

Potassium-Magnesium Petiole Contents in Relation to Grapevine Yield and its Quality

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Abstract: Our research hypothesis is that to study the correlation between potassium and magnesium- petioles contents and yield and quality of grapevine (*vitis vinifera L., cvs*) to define the optimum contents of both at which high grapevine yield with best quality can be reaching. In addition, define the proper rates of potassium and magnesium which can be applied through fertigation system in sandy loam calcareous soil and their effects on nutritional status. Therefore, two field experiments were carried out in a grapevine farm at Nubaria region, Egypt during two successive seasons. Five potassium rates as potassium sulfate (50 % K₂O), namely, K1; 25, K2; 50, K3; 100, K4; 150 and K5; 200 g K₂O/ vine/ year and five magnesium rates as magnesium sulfate (16 % MgO), namely, Mg1; 2.5, Mg2; 5, Mg3; 10, Mg4; 15 and Mg5; 20 g MgO / vine / year were applied to the selected vine grapes. The results indicate that there was a positive correlation (0.282) between K- petioles contents and grape yield, the grape yield reached to a maximum value of 49.75kg/ 5 vines at the K-petioles contents of 1.65 % and at a rate of K-application K3. Whereas, at the highest K- petiole content (2.06%) a higher TSS (18.3%) was reported than at the others with a highly positive correlation coefficient (0.80) at a rate of potassium sulfate application of K5. The same trend was found with total acidity in berry juice. With respect to the relation between the Mg - petioles content and grape yield, the grape yield reached to a maximum value of 45.49 kg/ 5 vines when the Mg-petiole content reached to 0.43% and at a rate of magnesium sulfate application of 10 g / vine. In contrast a weakest correlation (0.007) was found between petioles- Mg content and TSS. Petioles-Mg content was more highly negatively correlated with total acidity where at low petioles-Mg content (0.23%) the total acidity was high (0.63%) at a rate of magnesium sulfate application of Mg1. According to high correlation between petiole concentrations of both potassium and magnesium and grape yield, the grape yield was significantly affected due to their antagonistic effect. In this respect, the maximum yield (59.40 kg / 5 vines) were gained by application of 100 g K₂O and 10 g MgO/ vine (K3Mg3 treatment) which associated with a K and Mg- petioles contents of 1.65% and 0.45 %, respectively. Also the highest TSS (19.1 %) was found at the K5Mg3 treatment and at which the K and Mg - petioles contents were 2.1 % and 0.32 %, respectively. Accordingly, the reliable correlation between K and Mg-inputs, their concentration in petioles and grapevine yield is strong enough to be used as a predictive tool for grapevine fertilization.

Key words: grapevine (*vitis vinifera L., cvs*), calcareous soils, fertigation system, potassium and magnesium petiole content, yield and quality.

Introduction

Fertilization in viticulture is an essential process in order to save the yield quantitatively as well as qualitatively. Therefore in many places throughout the world scientists tried to figure out systems with which the optimal nutrient status could be assessed^{1, 2, 3}. In concern, a widely used system in many important grape growing countries is petiole analysis which can be carried out easily⁴. Petioles are mainly composed of conducting vessels and some supports materials. Therefore it is believed that this plant part may use as an indicator of the current nutritional status of the plant, because nutrients are unaffected, not yet metabolized and not built in organic structures⁵. From this point of view petioles may display the actual composition of the soil solution and the amount of assailable nutrients. Therefore be able to show the fertilizer application to crops as well as their demands.

¹ pointed out guidelines for interpreting petiole -contents results as follow: severe K deficiency with petiole contents below 1%, marginal 1.0 -1.3%, adequate with contents 1.3-3.0 % and high or toxic greater than 3.0 %. However, severe Mg deficiency with petiole contents below 0.30%, marginal 0.30-0.39% and adequate with contents greater than 0.40 %. These standards are also not appropriate for all grapevine varieties or rootstocks as they do not consider the effect of nutrient status on berry composition or quality.

