

II. TEHNOLOGII POMICOLE DURABILE – PROTECTIA MEDIULUI

FRUIT SUSTAINABLE TECHNOLOGIES – ENVIRONMENT PROTECTION

EVALUAREA UNOR SOIURI DE PRUN CULTIVATE IN SISTEM INTENSIV EVALUATION OF SOME PLUM CULTIVARS IN A HIGH DENSITY SYSTEM

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Abstract

Three plum cultivars bred in Romania ('Carpatin', 'Centenar' and 'Tita') were tested together with several standards ('Cacanska Rodna' and 'Stanley') in a high density experimental orchard established at Pitesti - Maracineni in the spring of 2009, with spacing 4 x 2.25 m. Trees were trained as spindles, grafted on 'Saint Julian' rootstock. In the orchard the following characteristics were evaluated: tree vigour based upon measuring of trunk-diameter, yields in kg/tree, time of fruit ripening and basic parameters of fruit quality. All Romanian varieties were characterized by earliness and large fruit, but production was relatively small. Instead, foreign varieties were characterized by high productivity in the 4th year after planting.

Cuvinte cheie: soiuri de prun, densitate mare, productivitate, vigoare, calitate fruct, epoca de maturare.

Keywords: plum cultivars, high density, yields, tree vigour, fruit quality, ripening time.

1. Introduction

Unlike apple, which particularly large range of vegetative rootstocks with different vigor, enabled rapid advances in technology culture, at plum using almost exclusively 'Mirobalan' rootstock, with some negative points (too vigorous growth and insufficient compatibility with some cultivars – Kaufmane et al., 2007), obliged to adopt the classical system, with distance of 6 m between rows and 5.0 m between the trees one at a time (333 trees / ha), with productivity as about 5-8 t/ha.

In the period 1976 - 1980 was triggered action to increase the density of trees - so called modernization, setting the standard distance of 5.0 / 4.0 m which we consider acceptable in new plum orchard located on land in the hills, sloping.

Currently there is a trend of expansion in holdings of a dense system, with planting distances of 4 x 2 m (1,250 trees / ha) with low vigor rootstock ('Saint Julien'), with trees training form spindle bush, under fertirigation (Blazek and Pistekova, 2009, 2012).

In the Research Institute for Fruit Growing Pitesti, the experimental orchard was established in 2009, with several new plum cultivars grafted on 'Saint Julien' rootstock. The paper present the results obtained in the first years of fruiting of the orchard.

2. Material and methods

The experimental orchard was established during spring 2009 at Pitesti - Maracineni. Five cultivars grafted on the 'Saint Julien' rootstock were planted in a spacing 4 m between the rows and 2.25 m between trees (1,111 trees / hectare). In this experimental orchard we planted the next cultivars: 'Carpatin', 'Centenar', 'Tita' (originally from Romania), 'Čačanska Rodna' (from Serbia) and 'Stanley' (originally from USA) as standards.

Climatic conditions of Maracineni are characterized by the average annual temperature of 9.7°C and the average annual rainfall of 663.3 mm.

Experimental trees were trained as spindles, under fertirigation.

The following records were taken annually: trunk diameter; yielding capacity; harvest ripening; fruit weight, flesh firmness, soluble solids content and colour of the fruits. Trunk diameter was measured with caliper digital; fruit production was determined by weighing in kg/tree; fruit weight was recorded with a balance in g/fruit; fruit firmness was measured with non-destructive penetrometer Qualitest HPE equipped with a plunger of diameter 0.10 cm²; soluble solid contents were measured with a digital refractometer, in % Brix; the external skin colour parameters (*L*, *a*, *b*) were measured using a Konica Minolta CR 400 chromameter, where *L* corresponds to Luminance, and *a* and *b* to the chromaticity coordinates (on green to red and blue to yellow).

Data were analyzed statistically using Duncan's multiple range test - $P \leq 0.05$.

