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RELATIONSHIP BETWEEN SOIL MANAGEMENT SYSTEM AND CULTIVAR IN BLACK CURRANT (*Ribes Nigrum L.*)

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SUMMARY: This experiment evaluated the effect of soil management systems in a black currant planting on the generative potential (number of flowers per inflorescence, number of berries per cluster and yield per bush), physical attributes of the cluster and fruit (berry weight and cluster weight) and chemical properties of the fruit (soluble solids content, total sugars, titratable acidity, total anthocyanins, total phenolic content and vitamin C) of black currant cultivars. Three soil management systems were used: treatment I – bare fallow i.e. continuous tillage; treatment II – sawdust mulch, and treatment III – black polyethylene foil mulch. Four black currant cultivars were included - 'Ben Lomond', 'Titania', 'Čačanska crna' and 'Tiben'. The soil management systems had a significant effect on the tested parameters. The cultivars also showed highly significant differences. Soil management system x cultivar interactions were observed for generative potential, and physical properties of the cluster and fruit, but not for fruit chemical traits, except in the soluble solids content.

Key words: black currant, soil management systems, generative potential, productivity, fruit quality

INTRODUCTION

Currants are ranked second small fruit globally after strawberries in terms of the volume of production. The importance of black currants lies in their early entry into fruit-bearing, their high regular yields, good adaptability to varied climatic conditions and easy adaptability to different soil management systems. The most common soil management system in black currant orchards is continuous tillage i.e. bare fallow. In recent years, sawdust or foil mulches have been increasingly used. Extensive research has shown the importance of soil mulching as an effective method of controlling weeds, maintaining a favourable soil structure and regulating soil water and temperature regimes (Sinkevičiene et al., 2009; Kumar and Lal, 2012). Soil mulching in black currant orchards favours bush growth and development, yield and fruit quality (Larsson, 1997; Dale, 2000; Kivijarvi et al., 2005). Another important issue regarding the need to intensify black currant production is a wide range of new genotypes characterised by high productivity and fruit rich in biologically active compounds that are essential for human health. Breeding work is dynamic and focused on the creation of later-flowering self-fertile genotypes with good fruit quality (firm, tasty, rich in anthocyanins and vitamins, particularly vitamin C) and high regular yields, exhibiting resistance to abiotic and biotic factors, and having an upright growth habit suitable for mechanised harvest (Mišić, 2002; Brennan and Graham, 2009).

The objective of this study was to highlight the impact of soil management systems on the vegetative growth potential, generative potential, physical properties of the fruit and cluster, and chemical properties of the fruit of the tested black currant cultivars. Moreover, this research addressed the combined effect of soil management systems and cultivars on the studied parameters.

MATERIAL AND METHOD

The research was conducted at the Fruit Research Institute, Čačak, during 2012-2014 (43°54' N latitude, 20°21' E longitude, 242 m a.s.l.). A black currant planting was established in the spring of 2011 using two-year-old plants.

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- Content of bioactive components in small and stone fruits as affected by cultivar specificities and growing conditions, and obtaining biologically valuable products by improved and newly developed technologies.
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Black currants were grown as bushes at a spacing of 3 m between rows and 1 m in the row. Three soil management systems were used: treatment I – bare fallow i.e. continuous tillage; treatment II – sawdust mulch and treatment III – black polyethylene foil mulch. Four black currant cultivars were included - 'Ben Lomond', 'Titania', 'Čačanska crna' and 'Tiben'. The experiment was laid out in a randomised block design (5 bushes x 4 cultivars x 3 soil management systems x 3 replications), giving a total of 180 black currant bushes. During the trial, standard cultural, training and pruning practices and drip irrigation were used.

Generative potential parameters (number of flowers per inflorescence, number of berries per cluster) were observed by counting. Cluster weight and berry weight were determined on a Mettler precision scale with an accuracy of 0.01 g. Yield per bush was determined by weighing harvested fruit on an ACS system electronic scale, whereas yield per unit area was the result of multiplying yield per bush by number of bushes per hectare.

