

## **MORPHOLOGICAL AND BIOCHEMICAL PROPERTIES OF FRESH FRUITS OF THE GERMAN PLUM CULTIVARS, TOP SERIES IN THE CONDITIONS OF THE TROYAN, MOUNTAINOUS REGION (BG)**

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### **Abstract**

*The cultivars from the Top series of the breeding program Dr. Jacob, Geisenheim, Deutschland are now widespread in almost all European countries. They are of interest for modern, sustainable plum production. The data we present are from the Troyan region, an experimental field of the RIMSA. The plantation was established in 2008, with the varieties Topgigant Plus, Topking, Top 2000, Topfive, Top, Topper, etc. The biometric indicators and biochemical composition of the fruits, as well as the color parameters of the fruit skin and fruit flesh in 2021 and 2024 were studied. It has been established that the mid-ripening varieties Topgigant Plus, Topfive, Tophit have larger fruits (40-50 g). Late-ripening varieties are characterized by a very high content of dry matter and total sugars and a low content of organic acids. This makes them extremely suitable for processing, given the small mass of the fruit (Topking, Topper). The color of the fruit skin in all varieties is dark blue, with shades of purple and dark purple. The fruit flesh is yellow, juicy, sweet.*

**Key words:** plum, cultivars, morphology, biochemical properties.

### **INTRODUCTION**

Plum is a traditional cultivar for growing in the mountain and foothill regions of Bulgaria. In these conditions, the cultivars reveal different degrees of resistance to abiotic factors and diseases, which is essential when selecting suitable cultivars for growing.

For 25 years, plum selection at Geisenheim has focused primarily on improving cultivars for ripening period - early, medium and late, resistance to plum pox, sufficient resistance to major pests and diseases, and general resistance to climatic conditions (Jacob, 2007). The cultivars Topfive, Topking, Toptaste, Topper, Top and Top 2000 are the subject of the study. The four cultivars Topgigant Plus, Topstar Plus, Tophit Plus and Topend Plus represent the large-fruited market segment (>50 g).

Three of the cultivars were registered as early as 1996, showing efficiency and stable yield (Jacob, 1998).

Top, as a hybrid of Auerbacher x Stanley, is very late ripening, Top goes into fruit early and bears profusely, self-fertile, compatible with all rootstocks and tolerant of some pests and diseases. Fruits are dark blue with good culinary and processing quality for cooler

climates. Extends plum harvest season by four weeks.

Topper, as a hybrid of Cacanska najbolja x Auerbacher, is medium to late ripening, produces very early and profusely, is self-fertile, has good cold hardiness and is compatible with all rootstocks, low growing. The fruits are blue, with excellent culinary and processing qualities for warmer climates. Topper is a high yielding cultivar, showing no alternability.

Tophit, as a hybrid of Cacanska najbolja x President, is late ripening. It produces early and profusely, is self-fertile, compatible with all rootstocks and tolerant of powdery mildew. The fruits are very large, dark blue, with excellent culinary qualities for all climates.

German plum cultivars are known for their large and tasty fruit, resistance to transport and comparative stability to disease. These characteristics make them suitable for cultivation in various regions, including the Troyan mountain region. At the Research Institute of Mountain Stockbreeding and Agriculture (RIMSA) - Troyan, they have already been tested, with a focus on their adaptability to climatic conditions in the region

(Stefanova & Popski, 2020; Popski, 2023; Popski et al., 2023; Stefanova et al., 2024).

Bozhkova and Savov (2016) presents results from a four-year study in the conditions of the Plovdiv region. According to the biometric analyses, the fruit weight of Topgigant Plus and Tophit Plus was over 60 g. In 2012, the percentage of flower buds destroyed by frost was estimated, with the lowest degree of damage recorded in the cultivars Tophit Plus, Topgigant Plus, and the highest in Toptast (51%). According to the results obtained, the most suitable plum cultivars recommended for cultivation in Plovdiv region are Topgigant Plus and Tophit Plus.

In Georgia, Maghlakelidze et al. (2017) recommended for further cultivation the cultivars Tophit and President for fresh production, Empress and Stanley (fresh/dry production). Which can improve the local plum assortment because they are characterized by early ripening, high productivity and high fruit quality. Tophit fruits for their study conditions ripen on 30.09, their mass is 42 g, yields for 2014-2015 are 60-70 kg per tree.

Čmelik et al. (2007) identified the qualities of Top (2005-2007) cultivars, recommending Topfirst and Tofive for early fruit ripening, (immediately after ripening the most common cultivar *Cacanska leptica*), excellent quality, easy crown formation.

Bulgarian producers are interested in new cultivars and opportunities to diversify the list of cultivars in their orchards. In response to this, since 2008 the RIMSA Troyan has been exploring the cultivars of the Top series. This study presents results for the 2021 and 2024 fruit harvests and evaluates the biometric and biochemical characteristics of the fruit.

