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EVALUATION OF INTRODUCED PLUM CULTIVARS UNDER AGROCLIMATIC CONDITIONS OF PLOVDIV REGION, BULGARIA

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Abstract

The study was carried out in the experimental plantation of the Fruit-Growing Institute - Plovdiv in the period 2014 - 2016 with six German plum cultivars: ,'Jojo', 'Topstar plus', 'Topgigant plus', 'Toptaste' and 'Tophit plus' compared to 'Stanley' as a standard. The tree volume, trunk diameter, angle of the skeletal branches, annual shoot length growth, average number of flower buds on spurs and shoots, some phenological characteristics, fruit biometrical analyses, chemical composition and the sensory characteristics were studied. The biggest tree volume and trunk diameter were calculated for the cultivars 'Toptaste' and 'Stanley'. The largest angle of skeletal branches was measured on 'Jojo'. The biggest shoot length was recorded in 'Tophit plus'. The earliest flowering time was observed on 'Jojo' and 'Toptaste', the latest one on the 'Topstar plus' and 'Tophit plus'. The ripening period of the investigated cultivars was in August and only for 'Stanley' and 'Tophit plus' in September. According to the biometric data 'Topgigant plus' and 'Tophit plus' were with the largest fruits in size. The highest sugar content and total soluble solid were found of 'Toptaste's fruits. The investigated cultivars are suitable to grow under agroclimatic conditions of Plovdiv region.

Key words*: plum cultivars, vegetative growth, phenological characteristics, fruit characteristics.*

INTRODUCTION

Plum is a traditional fruit crop in Bulgaria. The South Central Region represents 25.6 % of the total area occupied with plum trees, which is the first place among the six regions of the country (Agrostatistics, 2016).

The main grown cultivar is still 'Stanley', because of its good adaptability (Djuvinov V. and Vitanova I., 2002). A lot of new cultivars were registered in Europe as tolerant to Plum pox virus (Sharka disease), but few of them were accepted by the producers and spread in the orchards (Jacob, 2002; Blažek and Pištěková, 2009).

Till now only the plum cultivar 'Jojo' is known as resistant to Plum pox virus and in the past ten years was widespread in the orchards (Neumüller et al., 2010).

Unfortunately, it turned out that this cultivar is susceptible to late spring frosts, which force Bulgarian producers to look for other cultivars.

At the same time, the manipulation of tree architecture is the cornerstone of horticultural management.

According to Costes et al. (2004) an accurate knowledge of growth, branching and flowering processes within the tree canopy, i.e., tree architecture, is required to optimize the growing technologies and especially for the right choice of training and pruning methods.

As an answer to this need, some plum cultivars were introduced from Germany in the Fruit Growing Institute - Plovdiv.

In this study are presented the results of an investigation on some of those cultivars. The aim is to recommend the best one to the plum producers.

MATERIAL AND METHODS

The study was carried out in the period 2014-2016 at the Fruit Growing Institute, Plovdiv. The trees of the studied cultivars 'Jojo', 'Topstar plus', 'Topgigant plus', 'Toptaste' and 'Tophit plus' compared to 'Stanley' as a standard were planted in a collection plantation in 2011 on alluvial-meadow soil at a distance of 4×4 m and grown under non-irrigated conditions and without pruning.

Dimensions of minimum five trees were determined to be calculated the tree volume and trunk diameter. The angle between the skeletal branches and the central leader was measured

in four trees of each cultivar in three consecutive years, to trace if the angle will be changed during the period of tree growth.
One skeletal branch from four trees per cultivar was selected for measuring the average annual shoot length growth and the average number of flower buds in a spur and a shoot.
The observed phenological characteristics included flowering and fruit ripening. Biometrical, chemical and sensory analyses of the fruits were performed. Data were statistically processed by Duncan's test (Steele and Torrie, 1980).

