Effect of Fertilizing on Grapevine Fruit Maturity in Northern Conditions

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Abstract

The aim of the present experiment was to evaluate the influence of foliar treatments (PK fertilizer and glycinebetaine) on interspecific hybrid grape cultivars ‘Hasansi Sladki’ (HS) and ‘Rondo’ (R) maturity parameters in northern conditions. The plantation was established in 2007 and, in 2009, the experiment with foliar treatments: PK fertilizer, glycinebetaine, and glycinebetaine plus PK fertilizer was carried out.

The grape soluble solids content ranged from 13.7 to 21.5°Brix, foliar treatment had no influence and results variation was caused by cultivar properties. All foliar treatments increased soluble solids and titratable acids ration on R. The berries pH was lower on HS in all fertilizing treatments. Maturity index (soluble solids × pH) depended barely on cultivar and ranged from 116 to 135 in R and from 203 to 209 in HS. Total anthocyanins content was higher in R fruits and the content increased with PK-fertilizing. The study showed that foliar treatment had no influence on grape maturity and the latter was more affected by cultivar properties. Based on the study, cultivar HS is more suitable for wine production in northern conditions, whereas, R needs to be further investigated.

INTRODUCTION

Grapevine growing is not new in northern countries but has becoming popular among farmers in the last years. The yield development is mostly influenced by early autumn and late spring frost in Northland. The air temperature during the grapes ripening has a decisive influence on wine quality (Jackson and Lombard, 1993; Yamane et al., 2006). The selection of grapevine cultivars and growth technology give a possibility to produce healthy fruits in a cold climate zone. In short a summer condition, the choice of cultivar short ripening period is important. At the same time, however, a cool climate affects the quality of wines as well; the best French wines come from the cooler regions of the country (Jones and Davis, 2000). The importance of species genetic and environmental factors on grape and wine quality is also reported by Pereira et al. (2005). According to the Tonietto and Carbonneau (2004) classification, the suitable vine for cooler climate is obtained as a result of interbreeding among species. The most common species for breeding are Vitis vinifera (L.), V. amurensis (Ruapr.), and V. labrusca (L.). According to Lisek (2007) V. labruscana group has the best cold resistance. The hybrid cultivars of V. labrusca and V. vinifera are characterised by high sugars, especially sucrose, and low acids content (Liu et al., 2006). In addition, frost resistance depends also on the buds sugars content (Hamman et al., 1996).

Since the synthesis of bioactive compounds in the plant is related to environmental conditions, wine produced in Nordic climate can contain more health-enhancing compounds. However, agro-ecological factor, for instance the choice of cultivars, solar intensity, temperature and soil conditions additionally affect antioxidant anthocyanins content (Yokotsuka et al., 1999; Pomar et al., 2005; Teszlak et al., 2005; Fournand et al., 2006; Yamane et al., 2006; Molero et al., 2010).

Unfavorable growth conditions cause a stress in plants, resulting in reduced plant vitality, fruit quality and yield. One possibility to enhance plants tolerance to low

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231
temperatures is application of glycinebetaine (GB), which is quaternary ammonium compound and acts as an osmoprotectant in the plants by adjusting the osmotic balance inside the plant cells and tissues. Although, on the one hand, it is found, that GB has no effect on physiological parameters of non-stressed plants (Mickelbart et al., 2006). On the other hand, it was found that the vine stress tolerance can significantly increase with plants GB application, resulting in an increase of fruit polyphenols compounds and anthocyanins content (Teszlak et al., 2005).

Based on the previous, a hypothesis may be posed: spraying the vines with GB and PK fertilizer solution increases plants stress tolerance in Nordic conditions, and thus also affects the maturity parameters of the grapes. This study is the first one to find out cultivars suitability for wine production in Nordic conditions in Estonia. The aim of the present experiment was to evaluate the influence of foliar treatments (PK fertilizer and glycinebetaine) on grape interspecific hybrid cultivars ‘Hasanski Sladki’ and ‘Rondo’ maturity parameters in northern conditions.