Petiole testing can provide a snapshot of the nutrient status of the grapevine. Obtaining quantitative information on nutrient levels can assist in determining the effectiveness of fertilizer applications and also help identify the cause of any specific vine problems⁴.

The most common ways to enhance yield and quality of grapevine to meet exportation needs is reaching an optimal nutrients- petiole content through a balanced fertilization program ; especially, with potassium and magnesium. Potassium serves an important purpose in several different plant functions which is essential for grapevine growth and yield and its quality^{6, 7}. Magnesium has been also affected the productivity and fruit quality of fruit trees, which is required as a component of chlorophyll molecules, for metabolic processes, fruit formation and berry ripening⁸. On the other hand,⁹ concluded that Mg doses beyond those required for maximum yield rarely induce a further improvement of product quality.

Magnesium deficiency is well known in some Egyptian soils¹⁰ and many symptoms of deficiency have been recently noticed on trees grown in soils, which received heavy doses of potassium¹¹. Enhancing grapevine yield with best quality to meet exportation needs established through following good agriculture practices in addition to the importance and specific effects of potassium and magnesium and their interaction¹². Thus our research hypothesis is that to study how to reach the optimal petioles content of potassium and magnesium which is related to the highest grapevine yield with best needed quality for exportation, by application of different rates of both nutrients through fertigation system in calcareous soils taking into consideration the antagonistic effect between them.

2. Materials and Methods

Field investigations were carried out for two successive seasons in order to study the relation of potassium and magnesium petioles contents with yield and quality of grapevine grown in sandy loam calcareous soils to reach the proper rate of potassium and magnesium which can be applied through drip irrigation system during their effects on nutritional status.

In a vineyard site, belonging to Nubaria region, Egypt , five potassium rates as potassium sulfate (50 % K₂O), namely, K1; 25, K2 ; 50, K3; 100 , K4 ; 150 and K5 ; 200 g K₂O / vine / year and five magnesium rates as magnesium sulfate (16 % MgO) , namely, Mg1; 2.5, Mg2; 5, Mg3 ; 10, Mg4 ; 15 and Mg5; 20 g MgO/vine / year were applied to the selected vine grapes . Twenty five combinations of the preceding rates of both potassium and magnesium were tested. These treatments were arranged in the experimental design as split- plot with four replicates and five vines in each replicate. Representative leaves samples were collected from a position opposite to the grape clusters of the five vines of each replicates before version stage and petioles were separated and subsequently dried to constant weight, dry ashed at 500°C for determination of potassium and magnesium according to¹³. At harvest time grape yield was determined by weighing all grape clusters of each replicate and recorded as kg /5 vines. On the set of grape juice samples, a Total Soluble Solid; TSS (Brix^o) was determined by using a refractometer and Total Acidity was measured according to¹⁴. Some physical and

chemical analysis of soil samples of the experimental sites was determined according to ¹³. The soils have a sandy loam texture, pH 7.9, EC 1.40 ds/m, total CaCO₃ 12% and organic matter 0.59%. While N, P, K, Mg, Fe, Mn and Zn contents were: 21, 8, 360, 73, 1.25, 6.9 and 1.3 ppm, respectively.

All the recommended agronomic practices for grapevine were followed except for the treatments under investigation. Commercial Eight–years–old superior seedless grapevine variety (*vitis vinifera L., cvs.*) 700 vines / feddan were selected on the bases of preliminary study and analysis which indicating that there are problems in potassium and magnesium nutrition including of visual observation of magnesium deficiency symptoms ⁹ irrespective yearly of application of magnesium fertilizers to the vines which grown under drip irrigation system. All results were statistically analyzed according to ¹⁵. The combined analysis was conducted for all data of the two seasons according to ¹⁶ the significant least differences (L.S.D) were used to compare the means.