Chemical analysis of the fruit included following: 1. Soluble solids content was determined by a digital refractometer (Kruss); 2. Total sugars were determined using the Loof-Schoorl method (Egan et al., 1981); 3. Titratable acidity was measured using a burette containing 0.1 N NaOH. 4. Vitamin C was determined using a Perkin Elmer UV/VIS spectrometer (Lombda 25). The absorbance was measured at 665 nm. Results are expressed as milligrams of ascorbic acid per 100 grams of fresh weight (mg 100 g^{-1} FW); 5. Total anthocyanin content was determined by the single pH and pH differential method. The absorbance was measured at 515 nm and 700 nm. Results are expressed as milligrams of cyanidin-3-glucoside equivalent per gram of dry extract (mg C3G g^{-1} DW). 6. Total phenolic content was determined using the Folin-Ciocalteu method (Singleton et al., 1999). The absorbance was measured by a spectrophotometer at 765 nm. Results are expressed as milligrams of gallic acid equivalent per gram of dry extract (mg GA g^{-1} DW).

The experimental data obtained during the three-year research period were subjected to statistical analysis using Fisher's two-factor analysis of variance - ANOVA. The significance of differences between the mean values of the tested factors and the interaction means was determined by LSD test at $P \leq 0.01$ and $P \leq 0.05$ significance levels. Results are presented in figures and tables.

RESULTS

Generative potential parameters and physical attributes of the cluster and fruit were highly significantly affected by soil management systems, cultivars and soil management system x cultivar interactions (Table 1).

Table 1. Influence of soil management systems and cultivar on the generative potential and physical attributes of the cluster and fruit of black currant during three-year research

Cultivar/Treatment		**Number of flowers per inflorescence**	**Number of berries per cluster**	**Berry weight (g)**	**Cluster weight (g)**	**Yield per bush (kg)**
Cultivar(A)	'Ben Lomond'	8.16±0.08 c	6.54±0.06 c	0.90±0.02 c	5.92±0.13 b	1.25±0.13 c
	'Titania'	8.38±0.06 b	7.49±0.07 b	1.07±0.01 a	8.05±0.14 a	1.83±0.17 b
	'Čačanska crna'	9.73±0.08 a	8.29±0.10 a	0.99±0.01 b	8.28±0.18 a	1.74±0.23 b
	'Tiben'	5.90±0.08 d	4.91±0.09 d	1.02±0.01 b	5.04±0.13 c	1.95±0.20 a
Treatment(B)	bare fallow	8.21±0.27 a	6.98±0.24 a	1.00±0.01 a	7.04±0.25 a	1.66±0.15 b
	sawdust	8.17±0.23 a	6.87±0.20 a	1.02±0.02 a	7.03±0.26 a	1.86±0.20 a
	foil	7.75±0.22 b	6.58±0.23 b	0.96±0.01 b	6.39±0.27 b	1.55±0.15 c
ANOVA						
Cultivar (A)		**	**	**	**	**
Treatment(B)		**	**	**	**	**
A x B		**	**	**	**	**

Means followed by different letters within the cultivar and treatment columns are significantly different at $P \leq 0.01$ and $P \leq 0.05$ according to LSD test and ANOVA (F-test) results

Number of flowers per inflorescence and number of berries per cluster were highest in 'Čačanska crna', berry weight was greatest in 'Titania', and the highest values for cluster weight were obtained in 'Čačanska crna' and 'Titania'. During the three-year research period, the average yield per bush and that per unit area were highest in 'Tiben', and lowest in 'Ben Lomond'. Bare fallow and sawdust mulch treatments showed no significant differences

in the number of flowers per inflorescence, number of berries per cluster, berry weight and cluster weight, but they had significantly higher values compared to foil mulch treatment. The average yields per bush and per unit area were highest in sawdust mulch treatment and lowest in foil mulch treatment.

As for the soil management system x cultivar interaction, the cultivars showed significant differences across soil management systems. More flowers per inflorescence and berries per cluster were produced by 'Ben Lomond', 'Titania' and 'Čačanska crna' under bare fallow treatment, whereas 'Tiben' had higher values for these parameters under sawdust mulch treatment (Figures 1 and 2). Ben Lomond' had greater values for berry weight and cluster weight under bare fallow, whereas 'Titania', 'Čačanska crna' and 'Tiben' outperformed 'Ben Lomond' under sawdust foil treatment (Figures 3 and 4). Higher yields per bush under bare fallow treatment were obtained in 'Ben Lomond' and 'Titania', and higher values under sawdust mulch treatment were found in 'Čačanska crna' and 'Tiben' (Figure 5).