RESULTS AND DISCUSSIONS

Data concerning the tree volume and trunk diameter are presented in Table 1. The biggest tree volume and trunk diameter were calculated for the cultivars 'Toptaste' and 'Stanley'. Their growth dynamic is the faster. The other cultivars are in the second group. Among them, the smallest tree volume was registered on 'Jojo' and 'Topgigant plus' but statistically it is not proven.
Data concerning average trunk diameter shows there are no statistically proven differences. It is known that on fruit species the larger angle of the skeletal branches is preferred (Vitanov, 1977). Out of the studied cultivars, the largest angle of the skeletal branches was recorded for the cultivars 'Jojo' and 'Topgigant plus'. Nevertheless, it was found that the wood for the 'Topgigant plus' is fragile and very often under the weight of the fruits the skeleton branches are broken.
In 'Jojo' and 'Toptaste' the larges angle was recorded for the secondary branches. The dimensions for 'Jojo' are favorable and statistically proven.

Table 1. Tree volume and trunk diameter during the period 2014-2016

Cultivar	Tree volume, m^3				Trunk diameter, cm			
	2014	2015	2016	Average	2014	2015	2016	Average
'Jojo'	1.15	1.50	1.91	1.52 b[1]	14.38	23.00	25.13	20.84 a
'Tophit plus'	1.12	2.09	2.53	1.91 b	15.33	23.33	25.33	21.33 a
'Topgigant plus'	1.20	1.61	2.10	1.64 b	17.25	25.13	27,38	23.25 a
'Topstar plus'	1.25	1.93	2.55	1.91 b	17.00	26.38	28.00	23.79 a
'Toptaste'	2.46	3.05	3.89	3.13 a	21.25	28.75	30.75	26.92 a
'Stanley'	2.77	3.02	3.82	3.20 a	22.50	28.13	30.00	26.88 a

[1]Mean values followed by different letters within a column are significantly different by Duncan's multiple range test at $P \leq 0.05$.

Table 2. Angle of the main and the secondary skeletal branches (°)

Cultivar	Branch angle º (2014 -2016)							
	2014		2015		2016		Average	
	Main branch angle	Secondary branch angle	Main branch angle	Secondary branch angle	Main branch angle	Secondary branch angle	Main branch angle	Secondary branch angle
'Jojo'	66.25	77.50	70.00	76.25	78.00	75.25	71.42 a	76.33 a
'Tophit plus'	40.00	46.25	38.75	38.75	40.25	39.50	39.67 c	41.50 cd
'Topgigant plus'	47.50	44.29	51.25	45.00	55.75	47.00	51.50 b	45.43 c
'Topstar plus'	37.50	37.14	35.00	37.50	38.00	42.00	36.83 c	38.88 d
'Toptaste'	52.50	57.50	43.75	53.75	47.25	55.50	47.83 b	55.58 b
'Stanley'	35.00	42.50	37.50	36.25	40.50	38.25	37.67 c	39.00 d

[1]Mean values followed by different letters within a column are significantly different by Duncan's multiple range test at $P \leq 0.05$.

According to Costes et al. (2004) the final size of trees is a cumulative variable resulting from the annual shoot length developed each year. In the studied cultivars, the largest annual shoot length in 2014 was established in 'Topstar plus' and 'Topgigant plus' (Figure 1). In 2015 the largest annual shoot length was reported for 'Tophit plus' and 'Toptaste' and in the third vegetation for 'Toptaste' and 'Topgigant plus'. In the same year for all investigated cultivars were obtained the highest dimensions.

That confirms the research by some authors that shoot growth is strongly influenced by climatic factors and, above all, rainfall (Seleznyova et al., 2003). The average values of the studied trait showed that 'Stanley' and 'Jojo' had the smallest total annual shoot length and 'Tophit plus' had the largest one. The mean number of flower buds in the spurs

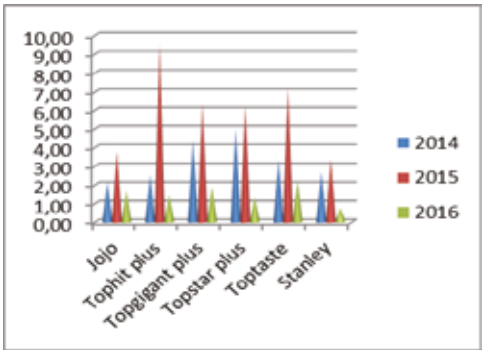

Figure 1. Annual shoot length per skeletal branch

of the studied cultivars varied from 3.26 to 3.96, but the differences between the cultivars are statistically insignificant (Table 3).

