Journal of Horticultural Science & Ornamental Plants 10 (1): 53-59, 2018
ISSN 2079-2158

DOI: 10.5829/idosi.jhsop.2018.53.59

Effect of Spraying Citric Acid Macro and Micro Nutrients on Yield and Berries Quality of Red Globe Grapevines

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Abstract: This investigation was conducted during the two successive growing seasons of 2016 and 2017 in a private vineyard located at Matay center, Minia Governorate; to evaluate the efficiency of foliar spraying citric acid and some nutrients on vegetative growth aspects, yield and berry quality attributes of Red Globe grapevines. The chosen vines were thirteen-year-old, grown in a sandy soil, spaced at 2 × 3 meters apart and irrigated by the drip irrigation system. The vines were pruned during the third week of January in both seasons of the study so as to maintain a load of 84 buds/vine (7canes × 12 buds/cane) and trellised by the Spanish Parron system. Eight foliar treatments were foliar sprayed as follows:- Tap water (control), citric acid at 1000 ppm, macro-elements (N,P,K,Mg) at 0.5%, micro-elements (Fe,Zn,Mn,B) at 0.1%, citric acid + macro-elements, citric acid + micro-elements, macro-elements + micro-elements and citric acid + macro-elements + micro-elements. The results showed that foliar application of citric acid (1000 pppm), macro-elements (0.5%) and micro-elements (0.1%) either alone or in combination among them had the best results in comparison with control in both seasons. Triple application of citric acid, macro-elements and micro-elements resulted in significantly the highest yield and good components as well as the best physical properties of clusters further improved the physical and chemical characteristics of berries, ensured the best vegetative growth aspects and increased leaf content of nitrogen, phosphorus, potassium and buds content of gibberellic acid and indole acetic acid of Red Globe grapevines.

Key words: Grapevines · Red globe · Citric acid · Macro-elements · Micro-elements · Yield · Quality.

INTRODUCTION

One of the most promising new cultivars planted in Egypt is Red Globe, late ripening seeded variety with colored berries. The quality of the clusters and berries is not rather good; since this cultivar is characterized by low vine vigour, which in turn reflected on increasing the possibility of berry exposure to sunburn damage and irregular colouration of the berry.

Antioxidants play an important role in protecting the cell from senescence as well as enhancing the production of organic fruits. They prevent the free radicals produced during plant metabolism from oxidation of lipids, the components of plasma membrane which accompanied with the loss of permeability and the death of cells [1]. Additionally, antioxidants with their protectant properties play an important role in plant defense against oxidative stress as well as the biosynthesis of most organic foods and activation of cell division process. Recent studies cleared that application of antioxidants gave a promising influence on the productivity of different fruit. Crops Elucidating the positive action of them on fruit crops needs more additional studies. Antioxidant merits on preventing environmental pollution as well as controlling the incidence of some plant diseases should be taken in consideration [2, 3].

Nutrition a key component in the management of viticulture production and sustainable exploitation of viticulture ecosystems [4-6]. Primary macronutrients play an important part in grapevine metabolism for growth processes, fruit development and quality. Additionally, the participation of micronutrients in grapevine nutrition has been studied a lot recently, because of their importance in various metabolic processes, enzymatic processes and also processes that determine the quality of viticulture products, [7-10].

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In fact, foliar does not totally replace soil applied fertilizer but it does increase the uptake and hence the efficiency of the nutrients applied to the soil. This application technique is especially useful for micronutrients but foliar sprays of macronutrients have traditionally not been recommended, because these elements are needed in much greater quantities and uptake through leaves alone is not sufficient to be of practical use [11]. However, major nutrients can be basically used because the amount applied at any time is small and thus it requires several applications to meet the needs of a crop. The increased efficiency reduces the need for soil applied fertilizer, minimizes leaching and run-off of nutrients and decline the impact on the environment of fertilizer salts [12, 13].

The aim of this investigation to evaluate the efficiency of foliar spraying citric acid and some nutrients on vegetative growth aspects, yield and berry quality attributes of Red Globe grapevines.