3. Results and Discussions

1. Effect of K-petioles content on yield and quality of grapevine:

Data in Figure 1 showed that there was a positive correlation (0.282) between petioles –K contents and grape yield. The grape yield reached to a maximum value of 49.75kg/ 5 vines when the petioles –K content reached 1.65 % with application of 100 g K₂O / vine. ^{17, 2} linked yield with petiole K content in grape. These findings were clearly associated with potassium application rates. By concerning the effect of the five potassium fertilization rates, data of table (1) cleared that raising potassium rates generally resulted in a significant increase in mean values of petioles –K content. Since the petioles -K content was increased about four times from 0.56% to 2.06% with increasing rates of potassium from 25 to 200 g K₂O / vine. Many investigators ¹⁸⁻²² reported that potassium fertilization increasing the petioles -K content and the total soluble solids and decrease of acid concentration. They postulate that increasing K fertilization improves sugar transport into the berries. It must be activating the enzymes involved in the conversion of carbohydrates to Ribose sugar, these findings are in parallel with those mentioned that K enhances translocation of sugars and starch, increases protein content of plant, builds cellulose and reduce lodging, and helps to retard crop diseases. These assumptions are compatible with by ^{23, 24}. The data of table (1) also showed that the highest TSS (18.3%) was at the higher petiole -K content (2.06%) with application of 200 g K₂O/ vine. The same trend was found with total acidity (0.62%) in berry juice. In the same time figures 2 and 3 indicate that there were positive correlations (0.79) between leaf petiole -K contents with TSS (%) and total acidity (%) in berry juice. Similarly, ^{18, 2} found positive correlations between petioles–K content with TSS (%) and total acidity (%) in berry juice. Also, ^{25, 26} found a significant positive linear relationship between juice pH and K concentration. This can occur due to K exchange with protons from organic acids.

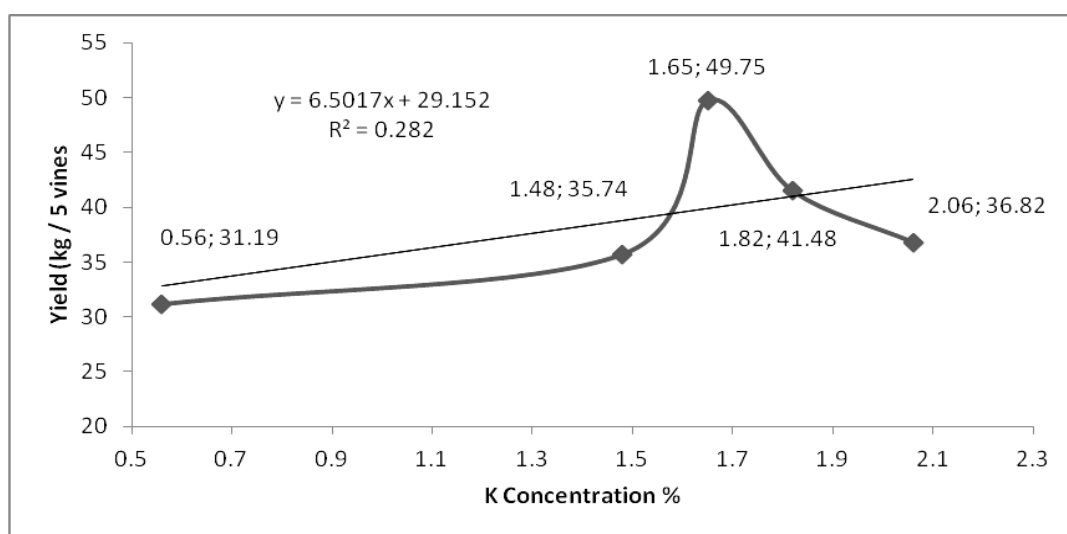


Fig. (1): The correlation between potassium concentrations (%) of leaf –petioles and grape yield.