The objective of the present study is to present a comparative characterization of German plum cultivars on morphological, biochemical characteristics and fruit color parameters, under the agroecological conditions of Troyan, Mountainous region.

## MATERIALS AND METHODS

The study was conducted in 2021 and 2024 in an experimental plantation of RIMSA Troyan (42°53'N 24°43'E), the altitude was 420 m. The

climate of the area is favourable for the cultivation of fruit species (including plum). The average annual temperature over a 30-year base period (1988-2017) is 10.6°C; the total annual rainfall recorded is 778 mm. Early autumn frosts usually occur in late October and around mid-April at the latest.

Specifically for the study period, the factors are presented in Figure 1.

Average temperatures in 2021 are higher than those of the 20-year base period, especially in June, July, and August. In July, the temperature is 22.7°C, which is higher than the 20.7°C average for that month. This has determined the warmer summer months in recent years related to global warming, but also drought compromising fruit production in 2021. In 2024 we also observed increased temperatures compared to the base period, especially temperatures in February and March, with a significant deviation from normal rates, in February the temperature was 2.1°C compared to -0.3°C in the 2001-2020 average, provoking an earlier onset of the growing season, and a resulting delay in flowering. Summer temperatures in June and July are similar to those of 2021, with maxima of 22.2°C and 23.5°C.

Precipitation in January 2021 was significantly above average (82.8 mm compared to the long-term (2001-2020) monthly average (45.2 mm)), but much less than normal in July and September (12.4 mm in July compared to 109.1 mm in the base period). In 2024, the results are more balanced by month and yet January and February rainfall are lower than the 2001-2020 average and typically the winter months are wetter. In summer, the months of June and July show relatively high rainfall rates, largely favoring higher plum yields for the 2024 crop.

In both 2021 and 2024, there are significant deviations compared to the long-term period, especially in terms of precipitation. Precipitation in July and September in 2021 is significantly less, while in 2024 the winter months are drier, with the exception of December. Temperatures, during the summer months, have shown a stable trend of increase in recent years, a typical indicator of global warming, and these trends have serious impacts on fruit production.

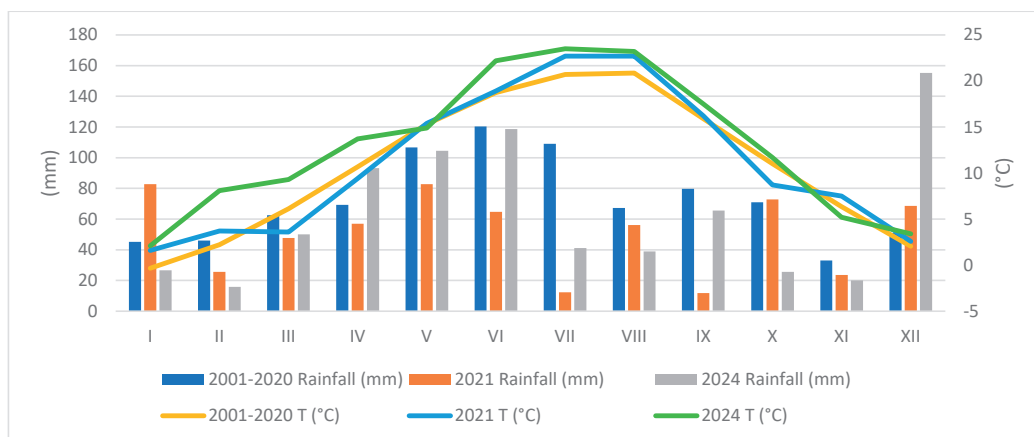


Figure 1. Average monthly temperatures (°C) and monthly precipitation sums (mm)

The German plum cultivars studied were Topgigant Plus; Topfive; Thorstar plus; p 33-6-94; Top 2000; Tophit Plus; Top; Topking; Topper. The plantation is in full fruiting.

The trees were grafted on yellow cherry plum (*Prunus cerasifera* Ehrh.) rootstock, on a 5 x 4 m scheme, grown on light grey forest soil, under non-irrigated conditions, with grassed inter-rows.

#### Measuring indicators

✚ Reproductive - yield (kg/tree), fruit weight (g), fruit size (mm) and stalk (mm);

✚ Chemical composition of fruit at ripening stage;

- Dry matter in refractometrically (Total Soluble Solids) (%);
- Sugars (%) (total, invert and sucrose) - according to Schoorl and Regenbogen method, (Donchev et al., 2001);
- Organic acids (malic, citric) (%) - by titration with 0.1N NaOH (Donchev et al., 2001);
- vitamin C (mg/%) to Tilman method (Donchev et al., 2000);
- Tanning substances (%) according to the method of Levental (Donchev et al., 2000);
- Anthocyanins (mg/%) according to the method of Fuleki et al. (1968);
- Total polyphenols (mg/g) - according to Singleton & Rossi (1965);

Fruits were determined at the laboratory of RIMSA Troyan;

✚ color (SC-30, Colorimeter for color difference) by the CIE Lab method. Three

types of colour coordinates were used during the measurement process: L, a and b;

L - colour brightness (L = 0 - black, L = 100 - white);

a - the positive values of the indicator display the amount of red, while the negative values signify the intensity of green;

b - the positive values are determinant of the yellow hues, while the negative values indicate blue.

