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ORIGINAL PAPER

Evaluation of yield reductions in vineyards in connection with the soil nutrient content: the Rumi grape variety

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Abstract

This study was conducted to determine the soil quality in vineyards where the Rumi grape variety is grown in Kilis Province. Low yields harvested in Kilis in recent years from the Rumi grape variety, which has high economic value, encouraged this study aiming to identify the cause. There is no fertilization in the vineyards submitted to the study, so the search for the reason for low yields was referred to the soil nutrient content. For this purpose, soil samples were taken from the soil in the vineyards at a depth of 0-30 cm. It was determined that the soil reaction varied from 7.19 to 8.34, 16.2% of the examined soils were neutral, and 83.8% were slightly alkaline. As regards the soil texture, 27% of the soils were loamy, 51% were clay loam, and 22% were textured clay. Although the lime content varied from 0.85% to 46.21%, 24.32% of the soil samples were found to be low calcareous, 16.21% were calcareous, 16.21% were found moderately calcareous, 24.32% were high in calcium and 18.91% were very highly calcareous. The organic matter content of the examined soils was determined at the lowest 0.62% and the highest 3.40%, with 5.40% of soils having very low, 35.13% – low, 51.35% – moderate and 8.10% – high organic matter content. The phosphorus content ranged from 1.04 kg da^{-1} to 6.86 kg da^{-1}, and 29.72% of the soil were found contain very small, 67.56% – small, and 2.70% – moderate amounts of phosphorus. The potassium content ranged from 31.85 to 164 kg da^{-1}, and it was found that 5.40% of the soils had sufficient K content and 94.59% had high K content. Significant relationships have been found between the physical and chemical properties of the soil. As a result of the study, it is recommended to apply farm manure or green fertilization in vineyards where vineyard soils are ideal in terms of texture but organic matter deficiency is determined, and phosphorous fertilization is recommended in the presence of high pH and high lime content. The current fertility of the soil should be maintained and improved over the years.

Keywords: nutrients, Rumi grape, soil fertility, vineyard

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INTRODUCTION

Vine is one of the oldest cultivated fruit species in the world. The history of this precious fruit dates back to 5000 BC. It is accepted that the motherland of the vine is the Caucasus and Asia. It is known that there are only 10,000 known species of vines in the said region, including Anatolia. It is thought that there are more than 1,200 grape varieties in Turkey. Approximately 50-60 of these grape varieties are used in intensive cultivation.

Grape is a nutrient with high calorie value due to the high sugar amount it contains. In addition, many minerals are rich in nutrients. Although it is widely consumed fresh, dried grapes are also rich in nutrients. The grape cultivation is highly diverse across Turkey, in terms of both regional differences and the range of varieties grown. In the Southeastern Anatolia Region, viticulture is usually carried out under dry conditions and with inoculated local varieties on inappropriate rootstocks. For these reasons, an average of 500 kg of product per decare can be obtained in viticulture in the region. The implementation of the GAP project has led to a variety change with irrigation in some regions, and an increase in yield in the vineyards has been observed. As a result of these changes in the Southeastern Anatolia Region, grapes are exported from Turkey to the Middle East countries. In the region, the Rumi variety is one of the important varieties with high economic value (Figure 1).

Fig. 1. Rumi grape variety (Anonymous 2022*a*)

Fertilization should be carried out to maintain the productivity of agricultural lands. In particular, organic fertilizers improve the physical conditions of the soil and increase its organic matter content (Kuzucu 2017, 2019*a*).

In the study conducted to determine the characteristics of the soils grown in Van Province, 40 samples were taken from the soil at a depth of 0-30 cm. Some physical and chemical analyses were performed. The results of the analysis were evaluated, and it was determined that the soil had a pH between 7.44 and 8.18, EC 0.12-0.34 dS m^{-1}, lime content between 5.83% and 46.80%, and soil organic matter between 1.31% and 2.97%. The average sand, clay and silt contents of the soil samples were 76.54%, 7.28%, and 16.18%, respectively. The textural classes of the soils examined were as follows: 47.5% were loamy sand, 45% were sandy loam and 7.5% had sandy texture. The soil reaction was neutral and alkaline, and the soil organic matter content for vine was determined at a moderate and sufficient level. Soil was in the saltless class, and its lime content and distribution were defined as moderately and highly calcareous. All the data obtained were evaluated and mapped. As a result, it has been reported that the soil properties examined are suitable for grapevine (Sancan, Karaca 2017).

