Using Soil and Foliar Applications of some Fertilizers to Improve the Yield and Quality Parameters of Table Grapes (*Vitis vinifera* L.)

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Abstract

The objective of the current study was to investigate the effect of soil and foliar application of some fertilizers on the yield and quality of table grapes cv. Alkdarri. Soil and foliar fertilizer application treatments included a control, Ca 200 g/vine, K 150 g/vine, N 200 g/vine, Ca 30 g/L, grow more ^{INC} fertilizer 10 g/L, K 20 g/L, and Cu 5 mg/L. Results indicate that soil and foliar fertilizer application increases quality and quantity of table grapes compared to control treatment. The highest berry diameter, a weight of 100 berries and a size of 100 berries were obtained in vines treated with Ca 200 g/vine, using the soil application method. The highest cluster weight was obtained in vines that were treated with K 150 g/vine, using the soil application method. The highest berry firmness was obtained in vines that were treated with K 20 g/L using the foliar application method. The highest pH and TSS were obtained in vines treated with Cu 5 mg/L, using the foliar application method. The highest fruit yield was found in vines that were treated with 150 g K.

Keywords: soil application, foliar spray, grape, fruit yield and quality

INTRODUCTION

The common grapevine (*Vitis vinifera* L.) belongs to Vitaceae family, and one of the most important horticultural crops in the world. The berries are a good source of vitamins (A, B and C) and minerals (Fe, Ca, P, Mg, K and Mn). The fruits are consumed fresh as table grapes and in processed form as raisins and fresh juice (Birjely *et al.*, 2017, Mohamadineia *et al.*, 2015).

Worldwide grape production contributes to about 16% of the total fruit production. The total area of grape orchards in the world covers 7.5 million hectares. In 2017, grape production was estimated at 73.3 million tons (OIV, 2018). In 2017, grapes were cultivated in Jordan on an area of 289,386 ha generating a total production 1849 kg/ha (Department of statistics, 2019). However,

production was negatively affected by several factors, including: poor soil fertility, drought, a high input of macronutrients, but a low input of micronutrients.

Plants need sufficient macro and micronutrient application in order to satisfy their needs and to produce optimum quantity and quality yield (Souri, 2016; Zivdar *et al.*, 2016; Tohidloo *et al.*, 2018). Deficiency in any mineral nutrient or deficiencies in several minerals can significantly inhibit crop growth and yield. When the nutrient supply is insufficient, plants may develop deficiency symptoms and reduced qualitative yield (Mengel and Kirkby, 2001; Sala and Dobrei, 2015).

Foliar application of nutrients is one of the most important practices, considering that foliar fertilization provides the stems, leaves or

fruits directly with nutrients. The application of nutrients during different growth stages can improve the nutrient balance of crops, which, in turn, leads to increased yield and improved quality (Zivdar *et al.*, 2016).

Nutrients are commonly applied directly to the soil. The effect of fertilizers applied to the soil is sometimes reduced due to many factors, ranging from soil type to plant features and the physiological condition (Bratasevec *et al.*, 2013).

Foliar application of fertilizers is an alternative when nutrient absence cannot be corrected by applications of fertilizers to the soil (Dehnavard *et al.*, 2017), so it is helpful when the roots cannot provide essential nutrients (Rawashdeh and Sala, 2015). It has been shown that under variable environmental conditions and adverse soil conditions, foliar fertilization is an important and effective method of nutrient supply to plants (Sala and Dobrei, 2015; Souri and Hatamian, 2019).

In arid and semiarid regions, the rainfall is usually low and erratic, with low soil fertility, leading to decreased yield (Souri, 2016). Fertilizer application plays a pivotal role in enhancing agricultural production. However, new strategies of orchard management are required to increase fruit yield and quality. For this purpose, applying an efficient nutritional management such as soil or foliar applications of fertilizers is one of the essential practices in this region. In this context, the present study targeted the following specific objectives. (i) To study the effect of soil application of N, K and Ca fertilizer at two growth stages. (ii) To study the impact on yields of enhanced foliar application of N, K, Ca, Cu fertilizer at two growth stages, as well as some quality parameters of table grapes.

MATERIALS AND METHODS

The experiment was carried out during 2016 and 2017 seasons on *Vitis vinifera* L. cv. Alkdarri grown in a private grape farm located at Sakhra,

Ajloun Governorate, Jordan, with an average annual rainfall of about 550 mm; the textural class of the soil was clay. Ten-year-old 'Alkdarri' grape trees generally planted at a distance of 4.0 m in rows spaced at 4.0 m were selected for the experiment. Grape trees were directed as bilateral cordons onto a single-curtain (wire) trellis system. Soil samples of about 1.3-1.5 kg were collected from two depths to determine the chemical and physical properties of the soil by using standard methods. The soil was air-dried, passed through a 2 mm sieve so as to obtain a more homogeneous soil sample. The physical and chemical properties of the soils are presented in Tab. 1.