The value of the colour tone or the dominant wavelength is represented by the a/b ratio.

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H (hue angle) =  $\frac{b}{a}$ . In the evaluation of H we used the most widely accepted international criterion of assigning the angle.

Statistical data processing was performed with ANOVA (Excel 2019). Treatments were declared different at  $p = 0.05$  level of significance. The analyses were performed in three replications and the obtained values were expressed as the means  $\pm$  standard error.

## RESULTS AND DISCUSSIONS

In 2021, the largest fruit and stone mass were recorded in the Topgigant Plus cultivar (45.17 g and 2.00 g), while the smallest values were recorded in Top 2000 (fruit mass 16.93 g, stone mass 0.80). The relative proportion of stone for 2021 ranges between 3.69% (p 33-6-94) and 6.33% (Topper) (Table 1).

In 2024, the fruit weight ranges from 54.38 g in the Topgigant Plus cultivar to 21.62 g in the

Topper cultivar. The cultivars with higher mass are Topfive (51.78 g) and Tophit Plus (42.66 g), and it is noticeable that the mass of most cultivars has increased compared to 2021. According to Suranyi (2019), Tophit Plus reaches 50-60 g. Topper agrees with our data (28-32 g), while for Topfive it gives only 31-35 g. Of course this depends entirely on the growing conditions and climatic factors at the time of the research, as is the case in our study. The stone mass in 2024 is 0.92 g (Top 2000), 1.14 g (Top), 1.18 g (Topking) and the highest stone mass is Topfive (2.18 g). However, the relative share of stone is highest in Topper

cultivar 6.03% (small fruit mass (28.54 g), large stone mass 1.72 g), followed by 5.25% in Topking and Topper. The smallest share is in Topgiant Plus and Top 2000 (3.88%). Kovac et al. (2013), considered that Tophit has 3% and its size is 43-44 mm (Table 1). Fruit size in 2021 was smallest in Top 2000 (height 35.30 mm, width 29.80 mm) and thickness (28.20 mm) and the largest fruit height was measured in Topgiant Plus (49.20 mm), Tophit cultivar had the widest fruit (40.60 mm), Topgiant Plus and Topfive had the largest thickness (Table 1).

Table 1. Fruit and stone morphological parameters of different cultivars of the Top series (2021-2024)