MATERIALS AND METHODS

This investigation was conducted for two successive seasons (2016 &2017) in a private vineyard located at Matay center, Minia Governorate; to evaluate the efficiency of foliar spraying with citric acid and some nutrients on vegetative growth aspects, yield and berry quality attributes of Red Globe grapevines. The chosen vines were thirteen-year-old, grown in a sandy soil (Table, 1), spaced at 2 × 3 meters apart and irrigated by the drip irrigation system. The vines were pruned during the third week of January in both seasons of study to maintain a load of 84 buds/vine (7canes × 12 buds/cane) and trellised by the Spanish Parron system. Ninety six uniform vines were chosen on the basis their growth depending on weight of pruning and trunk diameter of the vine as indirect estimates for vine vigour. Each four vines acted as a replicate and each three replicates were treated by one of the used treatments.

Eight Treatments Were Foliar Sprayed as Follows: Tap water (Control), Citric acid at 1000 ppm, Macro-elements (N, P, K, Mg) at 0.5%, Micro-elements, (Fe, Zn, Mn, B) at 0.1%, Citric acid + Macro-elements, Citric acid + Micro-elements, Macro-elements + Micro-elements and Citric acid + Macro-elements + Micro-elements.

All Treatments Were Foliar Applied at Three Dates: The 1st date (after bud burst stage), the 2nd date was (at fruit set stage) and the 3rd date was (after two weeks of fruit set stage). Triton B as a wetting agent was added to all spraying solutions at 0.05%.

Macro-elements of commercial product namely Green Tonic, (Green Tonic ® NPK Foliar, El Mohandes Co. for Agricultural Materials – Egypt).were used. The Green Tonic product contained 20%N, 20%P_2o2 and 20%K_2O). Micro-elements were added in chalted form (0.5% Fe, 0.5% Zn 0.5% Mn and B(boric acid) 0,05%).

The following parameters were adopted to evaluate the tested treatments:

Yield and Physical Characteristics of Cluster: Samples of nine bunches/vine were harvested at maturity when TSS reached about 16-17% according to Tourky *et al*. [14]. The following characteristics were recorded:

Yield/vine (kg) was determined by multiplying average cluster weight (g) X number of bunches/vine. Average bunch weight (g) and average cluster dimensions (length and width) (cm).

Physical Characteristics of Berries: Average berry weight (g) and average berry dimensions as length and diameter (cm) were measured.

Chemical Characteristics of Berries: Total soluble solids (TSS%) by hand refractometer, reducing sugars (%) and total titratable acidity as tartaric acid (%) were determined according to A.O.A.C. [15] total anthocyanin of the berry skin (mg/ 100g fresh weight) according to Husia *et al.* [16] were calculated.

Table 1: Physical and Chemical analysis of the vineyard Soil.

Physical					
Sand (%)	Silt (%)	Clay (%)	Texture	----	----
59.9	19.4	20.7	Sandy	----	----
Chemical					
Organic matter (%)	PH (1:25Extract)	EC (Mmhos/cm)	Caco3 (%)	N (ppm)	P (ppm)
1.3	0.8	0.76	1.23	21.3	3.5
K (ppm)	Ca (ppm)	Mg (ppm)	Fe (ppm)	Zn (ppm)	Mn (ppm)
81.3	70.2	4.6	1.7	2.2	1.05

Morphological Characteristics of Vegetative Growth: At growth cessation, the following morphological determinations were carried out on 4 shoots /per vine:

Average shoot length (cm), average number of leaves/shoot and average leaf area (cm^2) of the apical 5th and 6th leaves was taken at full bloom using a CI-203-Laser Area-meter made by CID, Inc., Vancouver, USA. Total surface leaf area/vine (m^2) was determined by multiplying average number of leaves/shoot by average leaf area then by the number of shoots per vine was counted.

Leaf Content of Mineral Elements and Buds Content of GA_3 and IAA: Samples of leaves (apical 5th and the 6th leaves) were taken at full bloom for determining total nitrogen (%) according to Pregl [17]; phosphorus (%) according to Shell and Snell [18] and potassium (%) according to Jackson [19].

Samples of buds were taken at winter pruning (during the third week of January) and GA_3 and IAA were determined according to Wasfy and Smith [20].

Experimental Design and Statistical Analysis: The complete randomized block design was adopted for this experiment. The statistical analysis of the present data was carried out according to Snedecor and Cochran [21]. Averages were compared using new L.S.D. values at 5% level [22].