The largest number of flower buds on shoots was reported in the cultivars 'Jojo' and 'Toptaste' and it is statistically proven.

Table. 3. Number of flower buds on spurs and annual shoots in plum cultivars

Cultivar	On one spur				On 1 m of annual shoot			
	2014	2015	2016	Average	2014	2015	2016	Average
'Jojo'	3.44	3.26	3.74	3.48 a	10.35	28.13	32.45	23.64 a
'Tophit plus'	3.54	3.32	3.56	3.47 a	0.92	12.66	11.38	8.32 b
'Topgigant plus'	3.40	3.28	3.28	3.32 a	9.93	12.13	13.01	11.69 b
'Topstar plus'	3.30	3.30	3.96	3.52 a	19.88	17.98	16.88	18.25 ab
'Toptaste'	3.34	3.38	3.70	3.47 a	20.58	25.18	23.11	22.96 a
'Stanley'	3.48	3.54	3.90	3.64 a	3.86	10.45	9.40	7.90 b

Among the investigated cultivars earlier flowering time was recorded for 'Jojo', and 'Toptaste'. Two to three days later started to flower the cultivars 'Stanley', 'Topgigant plus', 'Tophit plus' and 'Topstar plus'.

Fruits of the studied cultivars ripen within a period of one month - from the beginning of August to the beginning of September (Figure 2).

Similar results about the period of ripening of those cultivars were also obtained by other authors in the Czech Republic and Poland (Blazek and Pistekova, 2009).

According to the data of the biometric analysis the fruits of 'Topgigant plus' and 'Tophit plus' were very large (Figure 3).

The fruits of the other four cultivars were medium in size and it was statistically proven (Table 4).

The stones of the cultivars 'Topgigant plus' and 'Stanley' were above 2 g in weight and in the rest varied from 1.52 to 1.87 g, but the differences between the cultivars are statistically insignificant.

The fruits of 'Topgigant plus' were large but stones were small and the relative stone to fruit ratio is low (3.17).

This data for 'Stanley' is the most unfavorable.

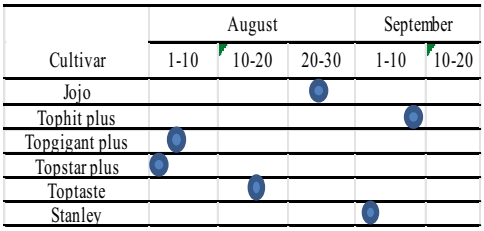

Figure 2. Fruit ripening time

Table 4. Fruit biometry (2014-2016)

Cultivar	Fruit				Stone weight (g)	Relative share (%)
	Lenght (mm)	Width (mm)	Thickness (mm)	Fruit weight (g)		
'Stanley'	50.06 ab	35.31 b	37.32 b	38.10 b	2.10 a	5.51 a
'Jojo'	47.55 ab	36.20 b	35.62 b	37.29 b	1.87 a	5.05 ab
'Toptaste'	42.67 c	36.51 b	37.61 b	35.43 b	1.66 a	4.66 abc
'Topgigant Plus'	51.11 a	42.27 a	42.78 a	53.06 a	2.10 a	3.97 bcd
'Topstar Plus'	46.15 bc	38.34 b	37.64 b	38.91 b	1.52 a	3.90 cd
'Tophit plus'	51.44 a	42.20 a	44.36 a	55.20 a	1.72 a	3.17 d

Determining the total soluble solids of the fruits is the quickest way to get information about the content of the major chemical components. The total soluble solids varied from 14.77% in 'Topgigant plus' to 25.90% in 'Toptaste' and the differences between them is significant (Table 5).

The data showed that the highest sugar content was established in the cultivar 'Toptaste'. The values for the other cultivars varied from 8.91% to 10.86% but statistically it was not proven. The acid content is low. Only in 'Topgigant plus' it was 1.75%. For all of the studed cultivars pH varied within a small range - from 2.99 in 'Topgigant plus' to 3.61 in 'Stanley'. According to the obtained data, the cultivar 'Toptaste' has the best chemical composition. The fruit quality is a complex of many different characteristics describing both external appearance and taste qualities. That is why the sensory evaluation is as important as the chemical analysis.