|                   | Fruit size (mm)     |                     |                       |        |       |           | Stone size (mm) |       |           | Fruit stalk<br>length<br>(mm) |
|-------------------|---------------------|---------------------|-----------------------|--------|-------|-----------|-----------------|-------|-----------|-------------------------------|
|                   | Fruit<br>weight (g) | Stone<br>weight (g) | Share of<br>stone (%) | Lenght | Width | Thickness | Lenght          | Width | Thickness |                               |
| 2021              |                     |                     |                       |        |       |           |                 |       |           |                               |
| Topgigant<br>Plus | 45.17               | 2.00                | 4.44                  | 49.20  | 40.20 | 39.80     | 28.20           | 17.20 | 10.00     |                               |
| Topfive           | 38.14               | 1.69                | 4.44                  | 45.40  | 39.20 | 37.80     | 29.00           | 16.80 | 10.20     |                               |
| Topstar<br>Plus   | 27.81               | 1.25                | 4.50                  | 43.50  | 34.60 | 34.30     | 26.70           | 15.90 | 9.20      |                               |
| p 33-6-94         | 35.56               | 1.31                | 3.69                  | 45.00  | 38.50 | 37.30     | 25.40           | 16.80 | 8.40      |                               |
| Top 2000          | 16.93               | 0.80                | 4.74                  | 35.30  | 29.80 | 28.20     | 21.10           | 12.30 | 7.80      |                               |
| Tophit<br>Plus    | 36.56               | 1.55                | 4.24                  | 46.10  | 40.60 | 36.20     | 25.89           | 15.67 | 9.67      |                               |
| Top               | 21.51               | 0.95                | 4.42                  | 38.10  | 32.90 | 30.20     | 21.20           | 13.90 | 8.50      |                               |
| Topking           | 20.37               | 1.12                | 5.48                  | 36.60  | 30.50 | 30.70     | 21.80           | 14.50 | 8.70      |                               |
| Topper            | 21.44               | 1.36                | 6.33                  | 39.00  | 32.00 | 30.10     | 25.10           | 14.40 | 8.80      |                               |
| cv (%)            | 33.71               | 27.79               | 16.41                 | 11.59  | 12.16 | 12.27     | 11.86           | 10.61 | 8.84      |                               |
| LSD 0.05          | 3.94                | 0.18                |                       | 2.17   | 1.92  | 1.63      | 1.20            | 0.73  | 0.51      |                               |
| 2024              |                     |                     |                       |        |       |           |                 |       |           |                               |
| Topgigant<br>Plus | 54.38               | 2.11                | 3.88                  | 50.50  | 42.70 | 42.60     | 28.10           | 17.00 | 10.50     | 12.50                         |
| Topfive           | 51.78               | 2.18                | 4.21                  | 51.00  | 43.00 | 42.90     | 29.10           | 17.90 | 10.90     | 12.29                         |
| Topstar<br>Plus   | 26.30               | 1.19                | 4.51                  | 39.50  | 33.00 | 34.40     | 23.70           | 15.00 | 9.40      | 19.29                         |
| p 33-6-94         | 39.61               | 1.76                | 4.44                  | 45.10  | 39.10 | 39.40     | 24.33           | 16.89 | 9.33      | 13.50                         |
| Top 2000          | 23.67               | 0.92                | 3.88                  | 37.80  | 33.00 | 33.80     | 20.20           | 13.20 | 8.60      | 15.22                         |
| Tophit<br>Plus    | 42.66               | 1.85                | 4.34                  | 46.90  | 40.00 | 40.20     | 24.78           | 15.67 | 10.22     | 15.13                         |
| Top               | 21.61               | 1.14                | 5.25                  | 37.20  | 31.70 | 31.70     | 20.90           | 14.10 | 8.90      | 15.63                         |
| Topking           | 22.37               | 1.18                | 5.25                  | 36.40  | 31.90 | 32.20     | 21.00           | 14.50 | 8.80      | 14.33                         |
| Topper            | 28.54               | 1.72                | 6.03                  | 42.50  | 34.20 | 35.20     | 26.00           | 15.40 | 9.10      | 15.33                         |
| cv (%)            | 37.19               | 29.71               |                       | 13.17  | 12.76 | 11.86     | 13.06           | 9.79  | 8.57      | 14.11                         |
| LSD 0.05          | 4.29                | 0.15                |                       | 1.96   | 2.03  | 1.60      | 1.06            | 0.64  | 0.46      | 1.86                          |

The large-fruited cultivars have fruit sizes around 50-51mm for height (Topgiant Plus and Top 2000), and their width at the abdominal suture and thickness are also the largest (42-43 mm). The parameters of the stones were also measured. Topfive has the greatest height 29.10 mm, followed by Topgiant Plus (28.10

mm), with a width of 17-18 mm and a thickness (10.5-10.9mm). It is noticeable that the thickness and width of the fruit are almost similar, for the relevant cultivar, with a coefficient of variation cv% of 11.86-12.76, while in the case of stone dimensions, it is noticeable that the thickness is over 8.6 mm and ranges up to 10.5-10.9 mm

(very low variation - 8.57%), while the width ranges in relation to the height in a wider range. In 2024, fruit stalk length ranged between 12.29 mm (Topfive) and 19.29 mm (Topstar plus), showing significant variation. An increase in fruit weight and an improvement in morphological parameters is observed between 2021 and 2024. The cultivars Topgigant Plus and Topfive stand out with the best morphological performance in 2021 and in 2024. Similar results were reported by (Molnar et al., 2016). The cultivars with a lower relative share of stone and better fruit sizes deserve special attention. All biometric indicators have very strong correlations with each other (Table 2). Fruit weight and stone weight were strongly correlated ( $r = 0.929686$ ), i.e., as fruit weight increased, stone weight increased. The extremely strong correlation between fruit weight and fruit width ( $r = 0.992923$ ) indicates that fruit width is a reliable indicator of fruit

weight. Practically, it can be used to quickly estimate weight when width measurement is more convenient. Mesa et al. (2021) also found this highest and significant correlation between fruit weight and equatorial diameter ( $r=0.96$ ). The strong positive correlation ( $r=0.982449$ ) between fruit height and fruit thickness indicates that they change proportionally, i.e. fruit with specific shape are characteristic of particular cultivars. A strong positive correlation between acidity and physical characteristics (e.g.  $r = 0.750$  with fruit weight) indicates that larger fruit may contain more acid, which influences taste. Dry matter was negatively correlated with fruit weight ( $r = -0.703$ ), width ( $r = -0.704$ ) and height ( $r = -0.710$ ). This can be explained by the fact that larger fruits often contain more water and less dry matter. It is important to note that these relations may have significant effects on the processing of fruits and their use in different industries, for example for drying.