RESULTS AND DISCUSSION

Yield and Physical Characteristics of Clusters: Data presented in Table (2) show that of citric acid, macro-elements and micro-elements either alone or in combination among them improved significantly yield, as well as weight, length and width of cluster over the check treatment in both seasons and number of clusters /vine during the 2nd seasons. The promotion of yield and its attributes was significantly associated with using macro-elements, micro-elements and citric acid in descending order. Combined use of these applications significantly was superior than using each application alone in improving yield and cluster characters. The best double application in this respect was using macro-elements and micro-elements followed in a descending order by foliar application of macro-elements plus citric acid. Triple application of citric acid, macro-elements and micro-elements resulted in significantly the highest values of yield and cluster quality attributes as compared with using double one in this respect during both seasons.

Physical Characteristics of Berries: As shown in Table (3), all berry physical characteristics i.e. berry weight, length and diameter were significantly affected by foliar application of citric acid, macro-elements and micro-elements either alone or in combination among them as compared to untreated vines (control) in both seasons. Foliar application of macro-elements, micro-elements and citric acid in descending order significantly enhanced those parameters. Combined use of these applications significantly was favourable in enhancing berry physical characteristics using each application alone. The best double application in this respect was using macro-elements and micro-elements followed in a descending order by foliar application of macro-elements plus citric acid. Highest significant values of those parameters were attained by triple application of citric acid, macro-elements and micro-elements as compared with using double one in this respect during both seasons.

Table 2: Effect of spraying citric acid and some nutrients on yield and physical characteristics of cluster of Red Globe grapevines during 2016 and 2017 seasons.

	Yield (kg/ vine)		Number of clusters/vine		Cluster weight (g)		Cluster length (cm)		Cluster width (cm)	
Treatments	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
Control (tap water)	20.17	25.12	28.34	32.07	711.7	783.3	28.07	29.24	19.52	20.54
Citric acid at 1000 ppm	20.99	26.24	28.62	32.29	733.3	812.6	28.32	29.41	19.65	20.71
Macro-elements at 0.5%	22.67	29.05	29.03	33.07	780.8	878.3	28.55	29.69	19.94	20.98
Micro-elements at 0.1%	21.51	27.64	28.47	32.73	755.4	844.5	28.36	29.52	19.73	20.82
Citric acid + Macro-elements	25.94	31.56	30.72	33.46	844.3	943.2	28.64	30.03	20.05	21.24
Citric acid + Micro-elements	24.48	30.06	30.24	33.12	809.6	907.5	28.58	29.72	20.02	21.13
Macro-elements + Micro-elements	27.12	33.31	30.69	33.89	883.7	983.0	28.67	30.24	20.13	21.43
Citric acid + Macro-elements + Micro-elements	28.35	35.17	30.43	34.17	931.5	1029.4	28.81	30.37	20.24	21.52
New LSD at 0.05	1.19	1.31	N.S.	0.27	47.3	46.1	0.11	0.09	0.08	0.06

Table 3: Effect of spraying citric acid and some nutrients on berries physical characteristics of Red Globe grapevines during 2016 and 2017 seasons.

	Average berry weight (g)		Average berry length (cm)		Average berry diameter (cm)	
Treatments	2016	2017	2016	2017	2016	2017
Control (tap water)	8.69	9.56	2.87	2.91	2.74	2.77
Citric acid at 1000 ppm	8.98	9.95	2.89	2.94	2.76	2.78
Macro-elements at 0.5%	9.63	10.82	2.96	2.99	2.79	2.81
Micro-elements at 0.1%	9.26	10.35	2.93	2.97	2.77	2.80
Citric acid + Macro-elements	10.49	11.72	3.03	3.05	2.83	2.84
Citric acid + Micro-elements	10.02	11.23	3.01	3.02	2.82	2.83
Macro-elements + Micro-elements	11.03	12.26	3.06	3.07	2.85	2.86
Citric acid + Macro-elements + Micro-elements	11.67	12.92	3.08	3.11	2.88	2.90
New LSD at 0.05	0.63	0.65	0.01	0.02	0.02	0.03

Table 4: Effect of spraying citric acid and some nutrients on chemical characteristics of Red Globe grapevines berries during 2016 and 2017 seasons

