INFLUENCE OF SOME SOIL AND CLIMATE FACTORS OF THE REGION OF TROYAN OVER THE YIELD AND QUALITY OF PLUM FRUITS OF 'KATINKA', 'TEGERA', 'ELENA' CULTIVARS, IN NATURAL GRASS ESTABLISHMENT

Stefanova Boryana, Georgi Popski, Ivan Minev

Research Institute of Mountain Stockbreeding and Agricultire, Troyan, Bulgaria

Corresponding author: stefanova_b@abv.bg

Abstract

Grey forest soils with heavy sandy clay structure and low nutrient availability are characteristic for the conditions of the region of Troyan. Climate conditions are the following: the average annual temperature is about 10°C and the annual rainfall is about 750 mm. The duration of vegetation period is 245 days. The experiment includes small-sized plum cultivars 'Tegera' and 'Elena', grafted on Mirobolan seedlings, and planted in 2000; and 'Katinka' grafted on 'Fereley' rootstock, planted in 2005, all are being grown under non-irrigated conditions. The aim is to determine the influence of soil and climate factors in the region of Troyan over the phenology and reproduction of the introduced German plum cultivars of 'Katinka', 'Tegera' and 'Elena'. The flowering, some vegetative and reproductive indicators were observed and chemical analysis of fruits was conducted for characterization of their taste qualities. It is found that in the foothill region of Troyan, plum cultivars find favourable conditions for growth and development, but they require regular agrotechnical measures and increased attention in extreme climate changes. In 2015, which was a favourable year, the plum harvest of 'Katinka' was about 40 kg per tree. Fruits had very small weight (15; 16; 21g), but the great quantity gave opportunity for high yield. The earlier ripening cultivars 'Tegera' and 'Katinka' accumulate less dry matter in comparison with the late ripening cultivar 'Elena'.

Keywords*:* Troyan region Bulgaria, agro-ecological conditions, plum, cultivars.

Introduction

The typical for plum production for the region of Troyan are agro-climatic conditions, which ensure the normal development and cultivation of the plum culture, meeting its biological requirements. The technologies being developed and tested in RIMSA include different elements for pre-ground preparation of the areas and different ways of maintaining the soil surface to ensure optimal yields and good quality of fruit production (Dinkova et al., 2006 b; 2010; Dinkova, 2009). The aim is to adapt to the requirements of sustainable agriculture. Sustainable farming technologies are aimed at: Not to destroy but to improve the natural environment, i.e. soil to be protected from erosion; To store the humus; Maximum moisture and nutrients to accumulate and economize; To better exploit the productive capacity of agricultural crops.

Scientific research shows that agrophysiological properties and, first of all, the structure have deteriorated sharply after extensive soil set-aside, especially without further introduction of organic matter (Merwin et al., 2004). The high aeration created as a result of soil cultivation leads to an intensive mineralization of the humus, which leads to soil degradation of organic matter. By bracing the interrow and maintained in the grass, it is possible to reduce the number of soil cultivation, at the expense of cultivation of green fertilization crops, which maintains the integrity of the soil surface and increases the content of organic matter, hence increasing the moisture holding capacity of the soil (Dinkova et al., 2006 a; Reeve et al., 2013). This reduces the surface runoff, the evaporation from the soil surface and the underground water reserves are increased (Savory and Butterfield, 1999; Devyatov et al., 2000). The cultivar is a major element in technology for growing and fruit production. It is required to be resistant to the abiotic factors of the ecosystem and to minimally apply chemical remedies. In this connection, for many years in RIMSA Troyan are tested

plum cultivars and among them are ‘Katinka’, ‘Tegera’ and ‘Elena’ (Dinkova, and Dragoyski, 2005; Dinkova et al., 2007; Dragoyski et al., 2009; 2010). The aim is to determine the influence of soil and climate factors in the region of Troyan over the phenology and reproduction of the introduced German plum cultivars 'Katinka', 'Tegera' and 'Elena'.

Material and methods

The experiment was conducted during the period 2014-2016 in the semi intensive plum plantation of RIMSA Troyan, founded in 2000 on a slope about 5-6º, with cultivars 'Katinka', 'Tegera' and 'Elena' and 'Stanley' for control, with a planting scheme of 5 × 3 m. The cultivation is under non-irrigating conditions, the interrow was maintained in grass.

Characterization of cultivars

Cultivars ‘Katinka’ and ‘Tegera’ ripen earlier (in the beginning of August) cv ‘Elena’ is the latest in our assortment – ripens at the end of September.Their fruits are small (‘Katinka’) to moderately large (‘Tegera’ and ‘Elena’). Placed under the same growing conditions they showed peculiarities in developmental and reproductive events, some of which require specific technological approach to cultivation. The very first results showed that the German cultivars ‘Katinka’, ‘Tegera’ and ‘Elena’ adapt well in terms of area. They bear fruit regularly and show satisfactory tolerance of viral disease Plum Pox.