Table 2. Pearson correlation coefficients matrix for fruit morphological values

|                  | Fruit weight<br>(g) | Stone<br>weight (g) | Lenght<br>(mm) | Width<br>(mm) | Dry matter<br>(%) | Total sugars<br>(%) | Acids (%) |
|------------------|---------------------|---------------------|----------------|---------------|-------------------|---------------------|-----------|
| Fruit weight (g) | 1                   |                     |                |               |                   |                     |           |
| Stone weight (g) | 0.929686            | 1                   |                |               |                   |                     |           |
| Lenght (mm)      | 0.984124            | 0.96277             | 1              |               |                   |                     |           |
| Width (mm)       | 0.992923            | 0.924911            | 0.982449       | 1             |                   |                     |           |
| Dry matter (%)   | -0.70276            | -0.63834            | -0.71032       | -0.7037       | 1                 |                     |           |
| Total sugars (%) | -0.30866            | -0.17774            | -0.34718       | -0.33317      | 0.561312          | 1                   |           |
| Acids (%)        | 0.749764            | 0.663712            | 0.723644       | 0.756579      | -0.75991          | -0.12493            | 1         |

On average, for the conditions of the Troyan region, ripening starts at the end of August with Topgigant Plus (20-23.08) and ends at the end of September with Topper (18-25.09) (Figure 2.). In both years, the cultivars Top2000;Tophit Plus; Topking; Top and Topper ripened after 15.09. for Troyan conditions, on 15.09; 20.09; 28.09. Sotirov et al. (2021) for the Kyustendil area, which is located in southern Bulgaria and where the climate is warmer, the same late cultivars ripened up to 10-15 days earlier, namely Topking (10.08); Top2000 (25.08);

Topper (08.09). The late cultivar Tophit Plus is given a timing of 15-18.09, which matches our results. Sotirov & Dimitrova (2019) show that the early cultivar Topgigant Plus is also ahead of the ripening date under Kyustendil conditions (10.08), compared to the Troyan area (20-23.08) (Figure 2). For central European conditions, Suranyi (2019), set the ripening date a month earlier for Topking 25.08 and ten days for Topper (10.09). The earlier cultivar, Topfive (12.08), matches the timing for Troyan.

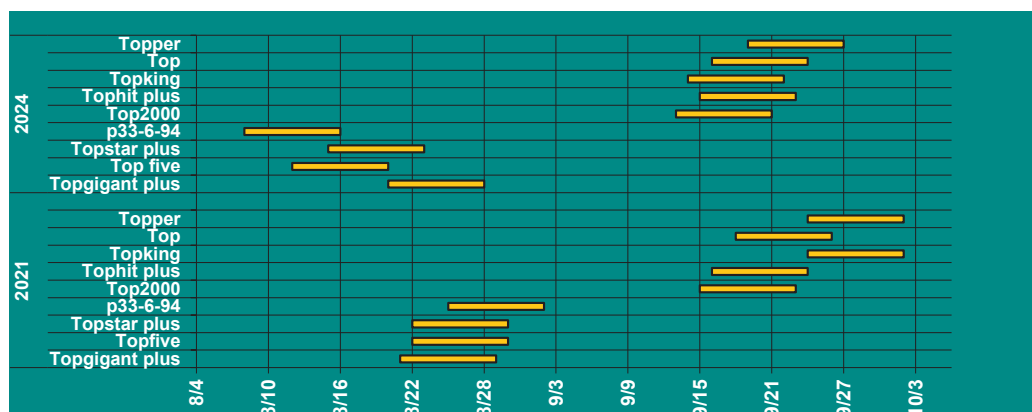


Figure 2. Ripening period 2021-2024

Yields from tree are significantly higher in 2024 compared to 2021 (Table 3). On average over the two years of the experiment, they range from 5 to 25 kg per tree. Fruit production was not regular over the years, showing

alternativeness, but this depended on climatic factors and agro-technical measures applied in the plantation. The potential of the cultivars is much greater with good care.

Table 3. Yield (kg/tree) (2021; 2024)

|                     | Topgigant Plus | Topfive | Topstar Plus | p 33-6-94 | Top 2000 | Tophit Plus | Top   | Topking | Topper |
|---------------------|----------------|---------|--------------|-----------|----------|-------------|-------|---------|--------|
| 2021                | 12.00          | 4.50    | 5.00         | 5-10      | 10.50    | 8.50        | 11.00 | 25.00   | 6.00   |
| 2024                | 35.00          | 28.00   | 10.00        | 2.00      | 15.00    | 45.00       | 18.00 | 25.00   | 12.00  |
| Average (2021-2024) | 23.5           | 16.3    | 7.5          | 5.0       | 12.8     | 26.8        | 14.5  | 25.0    | 9.0    |

Similar insufficient and low yields were reported by Suranyi, (2019), for the period of his research (2002-2003) 6 to 10 year old plum trees had 25-50 kg/tree yield and the fruits had low mass due to drought. It is the same for Sotirov et al. (2021), the average yields for 2019-2020 are 24 to 52 kg/tree.

