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YIELD AND FRUIT CHEMICAL COMPOSITION OF SOME PLUM CULTIVARS AFFECTED BY DIFFERENT SOIL TYPES

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Abstract

Soil type and properties, soil fertilizers have influence on development of root system, on crop productivity and aromatic and texture features of fruits. The aim of the present study was to compare the effect induced by three different soils type on plum fruit quality and yield. The plum 'Vânăt românesc' and 'Stanley' varieties were studied in two experimental orchards Caransebes and Lugoj areas. The plum quality parameters and yield were analysed to assess the relationship between soil type and fruit quality. There was little difference in the pigment content of the varieties, but variety such as 'Vanat romanesc' had a higher anthocyanin content, cultivated in the soil type typical brown luvic while the anthocyanin content increase at 'Stanley' variety cultivated in brown luvic pseudogleyic. The titratable acidity was similar in the both cultivars from all soil type. Also, significant differences were found in fruit weight and dry matter between soil type for every cultivar studied. The results obtained suggest that brown luvic pseudogleyic soil have a special favorability for 'Vânăt românesc' cultivar but 'Stanley' cultivar is much more suitable for cultivation in erodisol iluvial clay anthropically covered.

***Key words**: brown luvic soil, brown luvic pseudogleyic, fruit weight, pigments, soluble solids.*

INTRODUCTION

Plum (*Prunus domestica*) growing has a long tradition in Romania and this species is widely spread throughout country because of favourable pedo-climatic conditions this covering an area of 65,114 ha and having a production of 512,975 tons (Zamfirescu et al., 2019; Butac et al., 2015).

Nowadays, cultivated varieties are diverse depending on the environment, so different varieties have been adapted at different soil and climatic conditions. Selection of the appropriate cultivar for particular climatic and soil conditions is a factor of primary importance (Sarawathi et al., 1998) for improving fruit quality and yield. Therefore, some growing areas require a different selection of fruit cultivars than others.

Obtaining a high yield and good fruit quality is dependently by different factors such as climate (temperature, humidity, light) and soil characteristics and management practices (e.g., soil management, pruning, planting density, rootstocks, water management) (Reig et al., 2018; Zoppollo et al., 2011).

Soil texture influences soil water holding capacity (SWHC), and thus the availability of water for uptake by the roots in grapevine, which is a key factor for obtaining high quality grape (Lovisolo et al., 2016). In another study, a higher percentage of sand was positively correlated with increase of total soluble solids (TSS) and polyphenol concentration (De Santis et al., 2017).

It is well known that soil have an important impact on aromatic characteristic of fruits like grape (Royer et al., 2012). Also, studies of Cudur et al. (2014) supported that soil type influenced grape acidity and production but have insignificant effect on the sugar accumulation. The previous studies of Aruani et al. (2014) shows that soil have an hight impact on pear tree yield.

Several studies had shown that soil type exercised a considerable influence on grow characteristics, quality and minerals content of blueberries cultivars (Matsouka et al., 2017; Tasa et al., 2012; Ancu et al., 2010).

Little information has been available in the literature regarding to role of soil type on quality and yield of plums (Guerra and Casquero, 2009; Rato et al., 2008).
The objective of the present study is to compare the effect induced by three different soils (brown luvic typical and brown luvic pseudogleyic and erodisol iluvial clay anthropically covered) on yield and fruit quality of plums.

