

Behaviour of some Bulgarian plum cultivars in the pedo-climatic conditions of the Pitesti – Romania area

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ABSTRACT

In Romania and Bulgaria, plum is one of the most widespread species, both countries carry out a large breeding program. ‘Stanley’ is the most widespread cultivar in the plum orchards of both countries. Although it is a very productive cultivar, further requested by farmers, it presents some defects such as the low fruit quality and the sensitivity to Plum pox virus. That is why in both countries an improvement of the assortment was imposed by creating new cultivars in their breeding program, but also by introducing valuable cultivars obtained in other breeding centers from Europe. For this reason, researchers from both countries have changed biological material. In 2015, three Bulgarian cultivars were planted in a field trial by the Research Institute for Fruit Growing Pitesti, Romania. This paper aimed to evaluate the behaviour of these cultivars in climatic conditions from the Pitesti-Maracineni area. All Bulgarian cultivars were noted by good production, large fruits with high soluble solids content, as well as by tolerance to Plum pox virus. These cultivars can be recommended for extension in the commercial orchards from Romania, taking into account the requirements of the private fruit growers. Also, these cultivars can be used as genitors in breeding programs.

Keywords: *Prunus domestica* L., yield, fruit quality, blooming, ripening, Plum pox virus.

INTRODUCTION

In Romania and Bulgaria, plum is one of the most widespread species, both countries carry out a large breeding program.

In Romania, the plum is the dominant species, the area cultivated with plum being 66,710 ha which ensures a production of 665,730 t, Romania holds the 2nd place in the world after China and the first one in Europe (Butac, 2020; Data FAO, 2024).

In Bulgaria, the area cultivated with plums is smaller than in Romania (9,400 ha), and the production is only 56,650 t. However, the plum culture is very important ranking third place after the walnut and sweet cherry regarding the surface and the first place in terms of production (Nesheva and Butac, 2021; Data FAO, 2024).

‘Stanley’ is the most widespread cultivar in the plum orchards of both countries (Butac, 2020; Nesheva *et al.*, 2021; Butac *et al.*, 2023). Although it is a very productive cultivar, further requested by farmers, it presents some defects such as the low fruit quality and the sensitivity to *Plum pox virus*. That is why in both countries an improvement of the assortment was imposed by creating new cultivars in their breeding program, but also by introducing valuable cultivars obtained in other breeding centers from Europe (Bozhkova, 2013; Bozhkova *et al.*, 2018; Nesheva *et al.*, 2021; Butac *et al.*, 2023). The most important plum breeding objectives in both countries are resistance to Plum pox virus, fruit quality

and high-yielding capacity. The new cultivar must respond to the requirements of growers and consumers who are constantly changing (Bozhkova, 2013; Nesheva *et al.*, 2021; Nesheva and Butac, 2021; Butac *et al.*, 2023). Also, in order to obtain high and constant productions the cultivars must be well adapted to the pedo-climatic conditions specific to each culture area. Due to the correlation between cultivars and environmental conditions, it is necessary to properly zone the cultivars introduced or released (Nesheva *et al.*, 2021; Nesheva and Butac, 2021). To respond to these objectives, researchers from both countries have changed biological material. Thus, in 2015, three Bulgarian cultivars were introduced in a field trial by the Research Institute for Fruit Growing Pitesti, Romania. This paper aimed to evaluate the behaviour of these cultivars in climatic conditions from the Pitesti-Maracineni area.

MATERIALS AND METHODS

Plant material. Three new Bulgarian plum cvs. grafted on ‘Mirobalan C5’ rootstock were evaluated in comparison with the most widespread plum cvs. in Romanian orchards, ‘Stanley’ (Table 1).