Characteristics of soil

Prevailing soil type in the region is planosols with a pH 5.7, poor in nutrients. The area is maintained natural grass cover incurred, an agrochemical analysis for two consecutive years showed that organic matter concentrated in humus horizon 0-20 cm is slightly (1.72%) and decreases in depth horizon (20-40 cm) (Table 1). In 2015 reported higher values humus is stored, as they are not carried out soil cultivation. In 2015 the total nitrogen also reduced profile depth (0-20cm) by 42% compared to 2014. The low humus content and total nitrogen are the factors that determine poor preservation of the soil to absorb nitrogen. The content of assimilable phosphorus is low. Average stock is absorbed potassium. Soil reaction ranges from acidic to slightly acidic.

Table 1. Content of the main nutrients in the soil

Depth cm	pH H_2O	KCl	∑ $N\text{-}NH_4+NO_3$ mg/kg	P_2O_5 mg/100g	K_2O mg/100g	Humus %
2014						
0-20	4.8	3.6	28.2	2.7	20.9	1.72
20-40	5.7	4.7	20.2	3.7	16.6	1.21
2015						
0-20	6.1	5.6	15.0	18.0	25.3	3.26
20-40	5.0	4.1	11.5	1.1	14.9	1.17

Characteristics of climatic conditions

The average annual rainfall for the region of Troyan is 750 mm for the past 20 years, which is 20% more than for the country. Rainfall during the vegetation period is relatively evenly distributed. The average relative humidity is about 75%, the average annual temperature is about 10 °C. The length of the vegetation period is 245 days. Extreme abnormalities were observed during the study period, however, with an excessive amount of rainfall in the vegetation (1151 mm) in 2014. These extremely unfavorable climatic conditions during the flowering and the formation of harvesting compromised fruit harvest of all cultivars included in the study. In 2015, the cooler March and larger rainfall slowed the flowering phenophase. The highest rainfall is measured in June and September in 2015, and in 2016 in the spring months of April and May (fig. 1).

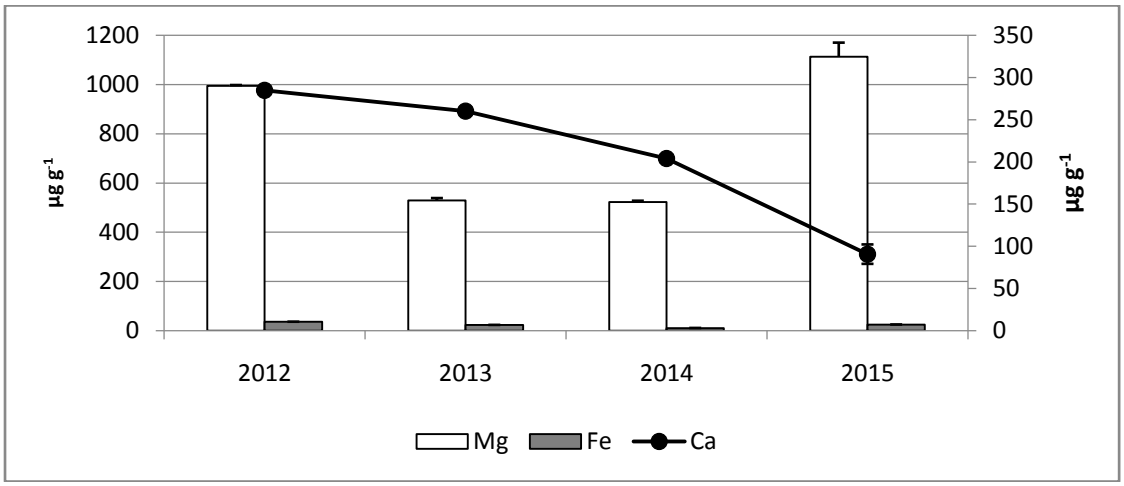

Figure 1. Climatic indicators 2014-2016

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 0,1n 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≤0,05.

Results and discussion

The most important one is the sensitivity of the flowers of the variety to cool weather conditions at blooming time. For instance, 'Italian Prune' is very sensitive to bad weather conditions during flowering as well as 'Valjevka' and 'Cacanska najbolja', whereas 'Cacanska lepotica' and 'Katinka' are relatively robust (Neumüller, 2011). In 2014 the earliest flowering began in plum cultivar 'Tegera' and was the longest (15 days). The latest blooming cultivar was 'Katinka'. During full bloom, rain fell in high amounts that probably prevented the normal flow of pollination in plums. In 2015, there was a delay in starting dates of flowering. Overall the flowering phase passed in the period from 15 to 25.04 (last 10 days). High temperatures in late March in 2016, prompted by 10-12 days early awakening of buds bloom was extended in the period from 28.03 to 15.04. The terms of ripening of early cultivars 'Katinka' and 'Tegera' include 15-20 July. Later ripening cultivars 'Elena' and 'Stanley' (control) are ripe with 15 to 20 days earlier in 2016. A better price is usually realised at the end and especially at the beginning of the harvesting season. Therefore, an extension of the ripening time is desirable.