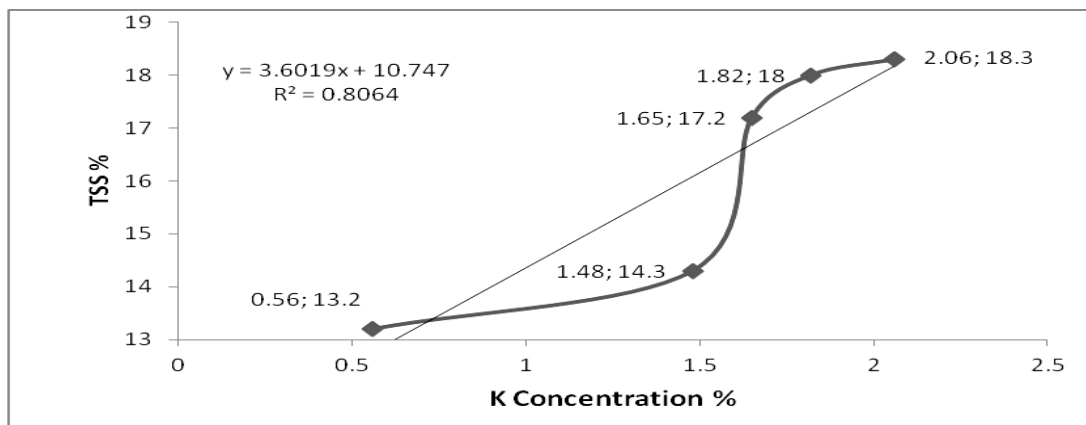


Fig. (2): The correlation between potassium concentrations (%) of leaf- petioles and TSS (%) of the berries at harvest.

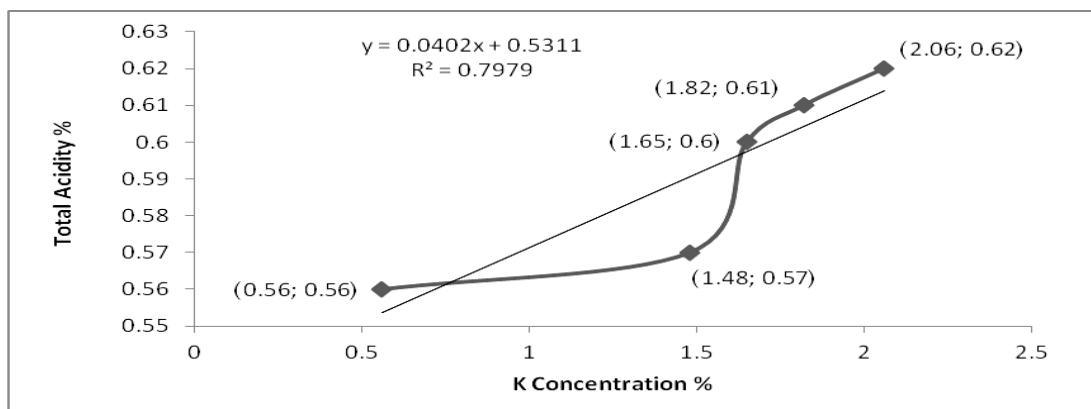


Fig. (3): The correlation between potassium concentrations (%) of leaf- petioles and total acidity (%) of the berries at harvest.

2. Effect of Mg-petioles content on yield and quality of grapevine.

Regarding the relation between the petioles- Mg content and grape yield, the grape yield reached to maximum values of 45.49 kg/ 5 vines at Mg -petiole contents of 0.43% with magnesium sulfate rate of 10 g / vine. This positive correlation as shown in Fig.4 may be due to the effect of magnesium addition which led to a better nutritional balance and an increase in leaf total chlorophyll content and consequently photosynthesis level was increased²⁷. These positive yield increases were also derived from an improved root growth, photosynthesis and translocation of photosynthates, and enzyme activities^{28, 8, 9, 29}. So that, the enhancement effect on chlorophyll was reflected in more carbohydrates production through photosynthesis process and increasing vegetative growth and consequently improved fruit set percentage, retained fruit percentage, yield and bunch weight.