Table 1. List of plum cultivars studied

No.	Name of cultivar	Parentage	Year of registration and origin
1	Ulpia	President O.P	2011, FGI Plovdiv, Bulgaria
2	Sineva	Stanley O.P	2011, FGI Plovdiv, Bulgaria
3	Plovdivska Rencloda	Stanley O.P	2011, FGI Plovdiv, Bulgaria
4	Stanley	d’Agen x Grand Duke	1926, USA

Source: Zhivondov, 2010; Zhivondov and Bozhkova, 2010

Field trial and climatic conditions. The field trial was established in 2015, in the Genetic and Breeding Department of the Research Institute for Fruit Growing Pitesti, Romania (central part of Romania 44°53’56” Northern latitude, and 24°51’35” Eastern longitude). The trees were planted at a distance of 4 x 3 m, in 3 replications with 3 trees per variant. The trees were trained as flat open center, without irrigation. Soil is medium-textured, heavy-clay, with low humus content. The 2020-2024 climatic conditions were analyzed comparative with the last 55 years period (1969-2023). During the study period, the average annual temperature was 2.2°C higher than the multiannual average, and the precipitation was 183.3 mm lower than the multiannual average (Table 2).

Table 2. The main meteorological parameters (2020-2024)

No.	Meteorological parameters	Years					
		2020	2021	2022	2023	2024 (until October)	1969- 2023
1	Average temperature (°C)	11.8	10.7	11.6	12.3	15.0	10.1
2	Maximum temperature (°C)	35.3	36.8	38.3	36.0	30.3	38.8
3	Minimum temperature (°C)	-10.2	-14.1	-12.0	-11.4	3.12	-24.4
4	Annual rainfalls (mm)	679.1	636.2	526.3	562.8	44.8	673.2

Measurements. In 2020 - 2024 period, the following parameters were appreciated and measured: flowering and ripening time by noting the calendar date, yield per tree (YT, kg) by weighting the fruits per tree (3 trees/each replication), fruit weight with an electronic balance (25 fruits/each cvs./each replication), fruit firmness with a penetrometer Qualitest HPE equipped with a plunger of diameter 0.10 cm² (25 fruits/each cvs./each replication); soluble solids content of the fruits with a digital refractometer (25

fruits/each cvs./each replication) and Plum pox virus susceptibility according to a rating scale from 1 to 9 (1=resistant, 2=very low susceptible, 3=low susceptible, 5=intermediate, 7=susceptible, 8=very susceptible, 9=extremely susceptible).

Statistical analysis. The data were included in an Excel database and statistically interpreted with the SPSS 14.0 program, which uses the Duncan test (multiple t-tests) at a 0.05 level of probability.

RESULTS AND DISCUSSION

Flowering time

Usually in Romania plum blooms in mid-April depending on weather conditions.

Late flowering is very important for plum cultivars because late spring frosts may occur in early April (Gravite and Kaufmane, 2017).

Average flowering time of the Bulgarian plum cultivars was at the beginning of the second decade of April in the same period with 'Stanley' cv. (Table 3). The earliest flowering was in 2023 and 2024 (first decade of April) due to the high temperature from February and March.

Our results regarding the flowering time confirm the results reported by Butac and Chitu (2007), Chitu *et al.* (2013), Florea *et al.* (2019). Respectively, due to the increased average air temperature there in the last periods was registered an advance of the beginning of the flowering stage with 12 days.

Ripening time

All three Bulgarian cultivars are earlier than 'Stanley' cv. 'Ulpia' and 'Sineva' cvs. ripe earlier than 'Plovdivska Renclođa' cv. The earliest year in terms of fruit ripening was 2024, and the latest year was 2023 (Table 3).

In the climatic conditions of Romania, the plum ripening stage extends over three months (July, August and September). The cultivars with Bulgarian origin enter the cultivars group with medium - maturation (August 15-20).

Table 3. Phenological characteristics of plum cultivars studied (day.month)

Year	Ulpia	Sineva	Plovdivska Renclođa	Stanley
Flowering time				
2020	12.04	12.04	13.04	12.04
2021	20.04	20.04	21.04	19.04
2022	11.04	11.04	12.04	11.04
2023	06.04	07.04	07.04	06.04
2024	02.04	03.04	03.04	02.04
Average	10.04	11.04	11.04	10.04
Ripening time				
2020	16.08	16.08	21.08	26.08
2021	18.08	18.08	22.08	27.08
2022	12.08	12.08	18.08	20.08
2023	20.08	20.08	22.08	28.08
2024	08.08	08.08	12.08	18.08
Average	15.08	15.08	19.08	24.08

Yielding capacity

Statistical analysis of fruit yield (kg/tree), using Duncan's multiple range test ($P \leq 0.05$), showed significant differences between the cultivars. The highest fruit yield was recorded 'Plovdivska Renclođa' cv. with 18.91 kg/tree, and the lowest fruit production was recorded at 'Ulpia' cv. (15.15 kg/tree on average). It can be seen that none of the Bulgarian cultivars has overcome the 'Stanley' cv. known as one of the most productive plum cultivars (Tabel 4).