3. Results and discussions

Trunk diameter

'Saint Julien' is one of the most popular rootstocks in Europe. It is known as a semi/dwarf rootstock (Botu and Achim, 2002). The tree growth vigour, expressed as trunk cross sectional area, shows that the greatest value was observed at 'Centenar' cv. (53.83 mm), and the lowest at 'Čačanska Rodna' (43.70 mm) cv. Some authors showed that 'Saint Julien' rootstock limit shoot growth in the first years after planting, but after few years it is become vigorous (Boyan et al., 1995, Wertheim, 1994). Thus, it is observed that after 3 years of measurements was recorded an increase of growth between 42.57 mm at 'Tita' cv. and 35.55 mm at 'Čačanska Rodna' cv. (Table 1). Regarding the Romanian varieties, the largest vigour had 'Centenar' cv. (53.83 mm), and the smallest 'Carpatin' cv. (47.89 mm).

Yielding capacity

The trees of the majority of the cultivars grafted on 'Saint Julien' rootstock came into bearing in the third year after planting, but production was very low (Rozpara et al., 2010). Beginning with the fourth year after planting were recorded relatively good production in most varieties. Thus in 'Čačanska Rodna' and 'Stanley' varieties were recorded the highest number of fruits per tree, which has led to the production of 14.87 kg / tree ('Čačanska Rodna' cv.), respectively 19.28 kg / tree ('Stanley' cv.). In the fourth year after planting, Romanian varieties had a small number of fruit per tree, respectively small productions due to low temperatures during blooming time. In 2014 (the fifth year after planting) all varieties studied except 'Carpatin' variety recorded very good productions.

Statistical analysis of data on production per tree, using Duncan's multiple range test ($P \leq 0.05$) allowed grouping varieties studied in 3 homogeneous groups of yields between varieties were significant differences. However, the best production had 'Stanley' variety (17.30 kg / tree - mean in the two years of study). This value corresponds to a total harvest per hectare of 19.22 tons. From Romanian varieties noted 'Tita' cv. with 14.95 kg/tree, which means 16.61 tons. The smallest yield was obtained from the 'Carpatin' variety (2.62 kg/tree, respectively 2.91 tons/hectare) (Table 2).

Average yields on the 5 plum varieties studied had a value of 11.56 kg/tree and the standard deviation was 9.55 g (Fig. 1).

Productivity index

The productivity index, calculated like yield (kg/tree) per trunk section area (cm^2) had an average value of 0.60 kg/cm^2 , ranging between 0.8 kg/cm^2 at 'Stanley' cv. and 0.15 kg/cm^2 at 'Carpatin' cv. From Romanian varieties the highest productivity index had 'Tita' cv. (0.69 kg/cm^2) (Table 2).

Harvesting time

Normally in the southern hilly area of Romania, the plum ripening period expend for 3 month (July, August and September) (Butac et al., 2013). Romanian varieties distinguished by earliness (fruit ripening time in the end of July). On the contrary, the latest time of fruit ripening was marked by the standard cultivars ('Stanley' and 'Čačanska Rodna'), which had a mean date of harvest in the end of August (Table 3.a).

Fruit characteristics

Fruit weight

Good fruit size is very important for successful marketing of fruits (Hartman et al., 2007).

Statistical analysis of data on fruit weight, using Duncan's multiple range test ($P \leq 0.05$) allowed grouping varieties studied in 4 homogeneous groups of weight, between varieties were significant differences. Average weight of fruit on the 5 plum varieties studied had a value of 44.43 g, the highest average weight recorded in 'Tita' variety (56.47 g) and the lower average values variety 'Čačanska Rodna' (30.56 g). The standard deviation was 9.39 g, and the coefficient of variation (standard deviation / mean, expressed as a percentage) was medium, 21.13% (Table 3.a; Fig. 2).

After European descriptors *Prunus* Data Base (EPBD) used to describe varieties in *Prunus* genus, it appears that the Romanian varieties studied were placed in Group 7 - Fruit large (41-55 g), and they are recommended for fresh consumption, excepting of 'Čačanska Rodna' variety which was placed in Group 3 - Fruit medium (26 - 40 g) and it is recommended for fresh consumption and also for processing.

Firmness measurements

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 variety testing and programs including fruit quality (Sekse and Wermund, 2010).