Under the dry air conditions of Kilis Province, leonhardite fertilization, rainwater harvesting, and soil moisture conservation were carried out in 20-year-old Horoz Karasi vineyards. At the end of the study, it was reported that the application of leonhardite between 5 and 7 kg per vine stock increased the soil organic matter content and product efficiency (Kuzucu 2019*b*).

The soils of the vineyards in Manisa Alaşehir Region were analyzed, and it was found 97% of the soils had very low organic matter content, 83% had very low total nitrogen content, 21% had very low available potassium content, and 3% had very low available calcium and magnesium content (Yıldız et al. 2022).

Soil samples taken from 20 different regions were analyzed to represent the grapevines (*Vitis vinifera* L.) commonly grown in Ovacık Village at Hilvan District of Sanliurfa Province. According to the results obtained, it was determined that the soils cultivated with grapevines were generally clay textured, moderately calcareous, slightly alkaline, saltless, with high CEC and low organic matter. The total nitrogen content of the soil samples and the phosphorus content were found low, and the potassium content was found to be sufficient (Kızılgöz et al. 2011).

The Rumi grape variety, which is grown intensively in Kilis, has decreased in yield in recent years. In this grape variety, which is one of the important sources of livelihoods in the province, producers continue to grow grapes without fertilization. This study was conducted to determine yield reductions associated with the soil nutrient content. The aim of this study

has been to reveal any nutrient deficiency in the fertile top layer of the soil, and to inform the producers about recommend fertilization so as to ensure the continuation of the production of the Rumi grape variety.

MATERIAL AND METHOD

Material

This study was carried out in the Rumi variety vineyards maintained in Kilis Province located at the coordinates of 36°-37° latitude and 37°-38° longitude in Turkey. The vegetation period of this variety is between March and October. Kilis Province has an area of 1,412 km² and lies on the altitude of 643 meters (Figure 2). The vineyards in the province are generally established on slightly sloping and slightly stony soils. The annual average precipitation is between 450 and 550 mm, the annual average temp. is 17°C, and viticulture is generally carried out under dry weather conditions (Anonymous 2022*b*).

The soils constituting the material of this study show transition characteristics from the Southeastern Anatolia Region to the Mediterranean Region, and are diverse in values of soil properties. There are Reddish brown soils in the northeast of Kilis city and Musabeyli, Limeless Brown soils in the west of the province, Coluvial soils in Elbeyli district, Red Mediterranean soils in Polateli district, and Basaltic soils in Musabeyli, Elbeyli and Polateli district.

Fig. 2. Map showing the location of Kilis Province in Turkey

The Rumi variety, from which molasses and other grape products are produced in the center district of Kilis, was sampled from 16 different villages and 37 different sites in the vineyards. These soil samples were taken from a 0-30 cm depth of the soil in the post-harvest period, namely in November 2022. Production was carried out under dry weather conditions in the vineyards from which soil samples were taken. The depth of tillage in the region is 0-30 cm, which is the fertile top layer of the soil. Since vineyards in this region are continuously plowed to the same depth, a plow bottom is formed. This depth was taken into consideration in order to interpret soil fertility.

The study included the soil types mentioned above. The names of the villages where the soil samples were taken, the number of samples, the % distribution according to the villages and their coordinates are shown in Table 1.