MATERIAL AND METHODS

The study was carried out in experimental outdoor vineyards of the Estonian University of Life Sciences (58°35′N; 26°52′E). In vitro propagated vines were planted in June 2007 with spacing of 2 m between the plants and 2.5 m between the rows and cultivated on their own roots. Vineyards soil pHKCl was 5.8 and humus content was 4.4%. The content of P, K and Mg was high in the soil and Ca content was sufficient. The last night frost was on 24 April in 2009, with a temperature drop below -1.4°C. The average temperature was +5.3°C in April and +14.4°C from June to September. Thereby, June was the coolest month and September – the warmest compared to the many years' average temperature. The first autumn frost was registered on 3 October, when the average daily air temperature was -0.4°C. The sum of active temperatures in 2009 was 2156.

Two red grape hybrid cultivars, such as Russian Primorsky Krai breed ‘Hasanski Sladki’ (HS; interspecific hybrid of V. amurensis, V. labrusca, V. riparia and V. vinifera) and former Czechoslovakia breed ‘Rondo’ (R; crossing by V. amurensis cultivars) were under investigation. The rows were covered with 0.04 mm thick black polyethylene mulch. Between the rows there was sawn grass, which was mown regularly during the vegetation period. A training system, where 2 horizontally curved woody branches were left per plant, each of which had up to 5 fertile canes, was used for the experiment. The plants were cut back in autumn. R hibernated under a textile covering, whereas, HS was without any covering. Every week in July axillary shoots emerging from the leaf axils were removed. In August, the cane top was cut back and basal leaves in the area of the clusters were removed. PK water soluble fertilizer 1-18-38 (in concentration of 20 g of fertilizer per 10 L of water) was used as a foliar treatment. The foliar-applied glycinebetaine as nitrogen product derived from sugar beet molasses was used in concentration of 62.5 g of fertilizer per 10 L of water. In the experiment there were 4 replications of each foliar treatment and each replication was conducted on 9 plants. The treatments were following:

1. control (C);
2. PK fertilizer (PK); applied once at the beginning of August;
3. glycinebetaine (GB); applied twice at the beginning of June (during the third leaf phase) and August;
4. glycinebetaine + PK fertilizer (GB+PK); applied once at the beginning of August.

The frozen fruit from the first harvest of November 2009 were used for biochemical analyses. Soluble solids (SS) content in fruit juice was measured by refractometer (Atago Pocket Refractometer Pal-1). Analyses were made once a week in September and once in early October. Titratable acids (TA) content was determined by titration method with aqueous 0.1 M NaOH solution. The TA content was expressed as citric acid mg per 100 g of fresh fruit. Soluble solids and titratable acids ratio (SS:TA) was calculated based on the content of SS and TA. Fruit juice pH was measured with pH-
maturity. Maturity index was calculated with the following formula: soluble solids content × pH. The content of total anthocyanins (TAC) was estimated by a pH-differential method. The pH values of diluted grape extracts were 1.0 and 4.5. Absorbance was measured by Jenway 6300 spectrophotometer at 510 and 700 nm. The total anthocyanins content was calculated in milligrams of pelargonidin-3-glucoside equivalent per 100 g of fresh weight.

A one-way analysis of variance was used for maturity parameters. To evaluate significances of differences among treatments, the least significant difference (LSD_{0.05}) was calculated. Different letters in the figures marked significant differences.

RESULTS

Grape SS content in HS ranged from 21.0 to 21.5 and in R from 13.7 to 16.0°Brix (Fig. 1A). Fertilizing had no influence on HS but increased R’s SS content in PK-treatment. TA content was influenced by the fertilizer; thereby PK and GB treatments decreased the content in HS (Fig. 1B). In R TA content was significantly lower in all treatments compared with control. Grape SS:TA ration varied in HS from 6.1 to 14.6 and in R from 9.7 to 13.1 (Fig. 1C). PK and GB application increased SS:TA ration in HS. In R, the ration was significantly higher in PK treatment. The grape juice pH ranged from 3.09 to 3.15 in HS and from 2.88 to 2.91 in R (Fig. 1D). In HS, juice pH was significantly higher in control variant and in R – in case of GB+PK treatment. Higher maturity index from 202 to 209 was in HS grapes (Fig. 1E). In R, it ranged from 114 to 136. Fertilization significantly influenced only R cultivar increasing its maturity index in case of PK treatment and lowering it in GB+PK treatment. The grape TAC content in HS berries ranged from 84 to 99 and, in R berries – from 160 to 219 mg per 100 g (Fig. 1F). Fertilization did not affect HS TAC content. PK treatment significantly increased TAC content of R berries.

