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EVALUATION OF GERMAN PLUM CULTIVARS IN THE REGION OF TROYAN

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Abstract

Due to the need to expand its plum assortment in the mountainous regions of the country, the German plum cultivars from the selection program of Prof. Jacob's collection at the Geisenheim Research Station in Germany, 'Topgigant plus', 'Topking', 'Topper', 'Top 2000', 'Top', 'Topend plus', 'p33-6-94', were introduced in the RIMSA Troyan in 2008. For the period 2016-2019, the climatic factors of the Troyan region were analyzed, the phenology of the cultivars (flowering and ripening time), vegetative and reproductive characteristics were supplemented, which were complemented by laboratory analyzes of the fruits. The 'Top 2000' cv. was first blossomed (at the end of March, the first days of April, depending on climatic conditions. The lowest growth was in the 'Topper' cv., which was adapted to intensify the planting scheme. The largest are the fruits of 'Topgiant plus' (77.34 g) and have the smallest share of stone (2.75%) for 2019, ripening relatively earlier than the others. The highest content of total sugars (9.4%) and high glucoacidimetric ratio (12.37) are of the 'Topper' cv.. 'Topper' (0.18 kg / cm^2) and 'p33-6-94' (0.15 kg / cm^2) are distinguished by high productivity values. The German plum varieties of the Top group are suitable for cultivation in the mountainous conditions of the Troyan region, using technologies that meet the specificities of each cultivar.

Key words*: plum, phenology, growth, fruit qualities.*

INTRODUCTION

Plum is the main fruit species in our country, where climatic factors are suitable for its development. The varietal assortment is constantly changing, and it is always good to be enriched with new, more productive and attractive plum cultivars.

German cultivars have been widely distributed in recent years, so it is especially important to investigate their economic suitability for a particular area. The breeding program at the Geisenheim Research Station in Germany has produced large-fruited cultivars such as 'Tophit' and high and regular bearing cultivars such as 'Topper' (Jacob, 1998).

The parameters for which the genotypes were sought in Prof. Jacob's breeding program are different maturing dates (early, mid-term, late-ripening), taste and aroma, disease resistance, especially measles, shelf life and storage, tolerance to climatic conditions for their widespread distribution (Jacob, 2007a). Most of them were created with the participation of the 'Cacanska najbolia', which the author considers to be a unique donor for the resistance to PPV and good taste (Jacob, 2007b).

Late-ripening varieties can be sold at a better price and most of them have a higher dry matter and sugars content than the earlier ones (Milatovic et al., 2019).

The aim is to study the technological and economic characteristics of the German plum cultivars of the Top series and the consumer qualities of their fruits, their suitability for cultivation under (in accordance with) the agro-ecological conditions of the Troyan region, to recommend them to other regions with similar ecological conditions.

MATERIALS AND METHODS

In RIMSA Troyan, in order to enrich the assortment list of pre-mountain plum production with new cultivars, the German plum cultivars of Top series, selected at the Geisenheim Research Station, were introduced 10 years ago.

This study covers the period 2016-2019.

The trees are grown in a plum garden in the Troyan region under the agro-ecological conditions of the Pre-Balkans. The climatic conditions for the study period (01.01.2016-30.09.2019) are compared with the conditions of a basic 30-year period (1965-2005).

The trees were planted in 2008 under a 5 x 4 m scheme, in planting pits loaded with 30-40 kg of fertilized manure, on slightly sloping terrain. The altitude is 420 m, the soils are light gray acidic forest, poorly stocked with nutrients.

The cultivation technology includes the formation of a free-growing crown, the maintenance of mowed rows that are mowed (Bozhanska et al., 2017) and once-a-year treatments in a row, standard plant protection, non-irrigation conditions, not further nourished during the years of experience.

The rootstocks is 'Myrobalan' (*Prunus cerasifera* Ehrh.). Each cultivar is an option represented by 5 threes.

