, self-fertility, excellent taste qualities, freestone. However, the cultivar has been excluded from modern breeding programmes because of its strong susceptibility to PPV.

In the period 2004-2012, 61 parent combinations have been developed at the Fruit-Growing Institute in Plovdiv, pollinating 43315 flowers and obtaining 1568 hybrid seeds (Bozhkova, 2011). The average percentage of

the obtained seeds for all the combinations was 3.6%. Some authors established that in open pollination of plum, the percentage varied from 3 to 45% (Vitanov, 1977; Iliev, 1985; Szabo and Nyeki, 2000). The most productive under the conditions in our country proved to be the parental combinations, in which the cultivars, 'Stanley', 'Althan's gage', 'Ortenauer' and 'Pacific' were used as the mother parent and the cultivars 'Cacanska leptica' and 'Cacanska najbolja' – as the father parent (Bozhkova, 2011). After conventional stratification, 459 hybrids were grown and planted in the collection orchard. The percentage to the total number of seeds is 29.2% and to the pollinated flowers - 1.05%.

Vitanov (1977) calculated the results of the 13-year long investigations and he established that the percentage of the fruit set to the total number of pollinated flowers is 15.04% and the obtained plants - 4.09%, respectively. Those data show that breeding is quite labour-consuming.

300 of the grown hybrids have not yet started to bear fruit and selection among them has not been carried out. Elite 1-14 was selected among the progeny of the parental combination 'Althan's gage' x 'Sineva'. Its fruit are 37.7 g in weight and the stone weight is 1.5 g.

Table 1. Evaluation of plum cultivars (selected results)

Cultivar	Average data of ripening	Fruit mass* (g)	Stone mass* (g)	Day matter*% (g)	Titrateable acidity (%)	Yield	Susceptibility to PPV	Susceptibility to drought
Tuleu timpuriu	05-10.07.	47.3b	2.1a	15.6c	1.2a	8	4	2
Topfirst	05.07.	27.9f	1.3bc	17.2bc	0.7b	7	4	4
Katinka	07.07.	28.3ef	1.1c	15.7c	0.6c	9	6	3
Cacanska rana	10.07.	46.3bc	2.1a	13.3c	0.7b	7	4	2
Malvazinka	10-15.07.	58.3a	1.5b	14.9c	0.6c	7	3	2
Opal	15.07.	21.9g	0.9c	13.1c	0.5c	9	3	4
Cacanska leptica	20.07-04.08.	37.4d	1.5b	20.3ab	0.8b	8	3	2
Mirabelle de Nancy	03-06.08.	15.4h	0.5d	20.6ab	0.8b	9	2	4
Green gage	8.???	22.8fg	0.9cd	19.8ab	0.8b	7	5	3
Pulpudeva	06-12.08.	27.4f	0.8d	21.3ab	0.5c	8	4	4
Toppigant plus	10-13.08	44.1cd	2.0a	18.9b	1.3a	9	4	2
Althan's gage	09-23.08.	39.5d	1.3b	18.7bc	0.7b	7	5	5
Pacific	10-24.08.	51.5b	1.5b	16.6bc	1.3a	7	1	4
Cacanska rodna	10.08.	30.2ef	1.3b	20.2ab	0.9b	6	4	3
Cacanska najbolja	11-24.08.	49.3b	1.8ab	18.3bc	0.8b	9	3	2
Promis	19.08.	17.4g	0.8d	19.3ab	0.8b	5	4	6
Stanley	20-31.08.	34.9d	1.8ab	17.9bc	0.6c	9	3	2
Kyustendilska sinya	23.aug	17.4g	0.6d	22.1a	1.1ab	6	6	5
Valevka	25.08.	19.8g	1.0c	15.6c	0.7b	6	4	6
Ortenauer	23.08.-10.09.	24.5f	1.0c	19.2ab	0.6c	7	4	4
Haganta	28.08-30.08	52.1b	1.8ab	17.4b	0.9b	7	4	3
Jojo	25.aug	42.9cd	1.6b	20.5ab	0.8b	7	1	2
Elena	05-07.09.	27.0f	1.3b	18.9b	0.6c	8	4	2
Anna Spath	02-15.09.	36.3d	1.4b	18.4bc	0.5c	7	5	3

Means followed by the same letter do not differ at 5% of significance; Duncan's multiple range test.

Table 2. Frost damages of plum cultivars

Year/date	Cultivar	Frost damages in %	Phenophase
2004-16.04. - 2.3° C	Elena	97	White bud
	Katinka	2	full flowering
	Malvazinka	30	end of full flowering
	Opal	17	full flowering
	Pacific	95	White bud
	Stanley	1	full flowering
	Tuleu timpuriu	8	full flowering
	Cacanska lepotica	8	full flowering
2006-09.02. -10.0 °C	Tuleu timpuriu	3	dormant buds
	Stanley	0	dormant buds
	Katinka	0	dormant buds
	Elena	22	dormant buds
	Ortenauer	0	dormant buds
	Tuleu timpuriu	3	dormant buds
	Stanley	0	dormant buds
2012-03.04. -2.2°C	Cacanska lepotica	28	Swell bud
	Cacanska najbolja	10	Swell bud
	Cacanska rodna	18	White bud
	Cacanska ranna	10	White bud
	Mirabelle de Nancy	9	White bud
	Bellamira	20	White bud
	Miragrande	18	White bud
	Topfirst	17	Swell bud
	Toptaste	51	Swell bud
	Haganta	13	Swell bud
	Jojo	16	Swell bud
	Topgigant plus	9	Swell bud
	Opal	19	White bud
	Elena	16	Swell bud
	Tuleu timpuriu	20	White bud
	Pacific	20	Swell bud
	Stanley	11	White bud

The elite is characterized by good coloration of the fruit skin, orange-coloured fruit flesh and a very high content of dry matter - 26.8%, measured in 2011. Total sugar content is 14.8%, 12.1% of which is inverted sugar and that is a good dietary characteristic. Acid content is 0.8%.

A population of 151 plants was grown from irradiated seeds obtained by open pollination of 'Althan's gage' cultivar. 10 elites were selected among them, showing good tolerance to PPV (with slight symptoms on the leaves only), bearing large-sized fruit and having very high fertility and good taste. They were planted in an orchard for final assessment.

From that group of elites, Elite 1-53 demonstrated very good qualities. Its fruit have a mean weight of 63.6 g and the stone is 2.7 g. The dry matter of the fruit measured in 2012 is 22.0%. Total sugar content is 13.2%, 9.0% of which is inverted sugar and the acid content is 0.31%.

That elite got an excellent grade after the sensory evaluation of fruit.

CONCLUSIONS

Study on plum genetic resources grown under natural PPV infection background and under stress abiotic factors, made it possible to compare their basic economic and biological characteristics and to select suitable donors for the further breeding process. The establishment of a rich genetic fund is a precondition for choosing promising elites and new cultivars.

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