Average fruit firmness was $40.41 \text{ N/0.10 cm}^2$, respectively $4.04 \text{ kg force/cm}^2$, the maximum amplitude variation being $25.40 \text{ N/0.10 cm}^2$, the lowest average recorded at variety 'Centenar' (28.47

N/0.10) and the highest average was recorded at 'Čačanska Rodna' variety (53.87 N/0.10 cm²). All Romanian varieties have had a medium firmness (they are known as varieties with flesh juicy and medium firmness). The standard deviation was 15.28 N/cm² and coefficient of variation was 37.81% (Table 3.b, Fig. 3).

Fruit soluble solids content

After statistical processing of fruit soluble solids content data, plum varieties were classified in three homogenous groups, the values were statistically assured. Thus, the average soluble dry substance was 17.13%, the highest soluble solids content in fruit variety is 'Čačanska Rodna' (18.82%) and lowest in variety 'Stanley' (15.03%). It should be noted that all Romanian varieties had more than 16% soluble solids, and of these, 'Carpatin' variety had the highest dry matter content (18.7 %) (Table 3.b). The standard deviation was low, of 1.46%, the coefficient of variation was 9.57% (very small variation) (Fig. 4).

Fruit colour

To appreciate the fruit colour of plum varieties studied we are using Konica Minolta chromameter.

The CIELAB colour scale is an approximately uniform color scale. The maximum for L* is 100, which represents a perfect reflecting diffuser. The minimum for L* is zero, which represents black. The a* and b* axes have no specific numerical limits. Positive a* is red, negative a* is green. Positive b* is yellow, negative b* is blue (Kovacs and Kallay, 2007).

Analyzing the data from Table 4, it is noted that, there are significant differences between varieties. Average value for L* is 24.87, values ranging between 21.25 ('Tita') and 33.15 ('Čačanska Rodna'), values which situated varieties on L* axis closer to black colour. Regarding axis a*, the average was 3.03, which is red colour, the highest values occurring at 'Carpatin' variety, 4.20 (light blue fruit) and 'Čačanska Rodna' (3.93 – reddish colour). The lowest values had 'Stanley' variety, 1.53 (dark blue fruit) (Table 4, Fig 4). On axis b* is found also that there are significant differences between varieties, most values are negative, indicating blue colour. The average value was -2.01, the highest values (positive) were 'Carpatin'(2.42) variety, which have red and blue fruit, and the lowest values (negative) occurring at 'Centenar' (-0.96), 'Čačanska Rodna' (-7,20) and 'Stanley' (-3.70) varieties, which have blue and dark blue fruits (Table 4, Fig. 5).

It is known that, when approaching of optimum maturity varieties become more lightness (L*), more red (a*) and more blue (b*) (Vangdal and Flatland, 2008).

4. Conclusions

Romanian varieties grafted on 'Saint Julien' rootstock had good results in the first years of fruiting.

However, these varieties were more vigorous than foreign varieties taken as control, except 'Carpatin' variety.

Regarding the yields, even in the first year of fruiting, the production of Romanian varieties was lower, in the second year of fruiting (2014), the yielding capacity of 'Tita' and 'Centenar' varieties was much higher than controls. On average of the two years of study, Romanian varieties had relatively good production, but did not exceed the control 'Stanley'.

The Romanian varieties were noted for earliness, fruit large, appearance and quality, designed for fresh consumption.

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Tables and Figures

Table 1. The tree growth vigour expressed as trunk cross sectional area (mm)

No.	Cultivar	Trunk diameter (mm)				Increase of grow
		2012	2013	2014	Average	
1	Carpatin	28.55c	46.13c	69.00a	47.89	40.45ab
2	Centenar	33.81a	56.38a	71.31a	53.83	37.50ab
3	Tita	30.92b	52.49ab	73.49a	52.30	42.57a
4	Čačanska Rodna	25.28d	45.00c	60.83b	43.70	35.55b
5	Stanley	31.02b	51.78b	67.37a	50.05	36.35b