MATERIALS AND METHODS

Studied cultivars 'Vânăt românesc' and 'Stanley' have been collected from experimental plum orchards located at Caransebeș and Lugoj regions. Both cultivars resulted by three different soil: brown luvic typical (S1) and brown luvic pseudogleyic (S2) and erodisol iluvial clay anthropically covered (S3).
Soil chemical composition from 0-20 cm and 20-50 cm soil depth is presented in Table 1. Mineral composition and humus content of three soils type was performed according to the methods described by Borlan and Răuță, 1981. Atomic absorption spectrophotometry was used for Ca, Mg, Mn, Zn, Fe, Co and Cu content determination, while flame photometry was used for available P and K content determination. Nitrogen content were determined by Kjeldahl method. Soil pH was determined with pH meter.
Yield per tree (kg) of each cultivar was measured on five trees on three replications. A sample of randomly picked 15 fruits per cultivar was harvested at commercial maturity for determining of quality attributes. Fruit quality parameters were immediately assayed after harvest with specific analytical methods.
Soluble solids content (SSC) was assessed in juices of fruits using a thermo-compensated Atago hand-refractometer (model PR-101, ATAGO, Japan) expressed as Brix (Harril, 1998).
Titratable acidity (TA) was determined by titration of known volume of juice aliquot with 0.1N NaOH to an end point pH 8.1 using a pH Meter (Hanna Instruments, Italy) and the total acidity calculated and expressed as malic acid (Crisosto, 2008).
Assessment of ascorbic acid content was achieved by quantitative reduction of 2,6-diclor- phenol-indophenol and the excess of dye is spectrophotometrical determined at 500nm (AOAC, 1990). The results were expressed as mg/100g fresh weight.
Flesh firmness (kg/cm^2) was averaged from two measurements taken at the equator of each fruit, after removing a peel evaluated with a penetrometer (Model FT 327) fitted with a cylindrical 11.1mm diameter head (Bramlage, 1983).
External color (L*, a*, and b*) was measured on 10 fruit from each group with Hunter Lab colorimeter (Model MiniScan XE Plus) according to the method of Hunter and Harold, (1987). Measurements were conducted in CIE L*a*b* system. L* is a measure of lightness, where values range from completely opaque (0) to completely transparent (100), a* is a measure of redness (or - a* of greenness) and b* of yellowness (or - b* of blueness) on the hue circle. The hue angle, h°, describes the relative amounts of redness and yellowness where 0°/360° is defined for red/magenta, 90° for yellow, 180° for green and 270° for blue colour.
The content of total anthocyanins of the fruit juice was determined by pH differential method previously described by Giusti et al. (2002). Results were expressed as mg cyanidin-3 glucoside/100 g fresh tissue.
Total phenolics were determined using the Folin-Ciocalteu colorimetric method described by Singleton and Rossi (1965). Results were expressed as mg gallic acid equivalents (GAE) per 100g of fresh weight of edible part of fruit.

RESULTS AND DISCUSSIONS

Our results showed that soil played an important role in quality of plum affecting plum yield and fruit chemical composition.
The soil pH was increased and ranged from 4.75 to 6.92. S1 and S2 have a low total nitrogen content (0.07-0.11%) but S3 had a moderate content of total nitrogen (0.228%). The contents of CaO, in the soil was lower in the case of S2 and higher in S1 and S3. However, the Mg content was lowest in S3 soil and highest in S1 soil. These values shows that the soil S1 and S2 has good cation exchangeable capacity.
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Table1. Soil chemical properties at different soil depth

Soil	Depth (cm)	Humus %	NO_3^- %	P_2O_5 ppm	K_2O ppm	Fe ppm	Cu ppm	Mn ppm	Zn ppm	Co ppm	Ca^{2+} mequiv./ 100g	Mg^{2+} mequiv. /100g	pH H_2O
Brown luvic typical (S1)	0-20	0.64	0.070	2	60	1	6	46	1	0	44.1	26.1	5.2
	20-50	1.51	0.119	4	123	5	4	79	1	0	45.4	13.2	4.9
Brown luvic pseudogleyic (S2)	0-20	1.96	0.110	90	149	10	5	189	2	0	37.6	16.7	4.75
	20-50	0.59	0.062	3	80	3	4	52	1	0	39.7	16.9	5.25
Erodisol iluvial clay anthropically covered (S3)	0-20	2.65	0.170	34	236	16	3	21	1	2	70.4	12.9	6.40
	20-50	4.52	0.228	2	200	21	4	17	2	0	76.33	8.6	6.92

Yield significantly differs between soil type and cultivars studied (Table 2). A comparison of brown luvic typical (S1) with erodisol iluvial clay anthropically covered(S3) and brown luvic pseudogleyic (S2) revealed marked differences between them both in yield and fruit weight. As for effect of type of soil on the plum production the data obtained put S3 on the first place followed at a hight difference by S1 for 'Stanley' cultivar studied which supported the higher economically efficiency of the S3 through bigger yield. However, in case of 'Vânăt românesc' cultivar was highlighted positive influence of S2 on yield.