DISCUSSION

The eligible SS content of berries used in wine production is 5°Brix 20 (Schalkwyk and Archer, 2000) and acid content is 0.7 mg 100 g⁻¹ (Dishlers, 2003). As it is sugar content that determines the alcohol content of wines, the main problem in northern conditions is particularly low sugar and excessively high acid contents. In the present experiment the same problem revealed in R cultivars. Still, it was found that even in case of low 5°Brix value it is possible to make wine with good taste properties by combining various cultivars. For example with Vitis labrusca type of grapes SS content ranging from 16 to 18 is necessary for ideal combination, and any increase of this value may lower wine quality (Khanizadeh et al., 2008). However, the present experiment showed that, in northern conditions, grape SS content in HS cultivars may be high. Albeit sugar accumulation in the berries starts during the ripening period and depends on the weather conditions, temperature effects on final sugar accumulation are reported to be relatively small (Coombe, 1987). Liu et al. (2006) has found that total soluble sugars are significantly higher in hybrids between V. labrusca and V. vinifera than that in V. vinifera cultivars. Both hybrids were used in the present experiment but SS content varied significantly due to variation in primary cultivars. PK treatment of the leaves only raised RÖ SS content. We may, thus, hypothesise that difference in the effect is related to cultivar properties. HS is an early ripening cultivar. Therefore, the berries in the clusters are sparse; R clusters are larger with densely growing berries. The latter affects the ripening of the berries. The more sparsely are the berries on the cluster, the better are the light conditions, and nutrients distribution occurs among a smaller number of berries. Similarly, GB application may not have any effect on the SS content due to loamy nutrient-rich soil with no plant stressors. Equally, hybrids may be more resistant to cold springs. Furthermore, in case of R it was confirmed that P fertilization could increase the content of soluble solids (Xue et al., 2012).

In order to produce quality wine with positive taste and preservation properties, juice pH should be from 3.2 to 3.6 (Dishlers, 2003) and ripening index should range from 200 to 270 (Schalkwyk and Archer, 2000). pH content is in close correlation with
titratable acids – long ripening periods characteristic of cool climates may cause organic acid content increase and, therefore, increase of grape pH (Schalkwyk and Archer, 2000). Lower pH level is more beneficial for wine production as, in that case, juice fermentation is cleaner and wine is less liable to microbial spoilage. Since pH linearly correlates with sugar concentration, one of the expected results of the present study was the fact that pH in R was lower compared to HS. Only HS cultivar maturity index remained within the eligible range, which confirms the hypothesis, that early ripening vine cultivars are more suitable for northern conditions. Fertilization influence on grape pH may be caused by potassium accumulation, which is temperature dependent. Potassium levels increase significantly in grape clusters, specifically, during grape maturation, because of potassium redistribution from other above-ground vegetative vine organs. Likewise, insufficient effect of PK and GB treatments may be caused by the fact that GB involving treatment reduces plant stress symptoms and create favourable conditions for plant vegetative growth.

Torchio et al. (2010), has found, that the anthocyanins content increased with the level of soluble solids. This fact was confirmed during the present experiment in case of cultivar R. TAC content increase induced by PK-fertilizer treatment in R, may be related to higher SS and P content of the fertilizer (Xuede et al., 2012). Thus P-rich fertilizer fosters both TAC and SS content increase. Therefore, TA content depended on fruit physiological state and cultivar. Grape anthocyanins content increase is both light and temperature dependent. Light is of decisive importance for anthocyanins content rise, particularly at the beginning of the maturation period. The experiment revealed that anthocyanins content increase linearly correlated with the amount of solar radiation (Cortell et al., 2007). The colour break stage of the cultivars used in the experiment starts at different times and varies in duration. In case of HS, it starts in August when temperature fluctuation is smaller than in September, when R cultivar colour breaks stage begins. Significant temperature fluctuation may be the reason for variation in TAC content. Additionally, numerous environmental factors, cultivar properties, and cultivation technologies influence grape TAC content (Teszlak et al., 2005).

CONCLUSIONS

The study showed that foliar application of glycinobetaine had no influence on grape maturity and the latter was more affected by cultivar properties. Foliar PK treatment increased ‘Rondo’ SS and TAC content as well SS:TA ratio. The study showed that ‘Hasanski Sladki’ is more suitable for wine production in northern conditions based on its fruit maturity parameters. ‘Rondo’ needs to be further investigated.

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