	TSS (%)		Acidity (%)		Reducing sugars (%)		Anthocyanin (mg/100gF.W.)	
Treatments	2016	2017	2016	2017	2016	2017	2016	2017
Control (tap water)	16.17	16.43	0.67	0.65	13.69	14.57	29.36	30.9
Citric acid at 1000 ppm	16.28	16.56	0.65	0.63	13.84	14.71	30.03	32.3
Macro-elements at 0.5%	16.56	16.79	0.62	0.61	14.23	14.95	31.56	32.4
Micro-elements at 0.1%	16.43	16.74	0.64	0.62	13.97	14.83	31.23	32.6
Citric acid + Macro-elements	16.74	16.98	0.59	0.58	14.38	15.29	32.06	33.3
Citric acid + Micro-elements	16.59	16.91	0.61	0.59	14.25	15.17	33.4	33.8
Macro-elements + Micro-elements	16.81	17.09	0.58	0.57	14.49	15.37	33.8	33.9
Citric acid + Macro-elements + Micro-elements	16.93	17.24	0.57	0.55	14.53	15.42	33.6	33.4
New LSD at 0.05	0.11	0.13	0.01	0.02	0.03	0.04	0.39	0.34

Chemical characteristics of berries: Data presented in Table (4) show that foliar application of citric acid, macro-elements and micro-elements either alone or in combination among them increased TSS% reducing sugars% and total anthocyanin while decreased total acidity% over the check treatment in both seasons. The promotion of berry quality was significantly associated with using macro-elements, micro-elements and citric acid in descending order. Combined use of these applications significantly was superior than using each application alone in improving berry quality. The best double application in this respect was using macro-elements and micro-elements followed in a descending order by foliar application of macro-elements plus citric acid. Triple application of citric acid, macro-elements and micro-elements resulted in significantly the highest percentages of TSS, reducing sugars and anthocyanin and the least percentage of acidity of the berry juice as compared with using double one in this respect during both seasons.

Morphological Characteristics of Vegetative Growth: As shown in Table (5) it is clear that shoot length, number of leaves /shoot, leaf area and total surface leaf area/vine were significantly stimulated by foliar application of citric acid, macro-elements and micro-elements either alone or in combination among them as compared to untreated vines (control) in both seasons. Foliar application of macro-elements, micro-elements and citric acid in descending order stimulated significantly of those parameters. Combined use of these applications significantly was favourable in stimulating some vegetative growth traits using each application alone. The best double application in this respect was using macro-elements and micro-elements followed in a descending order by foliar application of macro-elements plus citric acid. Highest significant values of those parameters were attained by triple application of citric acid, macro-elements and micro-elements as compared with using double one in this respect during both seasons.

Table 5: Effect of spraying citric acid and some nutrients on morphological characteristics of vegetative growth of Red Globe grapevines during 2016 and 2017 seasons.

	Average shoot length (cm)		Average number of leaves/shoot		Average leaf area (cm^2)		Total surface leaf area/vine (m^2)	
Treatments	2016	2017	2016	2017	2016	2017	2016	2017
Control (tap water)	153.9	167.4	25.7	27.9	134.9	147.2	23.2	27.5
Citric acid at 1000 ppm	158.7	173.1	26.5	28.5	141.7	152.6	25.1	29.1
Macro-elements at 0.5%	168.1	182.4	28.6	30.2	152.3	161.9	29.2	32.8
Micro-elements at 0.1%	167.3	179.2	27.9	29.9	149.4	158.7	27.9	31.8
Citric acid + Macro-elements	176.4	192.5	29.4	31.7	157.6	169.7	31.1	36.0
Citric acid + Micro-elements	174.5	190.3	29.1	31.3	155.8	167.8	30.4	35.2
Macro-elements + Micro-elements	177.9	193.9	29.6	31.9	158.8	170.9	31.5	36.5
Citric acid + Macro-elements + Micro-elements	181.7	198.3	30.3	32.6	162.2	174.7	32.9	38.2
New LSD at 0.05	3.7	4.1	0.4	0.5	3.1	3.3	1.1	1.4

Table 6: Effect of spraying citric acid and some nutrients on leaf mineral elements content and buds GA3 and IAA content of Red Globe grapevines during 2016 and 2017 seasons