We notice from the data presented in Table 2 that the fruits size of both cultivars is not influenced by soil type. However, we can observe that the fruits of 'Stanley' variety have a larger size compared to 'Vânăt românesc' with small size.

In case of 'Vânăt românesc' cultivar higher fruit weight is on brown luvic pseudogleyic (S2) and for another two types of soil the fruit weight is similar. Significantly higher fruit weight was found in 'Stanley' cultivar for all soil type, emphasize brown luvic typical (S1) and the erodisol iluvial clay anthropically covered (S3). These results are in accordance with previous studies carried out with 'Rainha Claudia Verde' plum cultivar, who found that fruits were bigger in the Haplic Luvisol soil compared to VerticLuvisol (Rato et al., 2008). Results of Matsoukaa et al. (2017) showed the blueberry fruit dry weight did not differ significantly by soil type, but was significantly influenced by the interaction across all soil types and treatments. As previously reported by Guerra and Casquero (2009) fruit weight of 'Green Gage' plum cultivar was positively influenced by soil type. Generally, the effect of soil on the fruit weight and yield varied function of cultivars and pedo-climatic factors.

Table 2. Influence of soil type on growth parameters and yield of plum

Cultivar/soil	Fruit weight (g)	Yield per tree (kg)	Yield per ha (t)	Length (L) mm	Width (W) mm	Thickness (T) mm
Vânăt românesc (S1)	18±0.28	9±2.05	2.3±1.09	37±0.68	27±2.05	25±1.43
Vânăt românesc (S2)	20±0.16	10±2.31	2.7±1.05	38±0.75	28±1.61	27±1.58
Vânăt românesc (S3)	18±0.25	8±2.41	2±1.06	38±0.80	28±1.48	26±1.45
Stanley (S1)	50±0.47	24±1.80	6.8±0.87	51±1.60	38±2.86	36±1.75
Stanley (S2)	48±0.47	16±1.55	4.7±1.43	53±1.88	37±2.51	35±1.84
Stanley (S3)	51±0.51	29.3±1.98	8.4±0.96	52±1.44	39±2.88	37±1.66

Values are expressed as means ± SD for n = 3

Soluble solids content, titratable acidity, pH, soluble solids/titratable acidity (SSC/TA) ratio of plum studied are shown in Table 3. There were no significant differences for titratable acidity among cultivars for all soil type. Can be seen from the obtained results that the soluble solids content is lower in fruit of Stanley cultivar growing in the brown luvic pseudogleyic soil (S2) but for ‘Vânăt românesc’ the lower content of SSC is in fruit from erodisol iluvial clay anthropically covered (S3) soil type. The effect of soil type on the soluble solids was obvious in ‘Stanley’ than ‘Vânăt românesc’ cultivar. However, results of Rato et al. (2008), regarding soluble solid content and SSC: TA ratio of plum fruit at harvest have shown that these parameters were not affected by soil, which means that would not be useful to distinguish fruit quality from different soil at harvest. Similar results were obtained by Usenik et al., (2008) which concluded that cultivars have a significant influence on soluble solids but not soil.