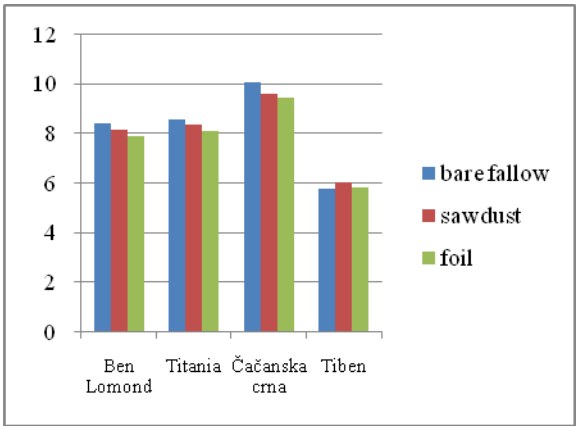

Figure 1. Interactive effect of soil management systems and cultivar on the number of flowers per inflorescence

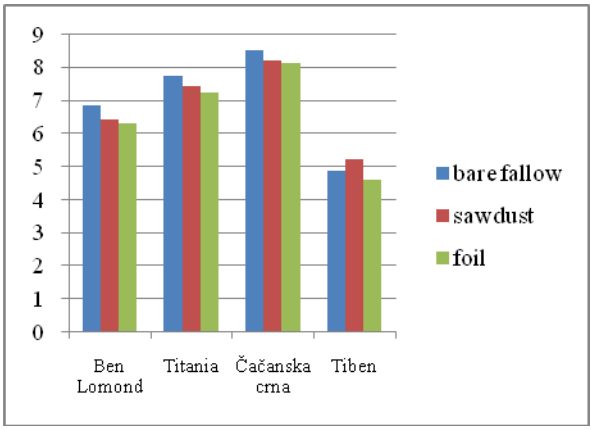

Figure 2. Interactive effect of soil management systems and cultivar on the number of berries per cluster

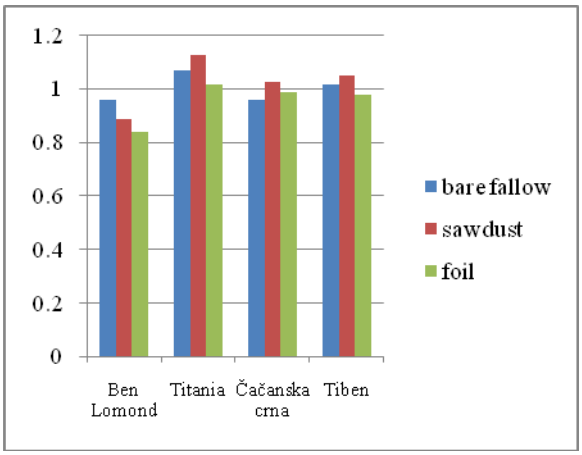

Figure 3. Interactive effect of soil management systems and cultivar on berry weight

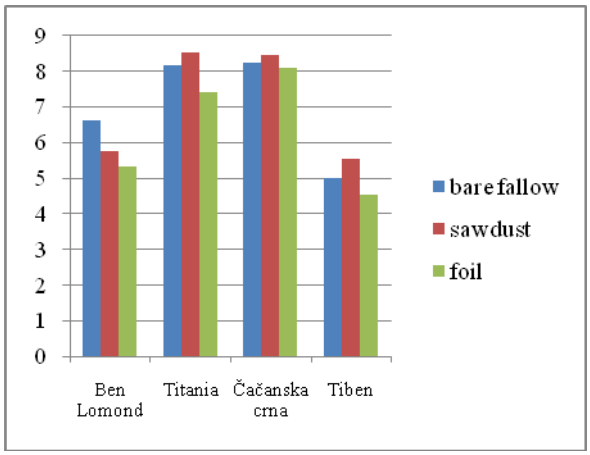

Figure 4. Interactive effect of soil management systems and cultivar on cluster weight