Table 1

Number of Rumi grape soil samples and distribution (%) by villages

Location	Number of samples (pieces)	Distribution (%)	Coordinates
Hisarköy	2	5.4	36.825453, 36.766302
Kızılgöl	1	2.7	36.814222, 37.137591
Yavuzlu	4	10.8	36.692429, 37.269647
Saatli	1	2.7	36.786467, 36.873564
Belenözü	3	8.10	36.877272, 37.073522
Oylum	1	2.7	36.700850, 37.181049
Gülbaba	4	10.8	36.828900, 36.792383
Kocabeyli	4	10.8	36.809952, 36.930379
Taşlıalan	2	5.4	36.820545, 37.079837
Bağarası	2	5.4	36.827800, 37.053591
Şenlikçe	3	8.10	36.870238, 36.869542
Ömeroğlu	1	2.7	36.870103, 37.195294
Söğütlü	1	2.7	36.821341, 37.122207
Kurtaran	4	10.8	36.895244, 36.971171
Hüseyinoğlu	1	2.7	36.924820, 36.931278
Koçcağız	3	8.10	36.912224, 37.028410

Method

Soil samples taken from the villages of the central district of Kilis province in the autumn of 2022, more precisely in November, were mixed homogeneously and transported to the laboratory. The dried soil samples were sieved through a 2 mm sieve and prepared for analysis (Chapman, Pratt 1961). The soil samples were analyzed in January 2023. In soil sam-

ples, soil texture was determined according to Ülgen and Yurtsever (1995), soil pH was determined by using saturation paste according to Kacar (1995), using a pH meter. Total soluble salt (%) was measured by an electrical conductivity (EC) meter (Staff, Staff 1951), and total lime was measured with a Scheibler calcimeter (Allison, Moodie 1965). The organic matter content of soil samples was determined by the wet oxidation technique according to Walkey and Black (1934). Potassium was determined by extraction with 1 N ammonium acetate according to Tüzüner (1990) and Kacar (1995), and absorbable phosphorus was assayed with the blue color method according to Olsen et al. (1965). Soil analysis results were classified according to the limit values determined by Ülgen and Yurtsever (1995).

Statistical analyses

Correlation analysis was performed by using the SPSS 11.0 (Statistical Package for the Social Science, version 11.0), SPSS, Armonk, NY, USA, software program. The statistical significance level of the relationships between soil properties was evaluated as $p<0.05$ and $p<0.01$.

RESULTS AND DISCUSSION

Soil reaction

pH values of the vineyard soils where the Rumi grape variety is grown in Kilis province were found to be between 7.19 and 8.34 (Table 2). According to the limit values determined by Ülgen and Yurtsever (1995), the pH content of 37 soil samples taken was found to be neutral in 16.2% of samples, while 83.8% of samples had a mild alkaline reaction. Since Kilis Province is under the influence of a semiarid climate, soil pH values were deemed to be high. It is known that high soil pH prevents the uptake of macroelements and especially microelements (Kacar, Katkat 1999). Çelik (1998) reported that the pH values of the soils in the vineyards of Erciş District of Van Province varied between 5.5 and 8.5. Positive relationships were found between soil reaction and soil fertility. While the toxicity of Fe, Al, and Mn micronutrients was observed at low pH, deficiencies in K, Ca, Mg, P and Mo nutrients were found. In alkaline soils with high pH, the intake of some nutrients can be prevented. It was reported that the optimum soil reaction should be neutral and nearly neutral for soil efficiency (Çelik et. al. 2017). High pH of the soil reduces the rate of utilization of fertilizers given to the soil (Lindsay 1979). Foliar fertilization is seen as a more suitable method of feeding since the solubility of nutrients decreases in soils with high pH value. At low pH, the solubility of most nutrients increases, and plants benefit (Aktaş, Ateş 1998). It has been reported that the optimal pH range of vineyard soils should be between 5.5 and 6.8 (Kurtural 2011).

Table 2

Limit values and distributions for some physical and chemical properties of the Rumi grape soils

Nutritional element	Limit values	Evaluation	Number of samples	Distribution (%)
	< 4.5	strong acid	-	-
pH	4.5-5.5	mid-acid	-	-
	5.5-6.5 6.5-7.5	mild acid neutral	- 6	- 16.2
	7.5-8.5	slightly alkali	31	83.8
	< 2	saltless	37	100
EC (ds m^{-1})	2-4	slightly salty	-	-
	4-8	moderately salty	-	-
	8-15	very salty	-	-
Lime (%)	0-1	low	9	24-32
	1-5	calcareous	6	16.21
	5-15	moderately calcareous	6	16.21
	15-25	very calcareous	9	24-32
	>25	excessively calcareous	7	18.91
Organic matter (%)	<1	very low	2	5.40
	1-2	low	13	35.13
	2-3	moderate	19	51.35
	3-4	good	3	8.10
	> 4	high		
	< 3	very high	11	29.72
P (kg da^{-1})	3-6	low	25	67.56
	6-9	moderate	1	2.70
	9-12	high	-	-
	>12	very high	-	-
K (kg da^{-1})	<20	low	-	-
	20-30	moderate	-	-
	30-40	sufficient	2	5.40
	>40	excessive	35	94.59
Texture (% saturation)	0-30	sand	-	
	30-50	loam	10	27
	50-70	clay loam	19	51
	70-110	clay	8	22
	> 110	heavy clay	-	-

