

The effects of different tillage methods on mineral substance of raisins in organic grape growing

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Abstract

Turkey is the major producer and exporter of seedless raisins in the world. The largest area under organic raisin is located in Manisa (2655 ha) then İzmir (580 ha) in the Aegean Region and almost all the grapes are dried and exported to European countries in particular. Organic raisin production constitutes 1.35% of the total raisin production of Turkey. The research was carried out in Alaşehir-Yeşilyurt Enterprise of Viticulture Research Station from 2006 to 2007. The research was established in a 15 year-old 'Sultani Çekirdeksiz' vineyard under irrigable soil conditions in organic parcel. Three different tillage methods: conventional tillage, mulch tillage, and reduced tillage were applied on the trial parcels. The research was carried out as randomized block design trials with three replicates consisting of 12 vines per parcel. Mineral substance analyses of the raisins obtained from the applications were performed using the ICP-AES technique. It was found that there was highest average potassium (K), calcium (Ca), iron (Fe) and copper (Cu) contents of the raisin in mulch tillage; highest average magnesium (Mg), phosphorus (P) and sodium (Na) contents of the raisin in conventional tillage; highest average manganese (Mn) and zinc (Zn) contents of the raisin in reduced tillage at 5% significant level.

Keywords: 'Sultani Çekirdeksiz', tillage methods, mineral substance, organic raisins

INTRODUCTION

Turkey is a major producer of grapes in the world and viticulture is one of the major branches of agriculture with respect to production area and its large share of income in Turkish national economy. Grapevine is grown in almost all parts of Turkey and has been produced commercially in many regions of the country for many years. Turkey is among the largest grapevine growing countries of the world with approximately 478,000 ha of vineyard area and 4.26 million tons of grape production (5th in area; 6th in production). Grape production mainly consists of 52.9% table grapes, 36.3% raisins and 10.8% must-wine varieties (Anonymous, 2010).

Vineyards where organic grapes are grown are generally located in the provinces of İzmir and Manisa, and almost all the grapes are dried and exported to European countries in particular. Organic raisin production constitutes 3.6% of the total raisin production of Turkey (Altindisli, 2004).

A study conducted by Pamuk (1999) investigated the impact of organic and conventional viticulture applications under upland conditions on efficiency and quality. The results of the study have revealed that the efficiency and quality of the organically grown grapes were superior to those grown with conventional methods.

According to Considine and Considine (1982) and also to Fidan and Yavaş (1989), mineral substances found in grape are taken up from the soil by the vine and transferred to the plant and the fruit. In their study in which they observed quantities of macro-elements and micro-elements in must made from three Hungarian grape varieties during the course of ripening, Diófási et al. (1986) stated that there was a positive correlation between the sugar quantity and N, P, Ca, Fe, and Mg elements.

In a study conducted by Adamyan (1988) comparing substance contents of local Armenian, Western European and Central European table grape varieties, it was reported



that Armenian grapes contained more mineral substances and had a higher Fe/Mn ratio; temporary varieties (seeded and seedless) contained more mineral substances compared to early-ripening varieties; and seedless early-ripening varieties contained more Cu and Mn than seeded ones.

Švejar and Okáč (1989) reported that amounts of Fe, Zn, Mn and Cu found in the grape and the wine were not only dependent on the presence of these minerals in the soil and that the composition of the soil, pH as well as climatic conditions were also important factors.

Boselli et al. (1995) stated there was a positive correlation between the pH in the grape must and the K content, and that pH in the must and K content could be affected by the rootstock used in a particular vineyard.

Aykut (2002) determined mineral substances found in musts of 'Sultani Çekirdeksiz', 'Muscat Hamburg' and 'Alicante Bouschet' grape varieties in mg kg⁻¹ as 1540-1750-1255 for K, 24-29.06-34 for Ca, 100-53.75-102.5 for Mg, 53.30-31.32-52.15 for Na, 136.9-97.20-168.2 for P, 1.88-0.71-1.38 for Fe, 2.5-1.69-0.8 for Cu, 0.68-0.79-0.35 for Zn and 0.80-0.49-1.45 for Mn, respectively.

The mass of the human body is made up approximately 50 elements (Keskin, 1981). Twelve of these elements (O, C, H, N, Ca, P, K, S, Na, Cl, Mg and Fe) constitute 99.9% of the total. Almost 99% of this ratio is O, C, H, N, Ca and P. These twelve elements are referred to as macro or quantitative elements, whereas the remaining ones are called micro or trace elements. Microelements are substances found in human body and nutrients in concentrations of less than 0.005% (Keskin, 1981; Gözükara, 1990).