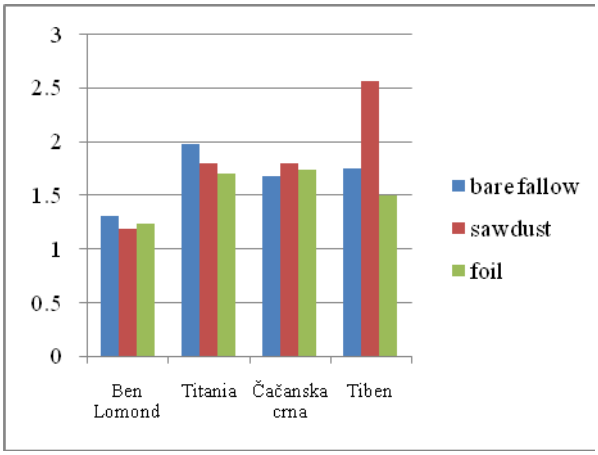

Figure 5. Interactive effect of soil management systems and cultivar on yield per bush

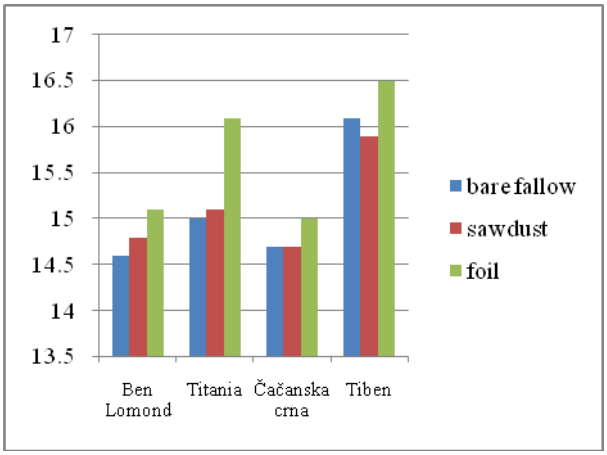

Figure. 6. Interactive effect of soil management systems and cultivar on soluble solids content

The analysis of data in Table 3 reveals highly significant differences in soluble solids content, total phenolic content and vitamin C contents among cultivars and treatments. Total sugars and titratable acidity were highly significantly different across cultivars, and significantly different across treatments. As for total anthocyanins, differences among cultivars were highly significant, whereas no differences were observed across treatments. No soil management system x cultivar interactions were exhibited for the content of most of the tested parameters of the fruit chemical properties, except for soluble solids content which displayed significant interactions.

Table 2. Influence of soil management systems and cultivar on chemical properties of black currant fruit during three-year research

Cultivar/Treatment		**Soluble solids content (%)**	**Total sugars (%)**	**Titratable acidity (%)**	**Total anthocyanins (mg C3G g^{-1})**	**Total phenolic content (mg GAg^{1})**	**Vitamin C (mg g^{1})**
Cultivar(A)	'Ben Lomond' 'Titania' 'Čačanska crna' 'Tiben'	14.8±0.08c 15.4±0.15b 14.8±0.07c 16.1±0.15a	9.18±0.06c 13.0±0.15b 14.1±0.29a 8.99±0.11d	2.48±0.13a 2.42±0.16b 2.37±0.10c 2.49±0.15a	2.54±0.21c 2.53±0.21c 3.69±0.08a 3.12±0.11b	10.5±0.18c 12.2±0.51b 11.6±0.73a 10.3±0.21d	2.15±0.41b 2.08±0.35c 2.28±0.49a 2.03±0.35d
Treatment(B)	bare fallow sawdust foil	15.6±0.12a 15.1±0.11b 15.2±0.11b	11.6±0.40a 11.4±0.41ab 11.1±0.41b	2.41±0.12 b 2.44±0.12ab 2.46±0.11 a	2.89±0.14 3.02±0.14 3.01±0.14	11.2±0.42a 11.2±0.42a 11.0±0.40b	212.5±3.71b 215.0±3.96a 212.9±3.87b
ANOVA Cultivar(A) Treatment(B) A x B		 ** ** *	 ** * ns	 ** * ns	 ** ns ns	 ** ** ns	 ** ** ns

Means followed by different letters within the cultivar and treatment columns are significantly different at $P \leq 0.01$ and $P \leq 0.05$ according to LSD test and ANOVA (F-test) results

Soluble solids content was highest in 'Tiben', whereas high contents of almost all parameters of the chemical properties were measured in 'Čačanska crna'. Soluble solids content, total sugars and total phenolic content were highest in currants under foil mulch treatment, and vitamin C in those under sawdust mulch. The soil management system x cultivar interaction showed that all cultivars had the highest soluble solids content under foil mulch treatment (Figures 6).