The following metrics were reported:

- Phenological data;
- Vegetative parameters:

Trunk cross-section area (cm^2); Crown volume (m^3); Projection of crown (m^2);

- Reproductive parameters:

Yield per tree (kg); Fruit weight (g);

- Chemical composition of fresh plum fruits: Soluble solids (refractometrically) (%); Sugars according to Schoorl (%); Acids, as malic, by titration with 0.1 n KCl (%); Tannins – according to Levental-Neubauer (%); Antocianins - Filsky and Fransis (mg%).

The studies were conducted according to Methods for Studying Plant Resources (Nedev et al., 1979).

The experimental data were subjected to statistical analysis by Fisher's single-factors ANOVA. The significance of differences between the mean values of the factors and the interaction means was determined by LSD test at significance levels of $P \leq 0.05$.

RESULTS AND DISCUSSIONS

The climatic conditions for the Troyan region were analyzed as a comparison of data on average monthly temperatures (°C) and total precipitation (mm) for the study period (01.01.2016-30.09.2019), with the same indicators for a 30 year base period (1965-2005) (Figure 1). There is a tendency for an increase in the average monthly summer temperatures for the months of June, July, August and September, compared to the baseline for 30 years period, an increase in the total rainfall for June and July and a sharp decrease in rainfall, compared to the average 30 years period for the months of August and September, when the period of ripening of the fruit.

This makes us consider the suitability of these cultivars for the conditions of the Troyan region as suitable for extending the harvest period, but providing some (partial) irrigation at the end of the growing season, during ripening.

For the study period, 'Top 2000' cv. started **flowering** earlier (28-30.03.2016; 27.03.2017), followed by 'Top' and 'Topping' cvs. for 2016 and 'Top' and 'Topper' cvs. for 2017 (30.03.2017) (Figure 2).

Flowering of 'Top', 'Top 2000' and 'Topper' cultivars lasted and longest - 15-16 days, which is a favorable factor for the pollination period.

For 2018, the flowering period is later and extremely short for all cultivars (5-15.04). Low March temperatures (5.1°C), similar to the baseline 30-year period (5.7°C), but lower than other years of experience (Figure 1), had an impact. Precipitation for March is higher for the survey years and about 30 mm more than the baseline. The average flowering time for all cultivars is 7-9 days, as in April the temperatures rise sharply, by about 3-4°C, compared to the base period, which leads to the rapid flow of phenophase. The end of flowering of the Top series for 2018 is April 14-16, which is very similar to the data of Milatovic et al. (2019) for a period of 5 years in the Belgrade area.

In 2019, cvs. 'Top' and 'Topper' start flowering as early as March 30.03. (due to higher temperatures and lack of precipitation), with a flowering phase of 15-17 days to 17-18.04. The remaining cultivars of the group bloomed from 1-2 to 15-17 April, at the latest 3-4.04. Has started its flowering 'Topgiant Plus' cv. and has completed about 17.04. All this indicates a long flowering period for 2019, with the cultivars with the longest flowering being represented with higher yields of 8-10-11 kg ('Top 2000' and 'Topper', 'Top' cvs. respectively).

Ripening time: - 'Top' (30.8-2.09); 'Topgiant plus' (12-15.08); 'Topper' (10-13.09).