Between the years of study, there are very significant differences of production, with yield per tree increasing from one year to another as expected in a young plum orchard. Our results are similar to results reported by Zhivondov and Bozhkova in 2010.

Table 4. The yielding capacity of plum cultivars studied

No	Cultivar	2020	2021	2022	2023	2024	Average
1	Ulpia	9.07±0.40 ^b	11.07±0.66 ^b	15.83±0.31 ^c	20.93±0.45 ^d	18.83±0.45 ^c	15.15±4.67 ^b
2	Sineva	11.30±1.10 ^a	13.47±0.91 ^{ab}	16.47±0.68 ^c	23.37±0.66 ^c	20.07±0.65 ^c	16.93±4.57 ^b
3	Plovdivska Recncloda	12.47±0.70 ^a	14.60±1.05 ^a	18.43±0.45 ^b	26.37±0.42 ^b	22.70±0.82 ^b	18.91±5.32 ^{ab}
4	Stanley (Control)	12.17±1.76 ^a	16.20±2.33 ^a	20.47±1.86 ^a	29.40±0.87 ^a	27.57±1.22 ^a	21.16±6.93 ^a
	Average	11.25±1.68	13.83±2.29	17.80±2.09	25.07±3.36	22.29±3.57	18.04±5.78

*Duncan multiple ranges test. Numbers followed by the same letter within a column are not significantly different ($P \leq 0.05$).

Fruits characteristics

The results regarding fruit characteristics were similar to those obtained by Zhivondov, 2010; Zhivondov and Bozhkova, 2010.

Fruit weight. An important factor in the marketing of plum cultivars designated for fresh consumption is fruit size (Milošević *et al.*, 2013, 2018). The largest fruits were recorded 'Plovdivska Rencloda' cv. (50.88 g) and the lowest fruits had 'Ulpia' cv. (42.93 g), between cultivars being significant differences (Table 5). 'Sineva' and 'Plovdivska Rencloda' cvs., have larger fruits than 'Stanley' control. Making a correlation between yield and fruit weight it is observed that there is a positive correlation. 'Sineva' and 'Plovdivska Rencloda' cvs. had large fruits and good yield and 'Ulpia' cv. had small fruits and small production.

Table 5. The fruits weight of plum cultivars studied

No.	Cultivar	2020	2021	2022	2023	2024	Average
1	Ulpia	42.33±1.66 ^a	45.37±1.76 ^b	45.00±1.45 ^{ab}	46.60±2.09 ^b	35.33±2.73 ^c	42.93±4.51 ^c
2	Sineva	44.50±0.96 ^a	46.07±0.81 ^b	49.40±3.81 ^a	50.43±1.04 ^b	42.93±6.04 ^b	46.67±3.53 ^b
3	Plovdivska Recncloda	45.83±1.34 ^a	48.33±0.66 ^a	49.30±0.70 ^a	60.77±5.93 ^a	50.17±3.79 ^a	50.88±5.99 ^a
4	Stanley (Control)	43.20±2.76 ^a	43.97±0.94 ^b	43.70±3.10 ^c	45.57±0.85 ^b	44.30±0.80 ^b	44.15±1.86 ^{bc}
	Average	43.97±2.07	45.93±1.91	46.85±3.45	50.84±6.85	43.18±6.02	46.16±5.15

*Duncan multiple ranges test. Numbers followed by the same letter within a column are not significantly different ($P \leq 0.05$).