DISCUSSION

The experimental results showed a significant effect of soil management systems on the generative potential, and physical and chemical properties of the fruit. The lowest values for the tested parameters were obtained in currants grown under foil mulch treatment. It seems that higher soil temperature and higher soil moisture content under foil mulch throughout the growing season compared to sawdust mulch and bare fallow do not favour the tested parameters. Conversely, Kivijarvi et al. (2005) and Dale (2000) stressed the positive effect of foil mulching in black currant orchards on yield. In 'Ben Lomond', Dale (2000) found a 26% increase in yield per bush, but observed no difference in berry size. Pedersen (2002) recorded lower yields in 'Ben Lomond' and 'Titania' under different mulches compared to the results of the present experiment. However, Larsson (1997) pointed out that foil or sawdust mulching in black currant orchards has a positive effect on fruit size and yield only in the first years after planting since the prolonged use of these mulches resulted in decreased values of these parameters. In later years after planting, the author recorded higher yields for currants grown on bare fallow. Thewis (2012) compared four types of mulches, including, among others, sawdust and foil, and found that growing 'Titania' under foil mulch leads to increased yields after the first year, whereas in the second year the yield was highest under sawdust mulch. The conclusions of these authors are not in agreement with the results of the present research.

Comparing the present data on the chemical properties of the fruit of the tested cultivars with the literature data suggests that the results of this study are not comparable with those of Pedersen and Andersen (2012) and Kaldmae et al. (2013) who recorded higher values for soluble solids content, titratable acidity, total anthocyanins and total phenolic content, but lower values for total sugars and vitamin C in 'Ben Lomond', 'Tiben' and 'Titania'. Vagiri et al. (2013) and Vagiri (2014) evaluated soluble solids content, total anthocyanins and total phenolic content and vitamin C contents in 'Titania' organically grown under foil mulch treatment and obtained higher contents of total anthocyanins and total phenolic content, a lower content of vitamin C and an identical soluble solids content compared to the results of this experiment.

CONCLUSION

The comparative research on four black currant cultivars and three soil management systems suggests an important relationship between cultivars and soil management systems. The poorest response with respect to all tested parameters was obtained by currants under foil mulch treatment. ‘Ben Lomond’, ‘Titania’, ‘Čačanska crna’ and ‘Tiben’ exhibited excellent physical and chemical characteristics of the fruit, primarily in terms of their high antioxidant activity, but ‘Čačanska crna’ stood out for its highest values for most of the tested parameters. Moreover, soil management system x cultivar interaction effects were observed for plant growth and generative potential, which should be considered when establishing commercial black currant orchards and choosing soil management systems.

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ODNOS IZMEĐU NAČINA ODRŽAVANJA ZEMLJIŠTA I SORTI KOD CRNE RIBIZLE (*RIBES NIGRUM* L.)

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Izvod: U eksperimentu je praćen uticaj načina održavanja zemljišta na generativni potencijal (broj cvetova u cvasti, broj bobica u grozdu, prinos po žbunu i prinos po jedinici površine), fizičke osobine grozda i ploda (masa bobice i masa grozda) i hemijske osobine ploda (rastvorljive suve materije, ukupni šećeri, ukupne kiseline, ukupni antocijani, ukupni fenoli i vitamin C) ispitivanih sorti crne ribizle. Primenjena su tri načina održavanja zemljišta: I – jalovi ugar odnosno stalna obrada zemljišta; II – zastiranje zemljišta strugotinom i III – zastiranje zemljišta crnom polietilenskom folijom.. Obuhvaćeno je četiri sorte crne ribizle: 'Ben Lomond', 'Titania', 'Čačanska crna' i 'Tiben'. Načini održavanja zemljišta u zasadu crne ribizle imali su značajan uticaj na ispitivane parametre. Sorte su se takođe međusobno visoko značajno razlikovale. Ispoljeni su interakcijski odnosi način održavanja zemljišta x sorta kod generativnog potencijal, fizičkih osobina grozda i ploda, ali ne i kod ispitivanih parametara hemijskih osobina plodova, osim u sadržaju rastvorljivih suvih materija.

Ključne reči: crna ribizla, način održavanja zemljišta, generativni potencijal, produktivnost, kvalitet ploda

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