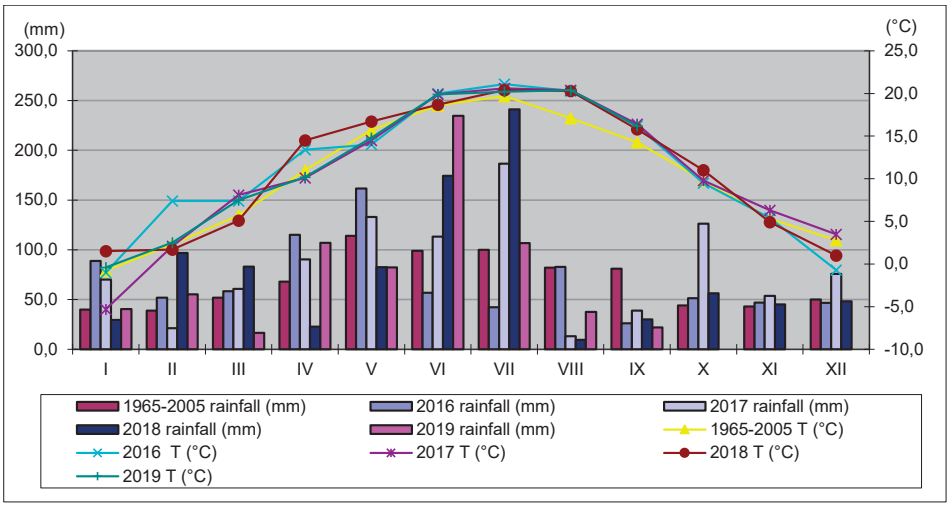

Figure 1. Evolution of climatic conditions for the Troyan region (2016-2019); a 30 year base period (1965-2005)

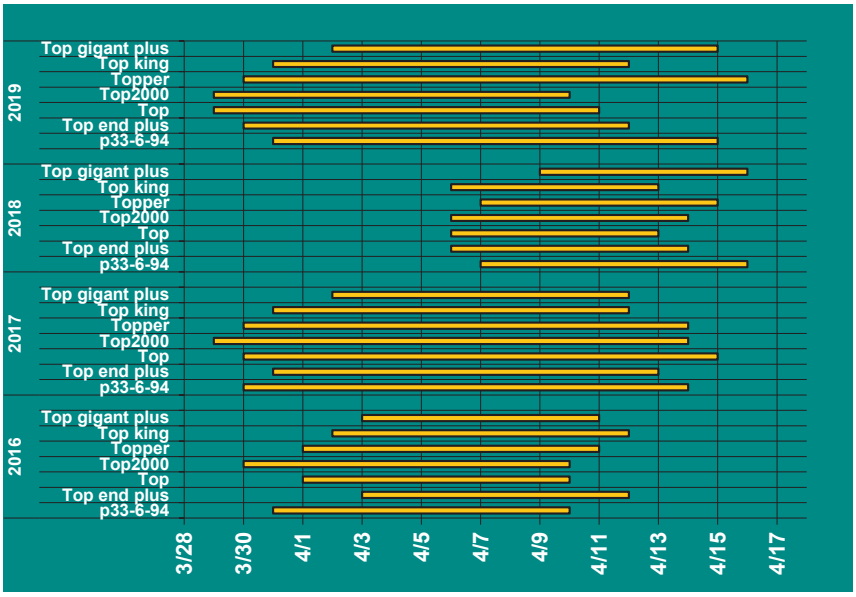

Figure 2. Phenology of plum cultivars of Top series, under the conditions of the Troyan region (2016-2019)

The growth characteristics of Top series cultivars (Table 1), showing that for 2016 the largest trunk cross section was calculated for the 'Topking' and 'Top 2000' cultivars (74.0 cm^2; 57.5 cm^2). The trunk cross-sections have minimum values for the cv. 'p33-6-94' (26.0 cm^2) and 'Topper' (11.7 cm^2), which defines it as the weakest so far.

For 2017, there is a greater increase in trunk cross-section in all varieties, with differences from 4 to 19 cm^2, with the largest increase at 'p33-6-94' and 'Topper', and the smallest increase for the year at 'Top' and 'Topgiant plus' cvs. (4 cm^2). The largest sections form the 'Topking' and 'Top 2000' cvs. (80.49 cm^2; 68.84 cm^2). For the sake of Blajek et al. (2012) consider that under their conditions the 'Top 2000' variety is weak.

The volume of crowns at the beginning of the study (2016) is quite large in the cvs, 'Topend plus', 'Top 2000', 'Top'. The smallest crowns

were measured at 'Topgigant plus' (1.06 m^3) (Table 1).