Petioles- Mg content showed weakest positive correlation (0.007) with TSS% (Fig.5). Where the highest TSS (16.8%) was obtained at petioles- Mg content of (0.43%) after that, TSS decrease with increase petioles- Mg content.

In contrast, petioles- Mg content was more highly negatively related with total acidity, where at low petioles-Mg content (0.23%) the total acidity was high (0.63%), vice versa, when petioles- Mg content was high (0.55%), the total acidity was low (0.54%). This relationship between petioles- Mg content and the total acidity (Fig.6) was found to be linear (0.89). In this respect,³⁰ found that Mg fertilizers induced a pronounced reductive effect on fruit total acidity content.

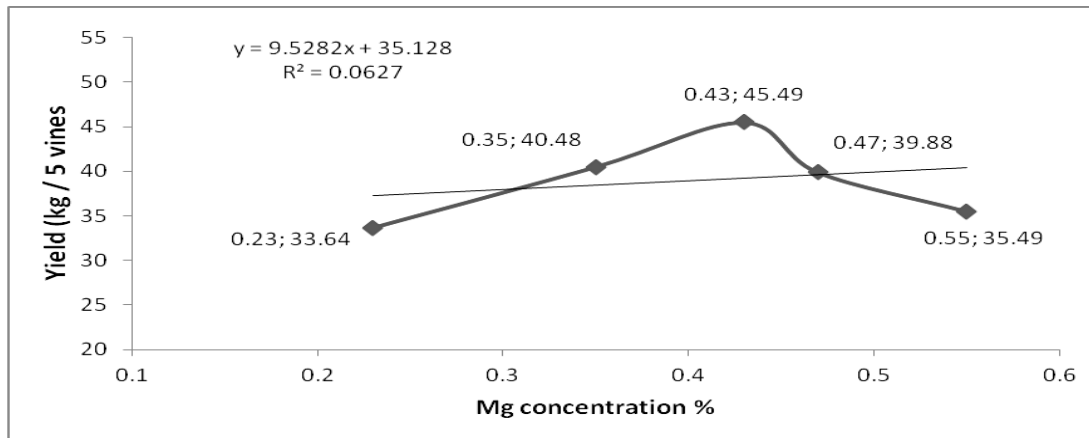


Fig. (4): The correlation between Magnesium concentrations (%) of leaf –petioles and grape yield.

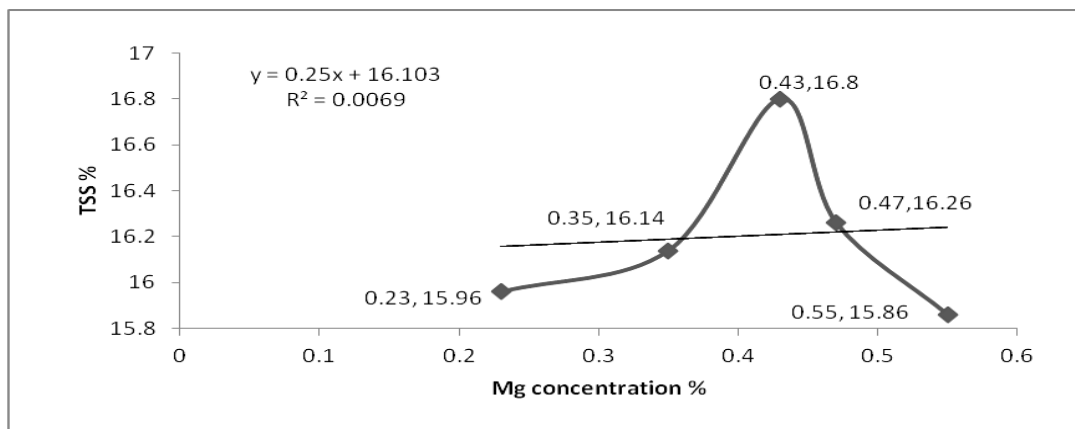


Fig. (5): The correlation between Magnesium concentrations (%) of leaf- petioles and TSS (%) of the berries at harvest.