The first 4 cultivars of the group are earlier ripening (end of August 18-28) than the next 5, which ripen after 15 September. This largely determines the high dry matter content in 2024 of Topper 22.5%, Top 2000 (23.5%) and Topking 27%. Topfive, Tophit Plus, Topstar Plus, and Top have dry matter contents around 21-22% (Table 4). In comparison, in 2021 the trend towards very high dry matter of this group of cultivars is confirmed (23-25.5%). We have similar data from results of Molnar (2016) Topfive (around 27%) and Kolev (2023), which also indicate a similar high percentage - Tophit Plus 22.6% Topper 22.4% dry matter for 2022 (Table 4).

*For the region of Kyustendil* (Kolev, 2023) found that the dry matter in fruits of the cultivars of the Top series ranged from 12.8% to 25.2%, the content of titratable acids from 0.52% to 1.47%, and of total sugars from 7.9% to 13.21%.

*For the Plovdiv region*, the total soluble solids content of the cultivars studied ranged from 15.7% in the Top cultivar to 24.75% in the Toptaste cultivar (Bozhkova, 2016).

In our study, total sugars for 2024 range with a cv coefficient of 22% from 13.5% (Tophit Plus) to 25.33% (Topking). In 2021 they range from 6.65% (Top 2000) to 22.00% (p 33-6-94). Accordingly, the cultivars Top 2000, Tophit Plus and Topking have the least amount of sucrose < 3% (Table 4). The variation in this parameter is the greatest, cv reaching 54%, and the values for sucrose content are between 2 and 9%, which in turn proves the absolutely suitable properties of the fruits for their inclusion in healthy menus of diabetics.

The content of titratable acids ranges from 0.47 to 0.74%, varying by a coefficient of 19.12%. Their content also determines the taste of the fruit, according to the value of the glucoacidimetric coefficient. For the 2024 conditions, the lowest value is p 33-6-94 (23.01), followed by Topgigant Plus (24,4) and Tophit Plus (25,04). The other cultivars studied have a much higher coefficient, which is due to the high sugar content or the much lower acid

content, and the fruits are characterized by a very sweet taste (Topking 25% sugars, 0.47% acids) (Table 4).

Tannins range from a maximum value in Topking (0.32%), which can affect texture and tartness, to minimum values of 0.19% in Topfive and p 33-6-94.

In polyphenols, the Topper cultivar stands out with an impressive 656.03 mg/g, suggesting a high antioxidant content (Table 4).

Table 4. Biochemical composition of fresh fruit (2021 and 2024)