Table 2. Phenology phases 2014-2016

	Beginning of flowering	Full flowering	End flowering	Fruit ripening period
2014				
Katinka	5-6.04.	8-10.04.	11-14.04	10.07
Tegera	28.03-3.04	4-8.04	9-14.04	25.07
Elena	30.03-2.04	3-8.04	9-13.04	11.09
Stenley	30.03.-2.04	3-8.04	16-18.04	23.08
2015				
Katinka	14-16.4	17-24.04	25-29.4	15-20.07
Tegera	16-17.04	18-22.04	23-29.4	28-30.07
Elena	15-18.04	19-22.04	23-29.04	15-20.09
Stenley	14-16.04	17-23.04	25-29.04	1-6.09
2016				
Katinka	2-5.04	6-12.04	13-15.04	14-16.07
Tegera	31.03-04.04	5-8.04	9-10.04	20-25.07
Elena	29-31.03	1-4.04	5-6.04	1-5.09
Stenley	1-4.04	5-8.04	9-11.04	3-6.08

Table 3. Vegetative and reproductive characteristics 2015-2016

	Katinka	Tegera	Elena	Stenley	*LSD 0,05*
Trunk cross-section area (cm^2)					
2015	39.01	93.15	130.02	87.08	
2016	46.23	157.35	161.28	90.31	
Crown volume (m^3)					
2015	2.82	5.73	18.34	21.56	*8.32*
2016	5.29	22.96	27.69	12.81	*6.86*
Projection of crown (m^2)					
2015	3.04	4.19	11.39	13.04	*5.99*
2016	4.71	12.40	14.37	7.72	*3.17*
Yield per tree (kg)					
2015	40.00	25.00	35.00	6.00	
2016	6.40	3.50	8.00	1.50	
Fruit weight (g)					
2015	16.69	24.16	14.91	28.14	*2.47*
2016	18.95	27.97	21.63	37.68	*2.35*
Yield efficiency (kg cm^{-2})					
2015	1.025	0.268	0.269	0.069	
2016	0.138	0.022	0.050	0,017	

Studied plum cultivars have different strength growth, 'Tegera' and 'Elena' are more vigorous than control 'Stanley'. Parameters trunk cross-section area and crown volume for 2016 are similar in value significantly different from 2015 (table 3). Trees cv. 'Tegera' for one season increased the trunk cross-section area by 64 cm^2, while those of cv. 'Elena' 31 cm^2, i.e. increase in 'Tegera' is doubly stronger than cv. 'Elena'. The volume of crowns in cv. 'Tegera' increased 2 times more than cv. 'Elena' (table 3). The projections of the crowns are 12-14 m^2, and according to the scheme of planting, provided their nutritional area of 10 m^2, therefore after the winter season will apply slightly

stronger pruning to reduce the size of crowns. Yield efficiency is the highest in cultivar 'Katinka' in 2015, as the resulting yield per unit section is the greatest (table 3). In favorable 2015 reported satisfactory yields of plum harvest. The highest in cultivar 'Katinka', about 40 kg per tree, followed by 'Elena' (35 kg). Their fruits are of very small weight (15-16 g), but their abundant amount allows for high yield. Popski et al. (2015) determine the size fruits of cv. 'Katinka' as large, medium and small with scales according to 21.27-12,26g, respectively average weight 16.69g, similar to the actual investigation. In the control cv. 'Stanley' yield is extremely low and is not compensated by larger fruit with weight 28-38 g. In all cultivars there is a significant decrease in yield in 2016 compared to 2015 (table 3).

Table 4. Chemical composition of fresh plum fruits

	Soluble solids (%)	Total sugar (%)	Inverted sugar (%)	Sucrose (%)	Total acids (%)	Tannins (%)	Anthocyanins (mg%)
2015							
Katinka	14,5	8,5	5,5	2,90	0,38	0,104	21,94
Tegera	15,0	8,9	5,0	3,71	0,61	0,125	15,32
Elena	20,5	8,9	3,2	5,42	0,58	0,166	12,10
2016							
Katinka	15,0	10,6	6,9	3,56	0,45	0,229	23,71
Tegera	17,3	10,0	4,9	4,94	0,64	0,270	19,19
Elena	21,0	10,9	5,4	5,27	0,45	0,187	18,23

There have been chemical analysis of fruits to characterize the taste qualities. Early cultivars 'Katinka' and 'Tegera' had very small dry matter (%), later cultivar 'Elena' was able to accumulate a larger percentage (20,5 to 21,0%) as the dry summer and sunny days favor this process. Total sugars and acids were almost identical for all three cultivars, and in 2015 were around 9%, in 2016 about 10%. The acids ranged from 0,4 to 0,6%, regardless of the year. Cv. 'Katinka' contained very small amount of sucrose, making it suitable for consumption by diabetics and the highest amounts of anthocyanins (22-23%) (table 4).

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 'Kantka', 'Tegera' and 'Elena'. In years with extremely different climatic conditions – severe over-humidification (abundant rainfall during the 2014 vegetation), the fruit harvest is completely compromised. Standard agro-technical measures can maintain optimal growth and yield regular and high yields as the studied cultivars have potential. Yield efficiency is the highest in cultivar 'Katinka' in 2015.

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