For 2017, the smallest by volume are the crowns of 'Topper' (1.13 m^3) and 'Topgigant plus' (1.89 m^3), but their growth compared to 2016 is more moderate, with the smallest expansion of 'Top 2000' and 'Topend plus' (with 0.17-0.21 m^3). Growth differences, assuming that they will continue to exist, suggest the possible choice of different schemes specific to each cultivar. In the studies conducted by Čmelik et al. (2007) observed lower growth in 'Toptaste' and 'Top 2000' cvs., stronger in 'Topfirst' and 'Topfive' varieties, and stronger in 'Tophit' cv.

By the end of the study period, 2019, the growth of the stems is extremely uneven in variants. The differences are from 1-2 cm^2 for 'Top' and 'Topper' cvs., to -13 cm^2 for 'Topgiant plus' cv. The largest crown had Topking (7.4 m^3) and Top 2000 (5.29 m^3).

The smallest and most harvested crowns, like the previous year, have 'Topper' and 'p33-6-94' trees. Their volume is 0.80-1.13 m^3.

Reproductive qualities

The productivity factor (yield per tree, per unit cross-section of the trunk kg/cm^2) for 2019 is extremely small in the case of the taller trees 'Topking', 'Top', etc. (0.04 kg/cm^2), but with high values are the 'Topper' (0.18 kg/cm^2), 'p33-6-94' (0.15 kg/cm^2), 'Topend plus' (0.14 kg/cm^2), 'Top 2000' cvs. with 0.10 kg/cm^2 which are more cost effective (Table 1).

Average for the study period, with the highest fruit mass being the early ripening cultivar 'Topgigant plus' (77 g) followed by 'p33-6-94' (37 g), with their stones are large, but the relative share of 'Topgigant' is 2.57%. For the other cultivars, the average weight of the fruit is 28-30 g and the smallest are the 'Top 2000' (20 g) (Table 2).

Fruit sizes - with greater height and almost equal width and thickness, with a confidence of results at p = 0.05, determine the elongated shape of the fruit in all cultivars.

Radiković (2014) shows remarkable differences between the studied cultivars in terms of pomological and physicochemical properties. The highest percentage of fruit meat and the smallest stone was found in the 'Topgigant plus' cv. (93.7% fruit flesh, stone share 3.97%, with us 2.57%), followed by the 'Top 2000' cv. (93.5% fruit flesh, stone share 5.24%, 3.44% for us), so they are the sorts desired for consumption as fresh fruits.

Chemical composition

Chemical analysis of fresh fruits was performed on 7 cultivars for 2019 at the analytical laboratory in RIMSA Troyan.

The highest dry matter content (22.5%) has the 'Topking' cv. and the lowest 'Top' (15.5%) (Table 3). Content of total sugars also is the lowest (5.7%) in the 'Top' cv. The highest amount of total sugars was determined in the 'Topper' cv. (9.4%), most of them in the form of invert sugar (7.2%).

Table 1. Vegetative characteristics of Top series cultivars (2016-2019)

	2016		2017		2018		2019		2019
	TCSA (cm^2)	Crown volume (m^3)	TCSA (cm^2)	Crown volume (m^3)	TCSA (cm^2)	Crown volume (m^3)	TCSA (cm^2)	Crown volume (m^3)	Yield efficiency (kg/cm^2)
To gigant plus	53.9	1.06	58.25	1.89	65.66	1.30	79.96	2.69	0.05
Topking	74.24	6.12	80.49	6.43	83.17	4.82	93.68	7.41	0.04
Topper	11.78	0.67	28.22	1.13	30.31	0.58	31.24	1.13	**0.18**
Top 2000	57.52	8.45	68.84	8.61	70.51	3.43	76.88	5.29	0.10
Top	49.84	7.04	54.19	3.66	67.65	4.64	69.06	3.49	0.07
Topend plus	49.76	1.70	65.92	1.91	66.28	1.97	71.47	5.05	**0.14**
p33-6-94	25.88	0.99	43.99	3.09	48.14	0.96	54.18	0.83	**0.15**