Flesh firmness. Firmness is an important factor in stone fruits often related to taste and shelf life, and firmness assessment is widely used both in the marketing chain to judge overall fruit quality and by researchers in cultivar testing and programs including fruit quality (Sekse and Wermund, 2010). Generally, flesh firmness decreases during maturation and ripening (Crisosto, 1994). All Bulgarian cultivars had firm fruits but less firm than 'Stanley' cv. Of the Bulgarian cultivars, the 'Sineva' cv. was noted with a firmness of 52.54 HPE units (Table 6).

Table 6. The fruits firmness of plum cultivars studied

No	Cultivar	2020	2021	2022	2023	2024	Average
1	Ulpia	41.43±1.07 ^b	42.33±2.83 ^b	47.43±6.97 ^b	56.23±3.16 ^a	45.33±14.12 ^a	46.55±8.26 ^b
2	Sineva	44.63±1.92 ^b	46.53±0.57 ^b	65.30±13.52 ^a	60.77±8.36 ^a	45.47±18.45 ^a	52.54±12.91 ^b
3	Plovdivska Recncloda	43.40±1.37 ^b	47.50±0.66 ^b	49.87±0.84 ^b	46.30±2.82 ^b	47.10±3.41 ^a	46.83±2.81 ^b
4	Stanley (Control)	64.21±8.24 ^a	62.28±8.84 ^a	72.73±1.85 ^a	61.83±2.14 ^a	52.50±1.83 ^a	62.71±8.19 ^b
	Average	48.42±10.28	49.66±8.82	58.83±12.82	56.28±7.61	47.60±10.50	52.16±10.82

*Duncan multiple ranges test. Numbers followed by the same letter within a column are not significantly different ($P \leq 0.05$).

Fruit soluble solids content (SSC). Statistical analysis of data on fruit soluble solids content (%) showed insignificant differences between the cultivars. The Bulgarian plum cultivars had higher fruit soluble solids content than 'Stanley' cv. (Table 7).

Table 7. The fruits soluble solids content of plum cultivars studied

No.	Cultivar	2020	2021	2022	2023	2024	Average
1	Ulpia	16.27±0.25a	19.50±0.36a	17.23±1.89a	17.13±1.46a	17.60±2.26ab	17.55±1.67a
2	Sineva	15.73±0.38a	18.10±0.20b	15.00±1.67a	16.70±1.71a	19.70±2.71ab	17.05±2.22a
3	Plovdivska Recncloda	16.10±0.30a	18.20±0.20b	16.40±0.26a	17.90±1.04a	20.73±1.04a	17.87±1.80a
4	Stanley (Control)	14.23±0.35b	14.20±0.62c	16.20±1.90a	16.23±0.74a	16.40±0.46b	15.45±1.34b
	Average	15.58±0.88	17.50±2.10	16.21±1.59	16.99±1.27	18.61±2.38	16.98±1.98

*Duncan multiple ranges test. Numbers followed by the same letter within a column are not significantly different ($P \leq 0.05$).

Correlations between the main traits

There are significant correlations between: fruit weight and yield ($r=0.328^*$); fruit soluble solids content and firmness ($r=-0.543^{**}$) (Table 8).

Table 8. The Pearson Correlations between characteristic studied

Indicator	Yield	Weight	SU	Firmness
Yield	1	0.328 *	0.125	0.247
Weight	0.328 *	1	0.125	0.016
SU	0.125	0.125	1	-0.543 **
Firmness	0.247	0.016	-0.543 **	1

* Correlation is significant at the 0.05 level (2-tailed);

** Correlation is significant at the 0.01 level (2-tailed);

Behaviour at Plum Pox Virus (PPV)

Plum Pox Virus, also called Sharka, is considered one of the most serious virus diseases of stone fruit in Europe. In Romania, Sharka causes great yield losses, especially to sensitive plum cultivars (Zagrai et. al., 2001).

Bulgarian cultivars are very low susceptible to PPV, showing symptoms only on leaves (note 2).

'Stanley' cv. is medium sensitive to PPV, showing symptoms on leaves (note 5) and few symptoms on fruits (note 3).