Table 5. Chemical composition of plum fruits (2014 - 2016)

Cultivar	Total soluble solids (°Brix)	Sugar, %			Titratable acidity, %	pH
		Total	Invert	Sucrose		
'Stanley'	18.15 b	10.77 b	6.69 bc	4.10 ab	0.82 b	3.61 a
'Jojo'	18.33 b	10.86 b	8.37 a	2.37 b	1.08 b	3.44 ab
'Toptaste'	25.90 a	13.18 a	7.79 ab	4.57 a	1.06 b	3.64 a
'Topgigant Plus'	14.77 c	8.91 b	5.70 c	3.05 ab	1.75 a	2.99 c
'Topstar Plus'	15.43 bc	9.56 b	5.37 c	4.05 ab	1.29 ab	3.07 bc
'Tophit plus'	18.13 b	9.00 b	6.43 c	2.42 b	1.03 b	3.40 ab

The results of the sensory analysis are presented in Table 6. The larger fruit size is always preferred not only for plum, but generally for all fruits. The difference in the score of this property between the studied cultivars was just 1.5 points and does not correspond exactly to the established fruit weight of the cultivars. In this case, the assessment is subjective and depends on the participants of the testing panel.

Compared to the fruit size, the score for the fruit shape varied less. Fruit colour together with fruit size contributes to fruit attractiveness. Judging by the scores given for fruit coloration, it is obvious that the dark coloured fruits are preferred (Figure 4).

Taste qualities combine the scores given for the texture, taste, aroma and sweetness. The taste is of the greatest importance for grading the cultivars in sensory evaluation.

The best taste had 'Toptaste' followed by 'Tophit plus' (Figure 5). For the other cultivars this score is not so impressive. The studied cultivars showed big variations in aroma and less in sweetness.

According to the final evaluation only for cultivars 'Toptaste' and 'Tophit plus' the sensory characteristic was excellent. Looking at the values of the chemical analysis we could not find a correlation between the chemical properties and the results of the sensory evaluation. Similar conclusions have been made in our previous studies of plum and apricot (Bozhkova, 2014; Bozhkova and Nesheva, 2016).

Table 6. Sensory evaluation of the investigated plum cultivars fruits

Cultivar	Appearance				Taste quality			Total score	Final evaluation
	Fruit size	Fruit shape	Fruit colour	Texture	Taste	Aroma	Sweetness		
'Stanley'	7.3	7.3	7.4	6.6	6.5	5.9	6.45	47.4	first class
'Jojo'	6.9	7.3	7.3	7.0	6.6	6.1	6.3	47.5	first class
'Toptaste'	6.4	7.0	6.7	7.5	8.4	7.2	7.8	51.0	excellent
'Topgigant Plus'	7.7	7.6	6.7	6.5	5.1	4.9	5.4	44.1	first class
'Topstar Plus'	7.8	7.8	7.6	6.8	5.6	5.4	6.0	47.0	first class
'Tophit plus'	8.4	8.1	7.2	7.3	7.1	6.7	6.9	51.8	excellent

Figure 3. Cultivar 'Topgigant plus'

Figure 4. Cultivar 'Jojo'

Figure 5. Cultivar 'Toptaste'

CONCLUSIONS

The biggest tree volume and trunk diameter were calculated for the cultivars 'Toptaste' and 'Stanley'. The largest angle of skeletal branches was measured on 'Jojo'.

The biggest shoot length was recorded in 'Tophit plus', but a more uniform growth rate over the years was established in 'Topgigant plus'. It was found that the wood of 'Topgigant plus' is quite fragile.

The earliest flowering time was observed on 'Jojo' and 'Toptaste', the latest one on the 'Topstar plus' and 'Tophit plus'.

The ripening period of the investigated cultivars was in August and only for 'Stanley' and 'Tophit plus' in the beginning of September.

According to the biometric data 'Topgigant plus' and 'Tophit plus' had the largest fruits in size.

The highest sugar content and total soluble solids were found in the 'Toptaste' fruits.

The investigated cultivars are suitable for growing under agroclimatic conditions of Plovdiv region.

We do not recommend to producers the cultivar 'Topgigant plus' and remind them to keep in mind that 'Jojo' is sensitive to late spring frost.

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