Raisins (*Vitis vinifera* L.) have been a favorite food since 1490 BC due to their nutritive value and high micronutrients content (Witherspoon, 2000). It has been one of the most important and popular dried fruits in the world because of their high nutritional value (Fang et al., 2010). Raisins should be of particular interest in these investigations due to their unique phytochemical composition and the natural qualities that make raisins an appealing source of necessary minerals including potassium, iron, vitamin B, calcium, magnesium, sodium, arsenic, cadmium, chromium, manganese and nickel (Şimşek et al., 2004; Fang et al., 2010).

For application of cover crop species in vineyard, annual small grains (barley, oats, and triticale), winter peas, common vetch, bell beans, daikon radish, Persian clover, and other annuals that grow well during the cool months are convenient to use.

In upland areas prone to soil erosion, where water is not available for irrigation of either the vines or the cover crop, it is highly recommended to use straw mulching or compost "overs" (coarse particles between one and two inches in size) to minimize the loss of soil from the vineyard while waiting for the cover crop to start growing in the fall (McGourty, 2004).

Harrold and Edward (1974) found that no-till systems prevent soil erosion especially after heavy rain. They found the soil loss 23 t ha⁻¹ for conventional tillage and 2.5 ton ha⁻¹ for no-till systems.

Freebaim and Wockner (1991) reported that soil erosion decreased from 29-62 t ha⁻¹ to 5 t ha⁻¹ by keeping residues on the soil surface. Besides reducing erosion, keeping residues on the soil surface also increases water holding capacity by 18-24% and decreases water loss by 10-17%.

Deep tillage method used before vine plantation to remove old vine roots and loosen subsoil may induce physical soil degradation that could affect soil structure and vine water supply. The deep tillage study results showed that (i) a significant soil compaction was observed after wet conditions only, (ii) deep ploughing produced more soil compaction than ripper because of a greater volume of soil affected by wheeling in the former operation and (iii) a specific response of soils is significantly observed in the case of deep ploughing only with an increase of compacted zones fragmentation in relation to a decrease of clay content (Coulouma et al., 2006).

Göblyös and Ulcz (2008) studied the effect of several cultivation methods on the yield and the quality of grape. They found that different cultivation methods have higher effect on

the yield than on the grape quality. Especially in the dry season they observed that straw mulch proved to be the best solution regarding the yield and the grape quality. Although they found no significant differences in the sugar- and titratable acidity content of the must, the ratio of noble rotted berries was higher on the straw mulched plots. Straw mulch could conserve the moisture content of the soil.

The effect of conventional and no tillage and 3 leaf removal treatments on leaf water potential (Ψ_{leaf}), yield, cluster and berry characteristics of cultivar ‘Syrah’ were investigated by Korkutal and Bahar (2013). Different soil tillage applications affected cluster length and berry fresh and dry mass. The leaf removal treatments affected only total leaf area per vine. They concluded that under these soil and climatic conditions, it could be advised that conservative soil tillage as an alternative to conventional soil tillage could be more economical.

The present study was conducted on ‘Sultani Çekirdeksiz’ grape variety, which has an important place in our national economy. The objective of this study was to determine the effect of different tillage methods: conventional tillage, mulch tillage and reduced tillage on the nutrient content of raisins produced from ‘Sultani Çekirdeksiz’ grapes in organic grape parcels during organic production (2006-2007). In addition to that research this study emphasized on the importance of raisins, organic raisins in particular, as a natural source of energy in human nutrition.

MATERIALS AND METHODS

The present study was carried out in Alaşehir-Yeşilyurt Enterprise of Viticulture Research Station from 2006 to 2007. The research was established in 15 year-old ‘Sultani Çekirdeksiz’ vineyard under irrigable soil conditions and on its own roots at intervals of 2.4×3.3 m long along the row using a “T” wire grape trellis training system in organic parcel.

‘Sultani Çekirdeksiz’ ripens in midseason. It grows strong with conical clusters, wings, normal density, small oval shaped berries and average berry skin thickness. Although it is a variety for drying, ‘Sultani Çekirdeksiz’ is also processed as table grapes.

The effect of different tillage methods on organic grape production was examined. In this research, conventional tillage, mulch tillage and reduced tillage were used (Table 1).

Table 1. Applied tillage methods.

Method	Application
Conventional method	Plough + Disk Harrow (two passes)
Mulch tillage	Plough + Disk Harrow (two passes) (no tillage in Spring)
Reduced tillage	Disk Harrow (one pass) + Reduced tillage combination (two passes)

For conventional tillage method, rows first were ploughed and then harrowed by disc harrow. In mulch tillage, conventional tillage was applied but spring tillage was not performed instead, planted mulch material was chopped and laid in the row. Cultivator with rotary harrow was used as a reduced tillage.