Table 2. Reproductive characteristics (average 2016-2019)

				Fruit dimensions (mm)			Stone dimensions (mm)			
	Fruit weight (g)	Stone weight (g)	Stone share (%)	length	width	thickness	length	width	thickness	Yield per tree (kg)
Topgigant plus	77.34	1.99	2.57	59.1	51.4	47.1	29.3	17.3	10.3	7.5
Topking	28.20	1.25	4.43	40.0	35.0	33.8	22.6	15.1	8.9	3.0
Topper	28.49	1.31	4.60	41.9	34.8	35.5	24.6	14.1	9.1	8.0
Top 2000	20.03	0.69	3.44	36.9	30.7	31.1	19.8	12.3	7.8	10.0
Top	30.57	1.15	3.76	43.2	36.3	35.1	23.3	15.2	9.6	11.0
Topend plus	36,39	1.35	3.71	43.3	37.6	37.5	24.1	16.0	8.9	2.5
p 33-6-94	36,81	1.38	3.75	44.1	38.4	38.3	24.9	16.7	9.6	3.5
LSD=0,05	*5,03*	*0.15*		*2.59*	*3.93*	*1.83*	*1.49*	*0.83*	*0.57*	

Table 3. Chemical composition (2019)

	Soluble solids (%)	Total sugars (%)	Invert sugar (%)	Sucrose (%)	Total acids (%)	Sugar/acid ratio	Tannins (%)	Anthocyanins (mg%)
Topgigant plus	15.5	7.35	5.85	1.43	0.88	12.32	0.163	7.26
Topking	22.5	8.90	6.65	2.14	0.76	11.71	0.208	8.55
Topper	17.5	9.40	7.20	2.09	0.76	12.37	0.229	11.61
Top 2000	18.0	6.15	5.00	1.09	0.50	12.30	0.125	11.61
Top	15.5	5.70	4.70	0.95	0.63	9.05	0.312	9.68
Topend plus	17.5	9.20	2.00	1.10	0.70	13.14	0.230	10.11
p33-6-94	16.5	7.20	4.85	2.23	0.63	11.43	0.229	12.58

It also has the lowest value of tannins and a relatively high value of anthocyanins (11.61%). 'Topper' is also the highest Glycoacidimetric factor (12.37).

The 'Top 2000' is represented by 18% dry matter (approximately as standard Stanley) and very low acid content (0.5%), so its sugar/acid ratio is high. This defines a balanced taste. The other cultivars contain acids from 0.63 to 0.76%.

By conducting serological analysis for the presence of Plum pox virus, the cultivars 'Topend plus' it was positive.

CONCLUSIONS

The soil-climatic and agro-ecological conditions of the region of Troyan are favorable for the normal development and regular bearing of plums from the introduced plums of German cultivars 'Topgigant plus', 'Topking', 'Topper', 'Top 2000', 'Top', 'Topend plus', 'p33-6-94'.

The flowering of the 'Top 2000'' cv. begins at the earliest. For all cultivars, the duration of the phenophase is 12-14 days, and in 2018 it is later and shorter (7-8 days).

The smallest (with crowns removed) are the 'Topper' trees (0.58 m^3), 'p33-6-94' (0.96 m^3), 'Topgigant plus' (1.89 m^3), which makes them suitable for thickening the planting scheme. The largest fruits have the early-ripening 'Topgigant plus' cv. (77 g), followed by 'Topend plus' cv. (39 g).

With high values of yield efficiency are distinguished 'Topper' (0.18 kg/cm^2), 'p33-6-94' (0.15 kg/cm^2), 'Topend plus' (0.14 kg/cm^2), 'Top 2000' cvs. with 0.10 kg/cm^2 which are more cost effective.

Based on the results obtained, for cultivation in the Troyan region, it is possible to recommend the cultivars of the Top group, as cultivars with

combined traits (suitable for both fresh consumption and processing). In addition, the early cultivar 'Topgigant plus' can be grown mainly as a table (for fresh consumption).

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