The experiment was laid out in a Randomized Completely Block Design (RCBD) with eight treatments and five replications. Each experimental plot consisted of nine vines for each treatment providing one "inner" tree for monitoring and for data collection and surrounded by border trees receiving the same treatment.

Grape vines were subjected to seven treatments (3 soil and 4 foliar applications), along with control treatment (untreated). Soil treatments were applied with irrigation on two occasions: at the final stage of flowering (BBCH 69) and when berries begin to develop their variety-specific colour (BBCH 81). Foliar treatments were applied at the same growth stages as in soil application. The soil treatments applied contained exclusively calcium as calcium oxide (27% Ca), potassium as potassium sulphate (44% K), and nitrogen as ammonium sulphate (21% N) as follows: 200 g/vine, 150 g/vine, and 200 g/vine respectively.

Foliar treatments were applied solely as follows: Ca 30 g/L as calcium oxide (27% Ca), Grow More^{INC} fertilizer 10 g/L (containing total N = 20%, P₂O₅ = 20%, K₂O = 20%, B = 0.02%, Cu = 0.05%, Fe = 0.1%, Mn = 0.05%, Zn = 0.05%), K 20 g/L as potassium sulphate (44% K), and Cu 5 mg/L as Cu-EDTA (12% Cu). Foliar solutions were sprayed using a high pressure hand sprayer, one litre per

Table. 1. Some physical and chemical soil properties

Depth (cm)	Texture	EC (ds/m)	pH	O.M (%)	N (%)	P ₂ O ₅ (µg/g)	K ₂ O ₅
0-20	Clay	0.48	7.82	1.12	0.15	23.80	369.62
20-40	Clay	0.55	8.00	0.64	0.07	14.61	412.40

vine. Tween-20 at 0.1% (v/v) as surfactant was mixed with the foliar solution, 1 ml per one liter, to enhance adhesion of the solution to plant foliage and an equal amount of water was applied to the control treatment. Spraying was performed in the morning (between 7.00 to 9.00 am). The solution was sprayed on the leaves observing uniform coverage until leaves were completely wet.

The following morphophysiological traits were measured at the stage of maturity: the cluster number per vine was counted and weighed to determine total yield per vine. Representative random samples of 10 clusters were taken from each replicate to the laboratory to determine cluster weight and cluster volume. A random sample of 100 berries per each replication was taken to determine (a) the physical properties of the fruit (berry diameter, weight, and volume of 100 berries, as well as berry firmness and (b) the chemical properties of the fruit (pH and TSS). The collected data were analyzed using MSTAT-C Computer Software version 2.10 (MSTAT-C, 1991). The means differences among the treatments were compared by employing the Least Significant Difference (LSD) test at 5% probability level.

RESULTS AND DISCUSSIONS

Cluster weight (g): Data in (Tab. 2) indicate that the highest cluster weight of 763.14g was obtained in vines treated with soil application of K 150 g/vine and the lowest single cluster weight of 533.11 g was observed in the control.

Weight of 100 berries (g): The effect of different sources of fertilizer nutrients on the weight of 100 berries was statistically significant at $p < 0.05$ (Tab. 2). The maximum weight of 100 berries was displayed by vines receiving soil application of Ca 200 g/vine fertilizer treatment, followed by vines receiving soil application of K 150 g/vine fertilizer treatment, while the minimum weight of 100 berries was gained by the control.

Size of 100 berries (cm³): Data presented in (Tab. 2) shows significant effects of different sources of fertilizer nutrients on the size of 100 berries. This results showed that soil application of Ca 200 g/vine has the greatest impact on the size of 100 berries, followed by vines receiving soil application of K 150 g/vine, while the smallest size of 100 berries was obtained by the control.

Berry diameter (cm): The statistical analysis of data in (Tab. 2) shows significant effects of foliar and soil application on berry diameter at $P < 0.05$. The maximum berry diameter was related to soil application of Ca 200 g/vine, followed by foliar application of K 10 g/L.

Berry firmness (g/berry): The berry firmness was significantly influenced by the application of soil and foliar fertilizers (Tab. 3). Also, berry firmness was enhanced by soil and foliar application, as follows: vines received foliar application of K 10 g/L, followed by soil application of K 150 g/

Table. 2. Effect of soil and foliar applications of some fertilizers on some yield features of table grape cv. Alkdarri