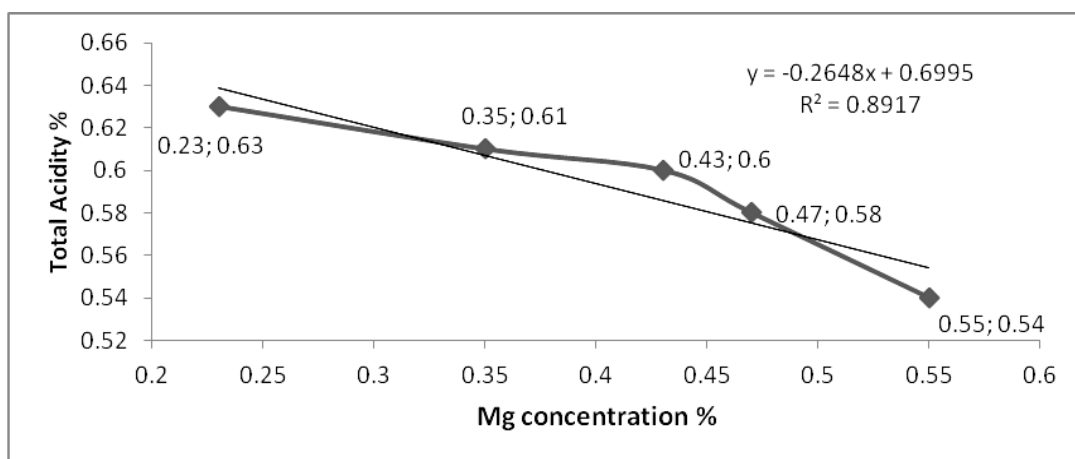


Fig. (6): The correlation between Magnesium concentrations (%) of leaf- petioles and total acidity (%) of the berries at harvest.

3. Interaction effects between K and Mg on petioles content and yield and quality of grapevine:

The petiole potassium and magnesium concentrations at different additives combinations clearly demonstrated the presence of the antagonism phenomenon between the two nutrients. A large excess of one nutrient led to a deficiency of the other, with a corresponding decrease in yield. In this concern Mg content was significantly reduced in the petioles with increasing K fertilization rate and vice versa (Table1). It is possible that a K-induced Mg deficiency could develop from the continued use of high levels of K fertilization.

³¹ reported that potassium fertilizer treatments increased petiole K concentration, whereas the opposite occurred with petiole Ca and Mg concentrations. Also, ³² found that magnesium could induce a K deficiency in the grapevine if the soil has an available concentration ratio of K/Mg less than 0.30. Conversely, high K concentrations in the soil have been found to lead to a reduction in Mg uptake by the grapevine.

Table (1): Effect of potassium and magnesium rates as soil application on petioles contents from K and Mg, grape yield (kg / 5 vines), TSS and total acidity of berry juice of superior grapevine grown in calcareous soil under fertigation system (combined analysis of two successive seasons).