K fixation increases with the increase in pH, especially in soils. In acidic soils, K may be more useful for plants (Mouhamad et al. 2016).

Soil texture

It was determined that 27% of the vineyard soils in the study had clay, 51% clay and 22% clay texture. In rough soils with a high sand content and acidic reaction, the retention capacity of nutrients is low, and the loss of potassium, especially cations, is high (Bayraklı 1998). Determination of soil structure is one of the most important analyses in soil fertility studies. The amount and type of clay contained in soils determine the potassium source of the soil. The fact that potassium is insufficient in nearly half of the soils examined in Samsun Province is due to the coarse texture of the soils (Çelik, Dengiz 2018). It has been reported that heavy clay, poorly drained, poorly aerated, and shallow soils are unsuitable for viticulture (Çelik et al. 1998). When evaluated in terms of texture, it was determined that the vineyard soils of Kilis Province are suitable for viticulture. Gravel and stony soil provides good drainage, the soil warms up easily and the vine grows well. Loamy soils are the most suitable substrate for viticulture (Çolakoğlu 2010).

Salt (EC)

The EC content of the soils under the Rumi grape variety vines of Kilis Province varied between 0.008 and 0.07 ds m^{-1}. According to the limit values determined by Ülgen and Yurtsever (1995), the EC values of the soils examined were less than 2 ds m^{-1} and there was no salinity problem. In salty soils, there were problems related to plant nutrition and consequently productivity. Deliboran and Savran (2015) claim that soil salinity occurs especially in arid and semi-arid climatic regions, particularly in areas where there is a lack of drainage. The presence of high sodium content in the soil also negatively affects the presence of microorganisms. It has been reported that vine is resistant to drought; however, it is very sensitive to salinity (Babalık, Baydar 2021).

Lime ($CaCO_3$)

The lime content of the vineyard soils in the study area was determined to be between 0.85% and 46.21%. According to the limit values of Ülgen and Yurtsever (1995), 24.32% of the vineyard soils were low calcareous, 16.21% were calcareous, 16.21% were moderately calcareous, 24.32% were highly calcareous, and 18.91% were excessively calcareous (Table 2). The soil structure of the lands with vineyards in Kilis Province is generally calcareous. Therefore, the lime content was found to be high. In addition, the lack of precipitation and the accumulation of carbonates in the province are seen as the reasons for the high lime content of the soils. The high lime content in vineyard soils causes various nutritional problems, especially iron chloro-

sis. It has been reported that the growth of native vines on their own rootstocks shows high lime resistance, which confirms the importance of growing durable and native varieties in lime soils (Zengin, Özbahçe 2011). While calcification practice is beneficial in acidic soils, the usefulness of fertilizers in soils with high pH and lime content decreases (Lindsay 1979).

Organic matter

The organic matter content of the examined vineyard soils varied between 0.62% and 3.40% (Table 2). It was determined that 5.40% of the vineyard soils were classified as very low in terms of the organic matter content, 35.13% as low, 51.35% as moderate, and 8.10% as good. It was determined that the organic matter content in the sampled vineyards was not sufficient for grape growth. It was concluded that there may be some difficulties in grape cultivation in the vineyards in Kilis Province due to the soils' high lime content. It has been reported that the amount of soil organic matter should be approximately 1.5% for viticulture (Zengin, Özbahçe 2011). In another study, it was reported that soil organic matter between 2% and 3% would provide ideal conditions for viticulture (Kurtural 2011). In Turkey, it has been reported that the organic matter content of our vineyard soils is generally low. Grapes grown in soils rich in organic matter and high in nitrogen are resistant to diseases. The grains of table grapes produced in these soils are soft and unsuitable for marketing (Çolakoğlu 2010).