Table 2. Yielding capacity of plum cultivars grafted on Saint Julien rootstock

No.	Cultivar	No. of fruits/tree			Yield/ tree (kg/tree)			Productivity index
		2013	2014	Average	2013	2014	Average	
1	Carpatin	16.67b	85.00c	50.83b	0.82c	4.44e	2.62b	0.15
2	Centenar	60.00b	483.33a	271.67a	2.50c	19.77b	11.13ab	0.49
3	Tita	9.33b	471.33a	240.33ab	0.47c	29.44a	14.95a	0.69
4	Čačanska Rodna	451.00a	287.33b	385.83a	14.87b	8.74d	11.81ab	0.79
5	Stanley	484.33a	351.67b	401.33a	19.28a	15.33c	17.30a	0.88
	Average	204.27	335.73	270.00	7.59	15.54	11.56	0.60

Table 3.a. Fruit characteristics of plum cultivars grafted on Saint Julien rootstock

No.	Cultivar	Harvest ripening	Mean fruit weight (g)		
			2013	2014	Average
1	Carpatin	28.07	41.90b	52.17b	50.48b
2	Centenar	25.07	48.80a	40.97d	41.43c
3	Tita	30.07	50.50a	62.43a	56.47a
4	Čačanska Rodna	22.08	30.67c	30.46e	30.57d
5	Stanley	25.08	42.83b	43.53c	43.18c
	Average		42.94	45.91	44.43

Table 3.b. Fruit characteristics of plum cultivars grafted on Saint Julien rootstock

No.	Cultivar	Firmness (N/0.10cm ²)			Fruit soluble solids content		
		2013	2014	Average	2013	2014	Average
1	Carpatin	22.86bc	45.80b	34.33b	19.17a	18.23a	18.70a
2	Centenar	20.27c	36.67c	28.47b	17.83b	16.03bc	16.93b
3	Tita	26.70b	36.86c	31.78b	16.07c	16.23b	16.15b
4	Čačanska Rodna	41.50a	63.40a	53.87a	19.20a	18.43a	18.82a
5	Stanley	43.83a	66.23a	53.62a	14.90c	15.17c	15.03c
	Average	31.03	49.79	40.41	17.43	16.82	17.13

Table 4. Colour parameters (L,a,b)

No.	Variety	Visual colour	Colour parameters (l,a,b) – average 2013 - 2014		
			CIE L*	a*	b*
1	Carpatin	Light blue	22.04c	4.20a	2.42a
2	Tita	Blue	21.25c	2.94ab	-0.64b
3	Centenar	Blue	22.22c	2.54ab	-0.96b
4	Čačanska Rodna	Reddish	33.15a	3.93ab	-7.20d
5	Stanley	Dark blue	25.70b	1.53b	-3.70c
	Average		24.87	3.03	-2.01