|                | Dry matter (%) | Total sugars (%) | Inverted sugars (%) | Sucrose (%) | Acids (%) | glucoacidimetric index | vit, C (mg/%) | Tannins (%) | Anthocyanins (mg/%) | Total polyphenols (mg/g) |
|----------------|----------------|------------------|---------------------|-------------|-----------|------------------------|---------------|-------------|---------------------|--------------------------|
| <b>2021</b>    |                |                  |                     |             |           |                        |               |             |                     |                          |
| Topgigant Plus | 15.00          | 16.20            | 16.20               |             | 0.67      | 24.18                  | 10.56         | 0.11        | 13.87               | 192.20                   |
| Topfive        | 23.00          | 11.95            | 7.85                | 3.90        | 0.60      | 19.92                  | 10.55         | 0.14        | 10.66               | 122.58                   |
| Topstar Plus   | 20.50          | 12.60            | 2.55                | 9.55        | 0.67      | 18.81                  | 8.80          | 0.15        | 9.84                | 111.64                   |
| p 33-6-94      | 20.50          | 21.90            | 11.60               | 9.79        | 0.74      | 29.59                  | 12.32         | 0.20        | 11.29               | 222.80                   |
| Top 2000       | 21.00          | 6.65             | 5.20                | 1.38        | 0.47      | 14.15                  | 21.12         | 0.22        | 11.29               | 102.28                   |
| Tophit Plus    | 23.00          | 14.30            | 6.50                | 7.41        | 0.67      | 21.34                  | 8.80          | 0.18        | 3.23                | 171.78                   |
| Top            | 21.50          | 13.80            | 9.40                | 4.18        | 0.67      | 20.60                  | 10.56         | 0.20        | 6.45                | 188.28                   |
| Topking        | 25.50          | 14.30            | 8.70                | 5.32        | 0.67      | 21.34                  | 8.80          | 0.13        | 4.03                | 123.96                   |
| Topper         | 23.50          | 8.70             | 4.50                | 3.99        | 0.60      | 14.50                  | 21.12         | 0.22        | 3.87                | 250.75                   |
| cv (%)         | 18.46          | 39.39            | 58.54               | 56.12       | 15.17     | 27.26                  | 41.55         | 23.08       | 49.09               | 29.57                    |
| <b>2024</b>    |                |                  |                     |             |           |                        |               |             |                     |                          |
| Topgigant Plus | 18.00          | 16.37            | 13.18               | 2.99        | 0.67      | 24.44                  | 7.04          | 0.21        | 32.10               | 449.51                   |
| Topfive        | 21.00          | 23.23            | 14.08               | 9.15        | 0.74      | 31.39                  | 12.32         | 0.19        | 15.48               | 345.25                   |
| Topstar Plus   | 22.00          | 16.38            | 9.86                | 6.52        | 0.60      | 27.30                  | 10.56         | 0.21        | 22.90               | 579.84                   |
| p 33-6-94      | 18.00          | 17.03            | 10.76               | 6.28        | 0.74      | 23.01                  | 12.32         | 0.19        | 17.90               | 409.41                   |
| Top 2000       | 23.50          | 14.94            | 12.40               | 2.35        | 0.47      | 31.78                  | 10.56         | 0.26        | 28.39               | 517.68                   |
| Tophit Plus    | 21.00          | 13.52            | 11.31               | 2.06        | 0.54      | 25.04                  | 10.56         | 0.21        | 21.77               | 275.08                   |
| Top            | 21.50          | 22.63            | 18.91               | 3.48        | 0.54      | 41.90                  | 10.56         | 0.28        | 11.29               | 461.54                   |
| Topking        | 27.05          | 25.33            | 22.22               | 2.67        | 0.47      | 53.89                  | 8.80          | 0.32        | 19.19               | 4.99.64                  |
| Topper         | 22.50          | 18.20            | 13.42               | 4.54        | 0.47      | 38.72                  | 8.80          | 0.24        | 22.26               | 656.03                   |
| cv (%)         | 12.77          | 22.02            | 28.77               | 53.93       | 19.12     | 30.65                  | 16.82         | 19.73       | 29.79               | 26.66                    |

The colour parameters of the different cultivars were characterized by significant differences (LSD=0.05), underlining the genetic diversity. The Tophit Plus and Top 2000 cultivars stand out for their high brightness values (L) and

reddish or yellow hue, which may make them preferred by consumers. As a result of different agro-meteorological conditions, there is a tendency for the parameters to change between



2021 and 2024, with an increasing trend in the values of the skin colour parameters (Table 5). Fruit colour is an important commercial factor. Bright and intensive colours are more attractive to consumers, making cultivars with high L values and a positive 'a' (red hue) favoured. Colour parameters are key to assessing the

quality of plum fruit. Differences between cultivars and variations between years underline the importance of genetic and climatic factors. Tophit Plus and Top 2000, the cultivars with bright skins and rich fruit flesh colours, have a high potential for market realisation.

Table 5. Fruit colour parameters (peel and flesh)

|             | Topgigant Plus | Topfive | Topstar Plus | p 33-6-94 | Top 2000 | Tophit Plus | Top   | Topking | Topper | LSD <sub>0,05</sub> |
|-------------|----------------|---------|--------------|-----------|----------|-------------|-------|---------|--------|---------------------|
| 2021        |                |         |              |           |          |             |       |         |        |                     |
| fruit peel  |                |         |              |           |          |             |       |         |        |                     |
| L           | 30.26          | 34.50   | 32.86        | 30.32     | 33.93    | 45.88       | 37.10 | 41.28   | 36.58  | 3.20                |
| a           | -1.62          | 0.57    | 6.07         | 2.79      | 4.69     | 17.47       | 4.95  | 11.54   | 7.88   | 2.84                |
| b           | -2.11          | -4.72   | -3.21        | -0.19     | -4.20    | -9.95       | -4.21 | -7.94   | -3.56  | 2.06                |
| fruit flesh |                |         |              |           |          |             |       |         |        |                     |
| L           | 41.49          | 39.48   | 44.76        | 48.72     | 47.99    | 44.78       | 42.67 | 43.17   | 47.16  | 4.02                |
| a           | -8.34          | -4.70   | 2.25         | 1.78      | -2.15    | -5.89       | -0.41 | -6.16   | -1.14  | 1.50                |
| b           | 25.99          | 44.55   | 40.23        | 39.67     | 52.56    | 42.05       | 40.48 | 40.88   | 50.63  | 8.80                |
| 2024        |                |         |              |           |          |             |       |         |        |                     |
| fruit peel  |                |         |              |           |          |             |       |         |        |                     |
| L           | 33.75          | 31.85   | 34.58        | 32.37     | 38.46    | 46.87       | 39.25 | 39.64   | 43.43  | 2.82                |
| a           | 6.64           | 2.73    | 5.02         | 2.32      | 13.17    | 17.53       | 10.73 | 10.16   | 11.67  | 3.13                |
| b           | -4.95          | -2.61   | -4.41        | -1.48     | -9.38    | -10.40      | -7.35 | -6.85   | -10.25 | 3.31                |
| fruit flesh |                |         |              |           |          |             |       |         |        |                     |
| L           | 40.80          | 44.12   | 44.65        | 45.30     | 49.89    | 44.95       | 45.71 | 41.81   | 48.42  | 3.46                |
| a           | -5.56          | -3.67   | 2.16         | 1.39      | -1.07    | -6.17       | -2.03 | -3.81   | -0.15  | 1.59                |
| b           | 30.58          | 30.75   | 50.67        | 39.15     | 49.63    | 42.14       | 45.56 | 34.86   | 49.77  | 6.63                |