Common vetch (*Vicia sativa* L.), Rye (*Hordeum vulgare* L.), and broad beans (fava beans) were used as mulch plants. In November, the soil was tilled using conventional method before planting mulch plants. The mix was planted by using fertilizer spreader. After planting, the soil was disked to incorporate the seeds with soil. The soil was tilled in spring and autumn in both conventional and cultivator plots, whereas, tillage was applied only in spring for mulch tillage system.

Potassium (K), phosphorus (P), sodium (Na), iron (Fe), copper (Cu), zinc (Zn), manganese (Mn), calcium (Ca) and magnesium (Mg) contents of the raisin samples were determined in a series of analyses carried out using an ICP-AES spectroscopy during organic production phase from 2006 to 2007.

The research was carried out as randomized block design trials with three replicates consisting of 12 vines per parcel. After a variance analysis was performed on the data

obtained was using the statistical software package “SPSS 20.0 for Windows”, an LSD (<0.05) test was used for comparison of average values.

Mineral substance analyses were performed on raisin samples obtained from applications using an ICP-AES spectroscopy. A 10 g raisin sample was placed in a crucible and dried in an incubator at 100°C. The samples were then put into the oven when their temperature reached 250°C and the temperature was then raised to 600°C. and left at this temperature overnight (13-15 h). If the samples were not reduced to white ash, they were moistened with water and dried in the oven for another 2 h until they turned white. The crucibles were then put in a desiccator and allowed to cool to room temperature. Later 6 ml extraction acid (HCl+HNO₃) and 50 ml distilled water were added to the crucibles and slightly heated to dissolve the ashes. The solution was strained into 100 ml volumetric flask using a black band filter and filled to the top with distilled water (The dilution factor was 10).

Desired standards were entered and the device was conditioned. Samples which have passed through the dilution procedure were fed into the device and potassium (K), phosphorus (P), sodium (Na), iron (Fe), copper (Cu), zinc (Zn), manganese (Mn), calcium (Ca) and magnesium (Mg) minerals were read using the emission technique. The results obtained were multiplied by SF and mineral substance quantities were found.

RESULTS AND DISCUSSION

Mineral contents for each parcel under different tillage methods are given in Table 2. According to the results of the statistical analysis, it was determined that tillage methods over the years had different important effects on the potassium, calcium, sodium, Iron, Copper, manganese and zinc contents of the organic raisins at 5% significance level.

As can be seen from Table 2, mulch tillage method, when compared with the other tillage methods, had the highest amount of potassium, calcium, iron, copper as 8385, 230, 17.9, 7.2 ppm, respectively. These results are similar to those reported by Yağcı and İter (2007), Çetin et al. (2011), Williamson and Carughi (2010) and Şimşek et al. (2004) in seedless raisin.

Table 2. Mineral content of each parcel of ‘Sultani Cekirdeksiz’ raisins produced under different tillage methods.

Tillage methods	K (ppm)	Ca (ppm)	Mg (ppm)	P (ppm)	Na (ppm)	Fe (ppm)	Cu (ppm)	Mn (ppm)	Zn (ppm)
Conventional tillage	7126 b	214 b	592	138	187 a	13.3 b	6.8 ab	1.7 b	6.6 b
Mulch tillage	8385 a	230 a	544	134	156 b	17.9 a	7.2 a	1.4 b	6.6 b
Reduced tillage	5919 c	220 a	551	132	157 b	13.7 b	6.3 b	2.3 a	8.1 a
LSD _{0,05}	759.4	10.23	NS	NS	23.3	2.1	0.8	0.36	1.4

Values in the same column with different subscript letters represent significant differences between production phases.

NS = Not significant.

The reduced tillage method only increased the amount of manganese and zinc, as 2.3 and 8.1 ppm, respectively whereas Reduced tillage generally had the lowest values of all minerals. Conventional tillage method only increased sodium content, 187 ppm. Mulch tillage method had the lowest sodium, 156 ppm. Similar results were found by Şimşek et al. (2004) and Yağcı and İter (2007).

When we compare the tillage methods, it was observed that mulch tillage method increased potassium, calcium, iron and copper while Reduced tillage methods increased magnesium and zinc contents. Conventional tillage method could only increase sodium.

CONCLUSIONS

According to the overall results of this research; it is concluded that organic production phase and transition to organic production phases raisins constitute a natural source of energies and many minerals such as potassium, magnesium, copper, zinc, calcium, phosphorus, sodium, iron and manganese that may prevent many diseases.

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