Table 3. Influence of soil type on the chemical composition of plum fruit

Cultivar/soil	Firmness kg/cm^2	Dry matter g%	Titratable acidity (TA) g malic acid/ 100 g fw	Soluble solids content (SSC) °Brix	SSC/TA ratio	Ascorbic acid mg/100 g fw
Vânăt românesc (S1)	1.10±0.33	18.50±0.26	1.2±0.02	16.8±0.98	14	3.8±0.40
Vânăt românesc (S2)	1.52±0.30	23.15±0.16	1.3±0.01	17±1.42	13.07	4.5±0.24
Vânăt românesc (S3)	1.05±0.36	17.40±0.18	1.2±0.02	16±0.55	13.3	4.2±0.26
Stanley(S1)	2.98±0.22	22.10±0.61	1.4±0.01	20±1.08	14.28	4.6±0.11
Stanley(S2)	1.63±0.19	20.14±0.52	1.3±0.01	17.5±1.45	13.46	4.1±0.31
Stanley(S3)	3.01±0.28	26.30±0.74	1.5±0.02	23±1.15	15.33	5±0.15

Values are expressed as means ± SD for n=3

Plums from ‘Vânăt românesc’ cultivated in S3 soil type showed dry matter content slightly lower than those from S1 and S2 soil type. However, S2 soil type influence positively dry matter content of ‘Vânăt românesc’ plum fruit. S3 and S1 soil type positively affected dry matter content of Stanley cultivar (Table 3). Effect of soil type on firmness in Vânăt românesc cultivar was not observed, but fruits firmness of ‘Stanley’ cultivar was influenced positively by S1 and S3 soil type. This results are in accordance with previous work carried out in plum by Rato et al. (2008) whose observed differences between sites in firmness of plum fruits. Also, our results are consisted with those of Royer et al. (2003) who reported that apples coming from orchards from loam and sandy-clay soil were crunchier and firmer (highest values of hardness) than apples from clay soil.

Regarding fruit anthocyanins content, data presented in Table 4 show that this compound was similar for all soil type in case of ‘Stanley’ cultivar but the content of this compound was higher for S1 an S3 soil type for ‘Vânăt românesc’ cultivar. From the obtained results we can observe that the phenols content is higher in the fruits of the ‘Stanley’ variety cultivated in S2 and S3 soils. Brown luvic typical (S1) soil only affected phenols content of ‘Vânăt românesc’ cultivar, the other two types of soil (S2 and S3) do not affect the amount of phenols in the fruits of this variety. But some authors, Diaz- Mula et al. (2008) have argued that this compounds it is dependent on the variety and not on the pedoclimatic conditions.

Lightness did not show any significant difference with regards soil type and cultivar. Chromatic parameter a* of ‘Stanley’ fruit have great value for S2 and S3 soil which means that the fruit has a pronounced degree of red, but ‘Vânăt românesc’ have an intense degree of red only for S1 soil type. Chromatic parameter b* of both cultivars in all three soil types have negative value which means that the fruit has a pronounced degree of violet. Kim et al. (2012) showed that sugar content, color and weight of grapevine cultivars were great influence by soils with hardened layers.

Table 4 Influence of soil type on the pigments content and color of plum fruits

Cultivar /soil	Total phenols mg GAE/100 g fw	Antocyanins mg/100 g fw	Color parametrs				
			L^*	a^*	b^*	C^*	h°
Vânăt românesc (S1)	125.3±1.85	57.4±0.44	24.27	2.32	-0.60	2.37	345.27
Vânăt românesc (S2)	111.3±1.65	48.9±0.95	25.04	1.34	-0.10	1.35	355.78
Vânăt românesc (S3)	115.2±0.19	50.3±0.98	25.67	1.47	-0.11	1.47	355.58
Stanley(S1)	150.2±1.75	68.4±0.21	25	1.93	-0.25	1.94	352.68
Stanley(S2)	185.6±0.79	71.5±0.11	25.2	2.69	-0.29	2.70	340.10
Stanley(S3)	180.1±0.55	70.35±0.13	25.99	2.61	-0.89	2.76	341.24

Values are expressed as means ± SD for n = 3

CONCLUSIONS

The resulted revealed that the brown luvic pseudogleyic soil (S2) had better performance for cultivated of 'Vânăt românesc' cultivar than S1 soil in terms of the accumulation of dry matter, soluble solids and ascorbic acid.

Erodisol iluvial clay anthropically covered soil type had especially positively influence on yield and quality potential of 'Stanley' cultivar.

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