**Fruit flesh.** The moderate positive relationship between L and a ( $r = 0.573814$ ) indicates that brighter fruit flesh is redder. In 2024 the correlation between brightness and reddish hue weakens ( $r = 0.491082$ ) compared to 2021. The correlation of L and b ( $r = 0.474621$ ) for 2021 is a moderate positive correlation, i.e. brighter samples have a stronger yellow component. In 2024 L and b ( $r = 0.781454$ ) correlate more strongly, suggesting that the yellow component becomes more important for flesh brightness (Table 6).

The a and b ( $r = 0.378702$ ) are weakly positively correlated in 2021, suggesting that the reddish and yellow components are related. For 2024, a and b ( $r = 0.628057$ ) are in a moderate positive relationship, stronger than in 2021. Gadze et al. (2011) considered that fruit peel colour is not a relevant indicator of fruit ripening and without analysis of organoleptic characteristics, soluble dry matter and acid content cannot be reliably used to determine harvest date.

Table 6. Pearson correlation coefficients matrix for CIELAB values and the considered colour indices of skin and fruit flesh in the cultivars of the Top series

|      | Fruit peel |          |          |         |     |
|------|------------|----------|----------|---------|-----|
| 2021 | L          | a        | b        | a/b     | b/a |
| L    | 1          |          |          |         |     |
| a    | 0.912973   | 1        |          |         |     |
| b    | -0.95036   | -0.82321 | 1        |         |     |
| a/b  | 0.299459   | 0.061231 | -0.47156 | 1       |     |
| b/a  | -0.02865   | 0.21044  | 0.140707 | -0.1983 | 1   |



| 2024        | L        | a        | b        | a/b      | b/a |
|-------------|----------|----------|----------|----------|-----|
| L           | 1        |          |          |          |     |
| a           | 0.935777 | 1        |          |          |     |
| b           | -0.91991 | -0.95511 | 1        |          |     |
| a/b         | -0.40932 | -0.47761 | 0.242252 | 1        |     |
| b/a         | 0.384825 | 0.472973 | -0.25199 | -0.99179 | 1   |
| Fruit flesh |          |          |          |          |     |
| 2021        | L        | a        | b        | a/b      | b/a |
| L           | 1        |          |          |          |     |
| a           | 0.573814 | 1        |          |          |     |
| b           | 0.474621 | 0.378702 | 1        |          |     |
| a/b         | 0.56773  | 0.956967 | 0.579242 | 1        |     |
| b/a         | 0.149051 | -0.04237 | -0.25152 | -0.08094 | 1   |
| 2024        | L        | a        | b        | a/b      | b/a |
| L           | 1        |          |          |          |     |
| a           | 0.491082 | 1        |          |          |     |
| b           | 0.781454 | 0.628057 | 1        |          |     |
| a/b         | 0.60075  | 0.979761 | 0.725407 | 1        |     |
| b/a         | -0.51062 | -0.16219 | -0.40177 | -0.195   | 1   |

## CONCLUSIONS

We confidently recommend the plum cultivars of the Top series for adding to the plum cultivar list in the Troyan region. Earlier ripening cultivars Topgigant Plus, Topfive, Torhit Plus have larger fruits (40-50 g). Late ripening cultivars are characterised by very high dry matter and total sugars and low organic acid content. The balance between acids and sugars, as well as the ratio of fruit to stone weight, can be important for processing companies.

Peel brightness (L) correlates strongly with the reddish (a) and bluish (b) components, underlining the importance of these colour parameters for the visual appeal of the fruit. In fruit flesh, the a/b ratio is a key indicator of the reddish component of the fruit flesh. Correlations between L, a and b vary between moderate and strong, but are more strongly expressed in 2024.

The combination of high sugar content and dry matter with appropriate physical characteristics can be the key to selection.

The cultivars have a high commercial value and growers can be more competitive even on foreign markets thanks to the fact that the fruit of the whole series can be harvested for almost two months. The harvesting period they cover extends from late July to late September.

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