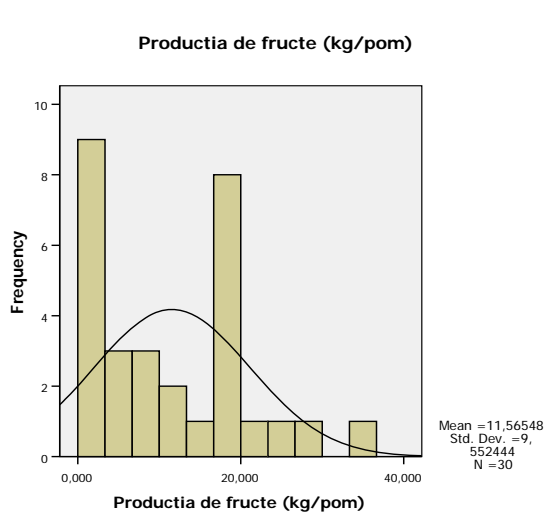


Fig. 1. Histogram of yielding capacity

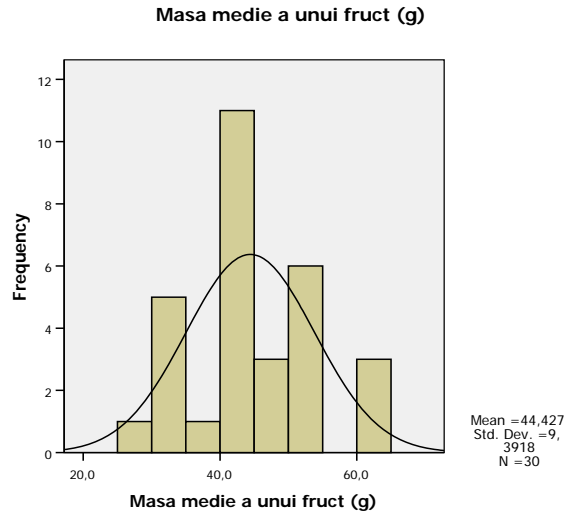


Fig. 2. Histogram of fruit weight

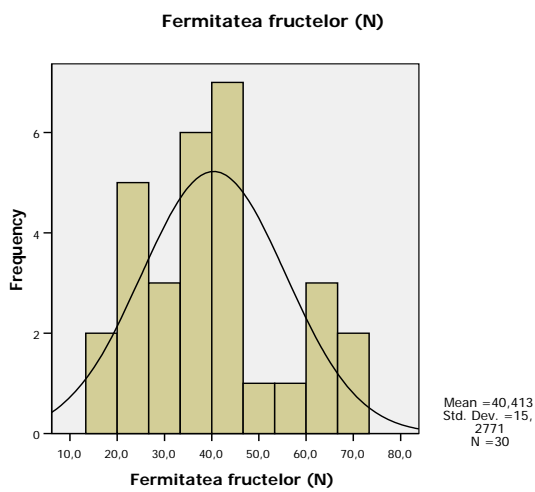


Fig. 3. Histogram of firmness

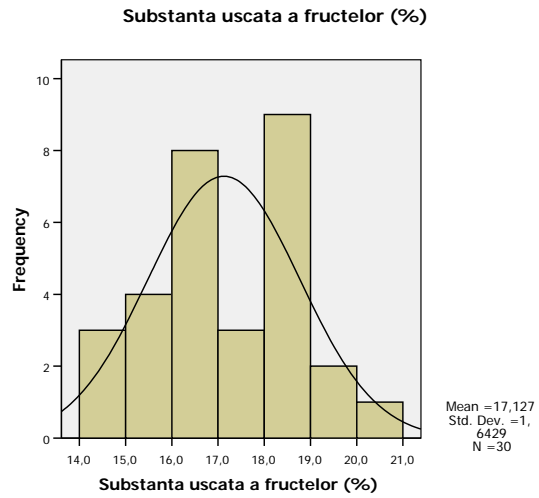


Fig. 4. Histogram of soluble solids content

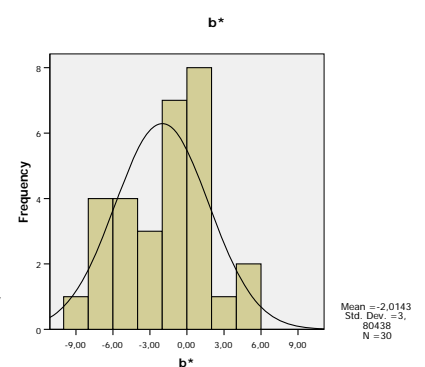
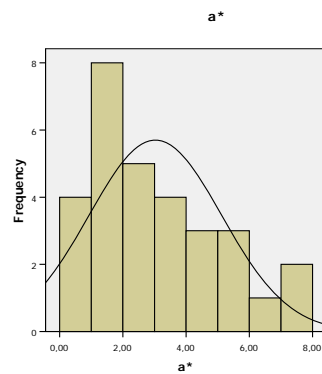
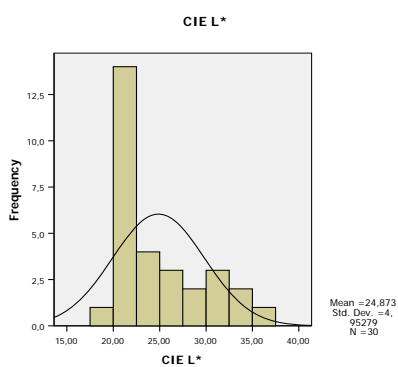


Fig. 5. Histogram of CIE L*a*b*