Treatments	Cluster weight (g)	Weight of 100 berries (g)	Size of 100 berries (cm ³)	Berry diameter (cm)
Control (No fertilizers)	533.11 ^d	439.0 ^d	483.3 ^e	1.51 ^b
Soil application of Ca	570 ^d	681.3 ^a	750.0 ^a	1.80 ^a
Soil application K	783.14 ^a	649.5 ^{ab}	675.0 ^b	1.673 ^{ab}
Soil application N	706.70 ^{abc}	533.0 ^c	560.0 ^{cd}	1.63 ^{ab}
Foliar application of Ca	740.00 ^{ab}	495.2 ^{cd}	538.3 ^{de}	1.73 ^{ab}
Grow more ^{INC} application	633.32 ^{bcd}	599.3 ^b	623.5 ^{bc}	1.61 ^{ab}
Foliar application of K	643.78 ^{bcd}	458.3 ^d	566.7 ^{cd}	1.75 ^{ab}
Foliar application of Cu	616.80 ^{cd}	520.0 ^c	578.3 ^{cd}	1.55 ^{ab}

Note: All the values followed by the same letter in each column are not statistically different at 5% by LSD test.

Table. 3. Effect of soil and foliar applications of some fertilizers on some chemical characteristics of the berries of table grape cv. Alkdarri.

Treatments	Berry firmness (g/cm ²)	pH of must	Total soluble solids (%)
Control (No fertilizers)	206.70 ^c	3.39 ^b	15.53 ^c
Soil application of Ca	252.00 ^{abc}	3.39 ^b	17.00 ^{bc}
Soil application K	276.00 ^{ab}	3.54 ^a	17.73 ^b
Soil application N	226.72 ^{bc}	3.45 ^{ab}	17.17 ^{bc}
Foliar application of Ca	267.36 ^{ab}	3.41 ^b	16.67 ^{bc}
Foliar application of grow more ^{INC}	228.70 ^{bc}	3.44 ^{ab}	16.50 ^{bc}
Foliar application of K	287.33 ^a	3.39 ^b	15.97 ^{bc}
Foliar application of Cu	264.69 ^{ab}	3.53 ^a	20.00 ^a

Note: All the values followed by the same letter in each column are not statistically different at 5% by LSD test.
Sources of Ca, K and N are calcium oxide (27% Ca), potassium sulphate (44% K), and ammonium sulphate (21% N).

Figure 1. The effect of soil and foliar applications of fertilizers on table grape yield (kg/vine).
All the values followed by the same letter in each column are not statistically different at 5% by LSD test

vine. There was no significant difference ($P < 0.05$) between soil application of N 200 g/vine and foliar application of K 10 g/L.

The pH value of must (grape juice): Data presented in (Tab. 3) shows that the highest pH was obtained in vines treated with foliar application of Cu 5 mg/L. It was, however, not significantly higher than the control followed by soil application of K 150 g/vine, N 200 g/vine soil application, and Grow More^{INC} fertilizer 10 g/L.

There was no significant difference between soil application of K 150 g/vine and foliar application of Cu 5 mg/L.

Total soluble solids (TSS): Data presented in (Tab. 3) indicates that the TSS was significantly affected by the fertilizer treatments, where the foliar application of Cu 5 mg/L produced the highest value, followed by vines receiving K 150 g/vine. There was no significant difference between soil application of K 150 g/vine, N 200 g/vine, Ca

30 g/L foliar application, Grow More^{INC} fertilizer 10 g/L, and foliar application of K 20 g/L in TSS. Raath (2012) found that application of K and Ca had little positive effect on the TSS of berries in table grapes. Abd El-Razek *et al.* (2011) reported that higher potassium supply significantly increased the total soluble solids in crimson seedless grapes.

Grapevine yield (kg/vine): The effect of soil and foliar fertilizers regarding the yield of grapevines is presented in (Figure 1). The data clearly indicates that potassium soil application of K 150 g/vine produced the highest significant differences when compared with other treatments followed by N 200 g/vine and Ca 200 g/vine. This treatment increased yield by 132.60%, 91.66% and 62.55% as compared to the control respectively. Zlámálová *et al.* (2015) also found that foliar application of potassium increased grape yield in three-year trials. Also, El-Boray *et al.* (1996) found that soil or foliar application during the two seasons increased grapevine yield. Huang *et al.* (2018) found that spraying 0.3 percent of the calcium nitrate solution increased fruit weight and fruit firmness in 'Ruby Seedless' grapes. Shedeed *et al.* (2019) found that grapes responded to fertigation with two potassium fertilizer treatments. Also, these may enhance nutrient content in grape plant tissues, promote the growth of grape plants and the yield of total and exportable fresh clusters.

CONCLUSION

Based on the results presented above, it can be concluded that foliar application of K 20 g/L significantly enhanced berry firmness. Also, soil application of N 200 g/vine, K 150 g/vine, and Ca 200 g/vine significantly increased cluster weight, as well as the weight of 100 berries, the berry diameter, the size of 100 berries, and the yield per vine. The highest yield/vine was obtained from soil application of K 150 g/vine. The control displayed the lowest values of all studied parameters.

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