Absorbable phosphorus

The phosphorus content of soils varies between 1.04 and 6.86 kg da^{-1}. It was determined that 29.72% of the soils were very low in phosphorus, 67.56% were low, and 2.70% were in the moderate class (Table 2). In the Rumi grape soil samples taken from 16 villages and 37 different sites, the level of phosphorus that in only one vineyard was determined to be moderate. In the present study, it was concluded that the phosphorus content of the soils examined for grape cultivation was insufficient. The phosphate form of phosphorus is dominant under high pH conditions, and plants cannot benefit from this form. They form Ca compounds that are difficult to dissolve. This element also becomes useless for the plant by forming Fe and Al compounds under low pH conditions (Ceylan et al. 2016). Phosphorus deficiency can also occur as a result of interactions with other nutrients in the soil. In the lower and upper soil layers with phosphorus deficiency, it is generally stated that the pH values of the soil reaction are high (Güneş, Aktaş 2008).

In the Rumi vineyard soils with a high lime content, it has been observed that the phosphorus content is in the low class. It is observed that phosphorus can be fixed in these calcareous and alkaline soils. R^2=0.6531 was found significant between the lime content and phosphorus content of the soils (Figure 3).

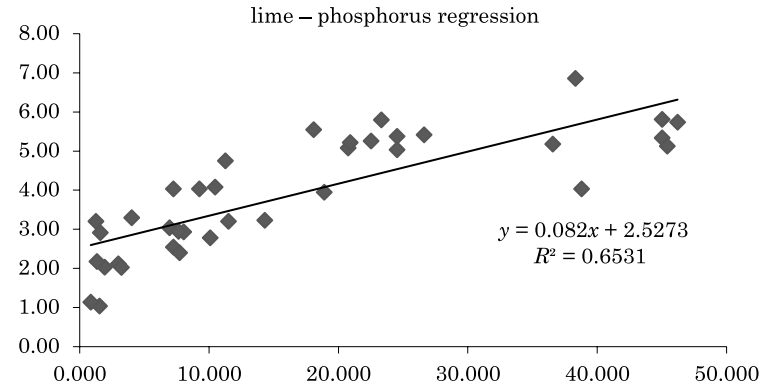

Fig. 3. Lime – phosphorus regression analysis

Available potassium

The K content of the vineyards where the Rumi grape variety is grown in Kilis Province was found to be between 31.85 and 164 kg da^{-1}. It was determined that 5.40% of the potassium content of these soils was in the sufficient and 94.59% in the excess class. It was determined that the examined soils contained sufficient and high levels of potassium for viticulture. It can only be determined whether the plant benefits from the potassium in the soil via plant analysis. During the crop season in the vineyards, the lands should be checked, and whether there is a potassium deficiency should be monitored. In general, there is a lack of K in vineyards in China. This deficiency mostly manifests itself in light-textured soils. Potassium is an essential nutrient element in viticulture, and grapevine fruit quality decreases in the case of its deficiency (Yağmur, Okur 2018). Potassium as a nutrient element can be more beneficial in terms of plant nutrition by calcification in acidic soils (Rogiers et al. 2017). Potassium is a nutrient element that increases product quality by taking part in many metabolic events, such as storage of reserve nutrients, transportation in cells with starch and sugar formation, protein synthesis, also contributing to longer shelf life and better cold resistance. Possible deficiencies in a product with high economic value, such as the sugar ratio, and marketing, such as grapes, should be eliminated by fertilization. The effects of different doses of potassium fertilizer on chlorophyll formation and membrane permeability in plants have been examined. In the current study, potassium fertilization reduced the negative effects of water stress. Potassium fertilization in dry conditions has been found to prevent water loss and fading by regulating turgor in plants and alleviating the effects of drought (Kuzucu 2021). It has been reported that the cell membranes of chickpea plants fertilized with potassium fertilizer were less affected under dry conditions, and the plants showed drought resistance when grown in turf soil mixture medium (Can, Kuzucu 2022).