Table 9. Behaviour of Bulgarian plum cultivars on the Plum Pox Virus

No.	Cultivar	Plum Pox Virus	
		On leaves	On fruit
1	Ulpia	2	1
2	Sineva	2	1
3	Plovdivska Recncloda	2	1
4	Stanley (Control)	5	3

1=resistant, 2=very low susceptible, 3=low susceptible, 5=intermediate, 7=susceptible, 8=very susceptible, 9=extremely susceptible.

CONCLUSIONS

All Bulgarian cultivars were noted by good production, large fruits, high soluble solids content, as well as by tolerance to Plum pox virus.

These cultivars can be recommended for extension in the commercial orchards from Romania, taking into account the requirements of the private fruit growers.

Also, these cultivars can be used as genitors in breeding programs.

REFERENCES

1. Butac M. and Chițu E. (2007). Impact of climatic changes on the phenological dynamics of some plum cultivars in the fruit growing Arges area. Scientific papers of RIFG Pitești, vol. XXIII: 139-147.
2. Butac M. (2020). Plum breeding. In: *Prunus*. Intech Open, London, United Kingdom (Open Access books).
3. Butac M., Mareși E., Stan A., 2023. Plum cultivars grown in Romania – a comparison between traditional cultivars widely grown and promising new ones. V Balkan Symposium on Fruit Growing, Zagreb, Croatia (in the process of publishing).
4. Bozhkova V. (2013). Plum genetic resources and breeding. Acta Hort., 734: 31-45.
5. Bozhkova V. and Savov P. (2018). Evaluation of introduced plum cultivars under agroclimatic conditions of Plovdiv region, Bulgaria. Scientific papers, series B., Horticulturae, vol. LXII, 77-82.
6. Chițu, E., Giosanu, D., Mateescu, E. (2013). Seasonal and Annual Extreme Temperature Variability and Trends of the latest three decades in Romania. Advances in Environmental Sciences - International Journal of the Bioflux Society, Online ISSN 2065-7647. Volume 5, Issue 2: 70-88; <http://www.aes.bioflux.com.ro>
7. Crisosto C. (1994). Stone fruit maturity indices: a descriptive review. Postharvest News and Information, vol. 5, no. 6: 65-68.
9. Florea, A., Chițu, E., Păltineanu, C. (2019). Dynamics of phenological stages due to climate change in plum trees in southern Romania. Acta Hort. 1289, 205-212. <https://doi.org/10.17660/ActaHortic.2020.1289.29>.
10. Gravite I, Kaufmane E. (2017). Evaluation of German plum selections in Latvia. Proceedings of the Latvian Academy of Sciences. Section B, vol. 71, no. 3 (708): 166-172.26.
11. Milošević T., Milošević N., Glišić I. (2013). Agronomic properties and nutritional status of plum trees (*Prunus domestica* L.) influenced by different cultivars. Journal of Soil Science and Plant Nutrition, 13 (3), 706-714.
12. Milosevič T. and Milosevič N. (2018). Plum (*Prunus* spp.) breeding. Chapter 5. In: Advances in Plant Breeding Strategies: Fruits. Springer International Publishing AG, part of Springer Nature 2018: 165-215.
13. Nesheva M., Bozhkova V., Butac M., 2021. Performance of Romanian plum cultivars in the agro-environmental conditions of Plovdiv, Bulgaria. Romanian Journal of Horticulture, vol. II: 57-62.
14. Nesheva M. and Butac M., 2021. Fruit quality of new introduced plum cultivars under the conditions of Bulgaria. Gruit Growing Research, vl. XXXVII: 45-49.
15. Sekse L. and Wermund U. (2010). Fruit flesh firmness in two plum cultivars: comparison of two penetrometers. Acta Hort. 874: 119-124.
16. Zagrai I., Ardelean M., Maxim A., Zagrai L. (2001). Researchers regarding the influence of Plum pox virus on production at different plum cultivars, clone and hybrids. Jubilee session of Horticulture Faculty from Iasi. Series Hort. 44: 150-151.
17. Zhivondov A., 2010. Plovdivska Renkloda – anew plum cultivar. Acta Hort. 874: 305-311.
18. Zhivondov A. and Bozhkova V., 2010. New Bulgarian plum cultivars. Acta Hort. 874: 345-351.
19. Food and Agricultural Organization (2024). www.fao.org/statistics/yearbook