K₂O (g / vine)	MgO (g / vine)	K (%)	Mg (%)	Grape yield (kg/5 vines)	TSS (%)	Total Acidity (%)
25	2.5	0.66	0.30	28.50	13.2	0.58
	5	0.62	0.46	33.15	13.4	0.56
	10	0.57	0.53	36.80	13.0	0.57
	15	0.48	0.60	30.00	13.5	0.55
	20	0.45	0.74	27.50	13.1	0.52
50	2.5	1.82	0.25	32.95	14.8	0.60
	5	1.68	0.38	35.50	14.0	0.58
	10	1.47	0.50	41.00	14.5	0.58
	15	1.30	0.53	35.50	14.3	0.56
	20	1.12	0.62	33.75	14.0	0.53
100	2.5	1.96	0.23	41.10	16.5	0.64
	5	1.82	0.35	49.75	17.2	0.61
	10	1.65	0.45	59.40	18.5	0.60
	15	1.51	0.46	53.40	17.0	0.58
	20	1.30	0.54	45.10	16.6	0.55
150	2.5	2.14	0.19	35.10	17.3	0.66
	5	1.96	0.32	44.00	17.9	0.63
	10	1.82	0.36	47.75	18.9	0.61
	15	1.65	0.40	44.25	18.1	0.60
	20	1.54	0.46	36.30	17.6	0.56
200	2.5	2.35	0.18	30.55	18.0	0.68
	5	2.21	0.26	40.00	18.2	0.66
	10	2.10	0.32	42.50	19.1	0.63
	15	2.00	0.36	36.25	18.4	0.60
	20	1.62	0.41	34.80	18.0	0.53
Mean values of K₂O	25	0.56	0.53	31.19	13.2	0.56
	50	1.48	0.46	35.74	14.3	0.57
	100	1.65	0.41	49.75	17.2	0.60
	150	1.82	0.35	41.48	18.0	0.61
	200	2.06	0.31	36.82	18.3	0.62
Mean values of MgO	2.5	1.79	0.23	33.64	15.96	0.63
	5	1.66	0.35	40.48	16.14	0.61
	10	1.52	0.43	45.49	16.80	0.60
	15	1.39	0.47	39.88	16.26	0.58
	20	1.21	0.55	35.49	15.86	0.54
LSD at 5%	K₂O	0.16	0.15	2.82	0.95	0.06
	MgO	0.25	0.10	4.30	0.94	0.05
	K₂O X MgO	0.09	0.04	1.46	0.98	0.02

According to high correlation between petiole concentrations of both potassium and magnesium and grape yield, the grape yield was significantly affected due to this antagonistic effect. The maximum yield (59.40 kg / 5 vines) were gained by petiole -K content (1.65%) and petioles- Mg content (0.45%) at application of 100 g K₂O + 10 g MgO / vine (K3Mg3 treatment). Also the highest TSS (19.1 %) was found at K content 2.10% and petioles- Mg content 0.32% at application of 200 g K₂O + 10 g MgO / vine (K5Mg3 treatment). While, the total acidity was generally increased as a result of increasing potassium application rates and decreased as results of increasing magnesium rates. The highest value of total acidity (0.68 %) was obtained at K content 2.35% and petioles- Mg content 0.18% at application of 200 g K₂O+2.5 g MgO/vine (K4Mg1 treatment). Similarly, ¹² mentioned that the higher level of potassium fertilization (150 or 225 g/vine) with magnesium sulphate at 60 g per vine increased SSC and SSC/ acid ratio in berry juice.

4. Conclusion

In conclusion, petiole analysis may provide an adequate guide for monitoring fertilization in grape. The results indicated a good correlation between the petiole contents and grapevine yield and its quality parameters including the probable application rate of potassium and magnesium. Accordingly, it can be define the optimal petioles content of potassium and magnesium under the favorable rates of both nutrients away from their interaction effects to reach the highest grapevine yield with the best quality to meet exportation needs. The final goal of this study is to develop reliable systems with which recommendations can be made for fertilizer application or quality improvements by 100 g K₂O and 10 g MgO/vine which associated with a K and Mg-petioles contents of 1.65% and 0.45 %, respectively. Also the highest TSS (19.1 %) was found at the treatment (200 g K₂O and 10 g MgO / vine) and at which the K and Mg - petioles contents were 2.1 % and 0.32 %, respectively. But an ample database should be generated (gathering data on environment, crop development and management) to overcome the year-to-year variation in yield response and the different climatic conditions and cultural practices.

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