Relationships between soil properties (correlation analysis)

Table 3 shows the relationships between the chemical and physical properties of soil samples taken from the Rumi grape variety vineyards in Kilis Province. The relationships between the soil properties examined were determined, and a positive relationship between soil structure (% saturation) and pH and potassium, as well as a negative relationship between lime, organic matter and phosphorus were found. Positive significant relationships were found between the pH contents of the soils and $CaCO_3$ and absorbable phosphorus contents at the level of $p<0.05$. The study showed a positive relationship with pH and soil organic matter and absorbable potassium content. Positive significant relationships were found between the lime content and organic matter (410*) at the level of $p<0.05$, with the acceptable phosphorus content (772**) at the level of $p<0.01$, and $CaCO_3$ and the acceptable potassium (-074) showed a negative relationship. A significant positive relationship was found between the organic matter and phosphorus content (545**) at the level of $p<0.01$. Organic matter was negatively correlated with potassium. Absorbable K (-062) was negatively correlated with absorbable phosphorus (Table 3).

Table 3

Relationships between soil and soil properties

Specification	Texture (% saturation)	pH	$CaCO_3$	Organic matter	Phosphorus (kg da^{-1})	Potassium (kg da^{-1})
Texture (% saturation)	1					
pH	0.201	1				
$CaCO_3$	0.312	**0.389***	1			
Organic matter	-0.161	0.124	**0.410***	1		
Phosphorus (kg da^{-1})	0.077	**0.404***	**0.772****	**0.545****	1	
Potassium (kg da^{-1})	0.154	0.148	0.074	-0.045	0.062	1

* significant at $p<0.05$ level, ** significant at $p<0.01$ level

CONCLUSION AND RECOMMENDATIONS

In many countries around the world, viticulture is carried out on different lands. In terms of texture, loamy, sandy loamy or slightly gritty soils are suitable, textured soils for vineyards. It is recommended that fertilization and irrigation applications in vineyards be performed in a controlled manner depending on the soil texture. It is known that vineyard soils should contain moderate amounts of lime, and nutritional problems are experienced in soils containing much lime. In soils with a moderate level of organic matter, vine-

yards can develop well and achieve the desired yield. Vineyard soils should be neutral or slightly alkaline, and soils without salt problems are considered ideal soils for vineyards. If the soil organic matter is low in viticulture, which has an important place in the agriculture of Turkey, organic fertilization must be performed. With organic fertilization, the physical, chemical, and biological properties of vineyard soils have been improved, and the expected increase in yield can be achieved. As a source of organic fertilizers, farm manure, compost or green fertilizers will be suitable. In vineyards with high pH and high lime content, sulfur fertilizers are recommended. The usefulness of some important nutrients that turn into non-absorbable forms can be increased in this way. At the same time, fertilization or foliar fertilization is recommended to deliver nutrients to the plant at a high level.

The Rumi grape variety, which is one of the grape varieties with high economic importance in Kilis, is produced without fertilization. This grape variety, which is mostly processed into valuable products such as molasses, fruit pulp and walnut sausage, is of great importance in the development of the province. Yield reductions in recent years have put producers in serious trouble. In addition, the shutdown of the grape juice factory in the city also contributed to the decline in grape production. In this study, the reasons for the low yield of the Rumi grape variety were investigated in terms of the soil nutrient content. It was determined that the soils were poor in organic matter, high in pH and very calcareous. For these reasons, it was determined that the usefulness of nutrients that play an important role in plant nutrition decreased. In order to maintain the fertility of the Rumi grape vineyard soils, it will be beneficial to add to the soil the nutrients removed from it. Giving mineral and organic fertilizers in accordance with the fertilizer recommendation based on soil analysis will ensure the continuation of productivity. In Kilis Province, which has dry conditions, the Rumi vineyards should be fertilized with well-burnt farmyard manure and base fertilizer containing 20% nitrogen, 20% phosphorus and 20% potassium, applied to a depth of 25 cm of soil, in autumn. This way, the roots are protected from cold and the number of flowers and fruit set increase in spring. During the period without rainfall in February, ammonium sulphate fertilizer containing 21% nitrogen should be applied to these soils which are calcareous and have high pH in order to ensure the development of the vegetative parts.

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