	Leaf N (%)		Leaf P(%)		Leaf K (%)		Buds GA_3 (mg/100g)		Buds IAA (mg/100g)	
Treatments	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
Control (tap water)	1.58	1.63	0.14	0.17	1.29	1.32	0.34	0.37	1.17	1.21
Citric acid at 1000 ppm	1.72	1.77	0.19	0.23	1.37	1.41	0.37	0.41	1.32	1.35
Macro-elements at 0.5%	2.07	2.03	0.31	0.36	1.53	1.58	0.43	0.49	1.73	1.77
Micro-elements at 0.1%	1.92	1.89	0.24	0.27	1.46	1.52	0.39	0.44	1.41	1.46
Citric acid + Macro-elements	2.19	2.12	0.38	0.41	1.61	1.66	0.48	0.56	2.61	2.72
Citric acid + Micro-elements	2.11	2.05	0.35	0.39	1.57	1.63	0.45	0.52	2.24	2.29
Macro-elements + Micro-elements	2.21	2.14	0.41	0.42	1.68	1.74	0.5	0.59	2.67	2.75
Citric acid + Macro-elements + Micro-elements	2.24	2.19	0.44	0.46	1.79	1.83	0.54	0.62	2.86	2.91
New LSD at 0.05	0.02	0.03	0.02	0.01	0.09	0.07	0.03	0.02	0.17	0.14

Leaf mineral elements, buds GA_3 and IAA Content: Data presented in Table (6) show that foliar application of citric acid, macro-elements and micro-elements alone or in combination among them increased significantly leaf nitrogen, phosphorus and potassium content as well as buds GA_3 and IAA content over the check treatment in both seasons., micro- Leaf NPK elements content and bud GA_3 and IAA hormones content were significantly enhanced by using macro elements followed by micro elements then citric acid. Combined use of these applications significantly was superior than using each application alone in increasing leaf content of mineral elements and buds content of GA_3 and IAA. The best double application in this respect was using macro-elements and micro-elements followed in a descending order by foliar application of macro-elements plus citric acid was significantly superior to using double one in this respect during both seasons. Triple application of citric acid, macro-elements and micro-elements resulted in significantly the highest values of leaf content of nitrogen, phosphorus and potassium and buds content of GA_3 and IAA as compared with using double one in this respect during both seasons.

The previous beneficial effects of antioxidants on productivity and fruit quality of Red Globe grapevines were attributed to its positive action on protecting the plant cells from senescence and disorders by preventing the free radicals which caused the oxidation during plant metabolism as well as enhancing cell division, the biosynthesis of natural hormones such IAA and activating the enzymes, the biosynthesis of chlorophylls and carbohydrates which were surely reflected on enhancing growth and vine nutritional status in favour of enhancing yield and fruit quality [23, 1].

Results pertaining to the positive effect of antioxidants spray on yield and fruit quality have been reported by Abd El-Motty and Fawzy [24] on Zebda and Langra Mango trees; Mansour *et al* [25] on Leconte pear trees; Abada and Abd El-Hameed [26] on Flame Seedles grapevines; Fayed [27] on Thompson Seedless grapevines; Ahmed *et al.* [28] on Thompson Seedless grapevines; Bondok *et al*. [29] on Ruby Seedless grapevines; Abada [30] on Thompson Seedless grapevines and Abd El-Wadoud *et al*. [31] on Red Globe grapevines ; Ali, *et al*. [32] on Superior grapevines.

Macronutrients play an important part in grapevine metabolism for growth processes, fruit development and quality. Additionally, the participation of micronutrients in grapevine nutrition has been studied a lot recently, because of their importance in various metabolic processes, enzymatic processes and also processes that determine the quality of viticulture products, [7-10]. Foliar application of nutrients and fertilizers has been an approach followed by researchers and growers to improve the quality and yield of different horticultural crops. For grape this approach has been quite popular and successful as it not only improves the economic benefits in terms of savings towards excess fertilizer costs and higher market value for the produce but also improves the nutrient use efficiency and soil health by direct absorption, utilization of nutrients and stabilizing nutrient balance in the soil which consequently reduces environmental pollution [12, 13].

Previous studies have emphasized the dynamics and the part that micronutrients and macronutrients play in grapevine growth and development and in the quality of grape [7, 33, 34].

CONCLUSION

It can be concluded that triple foliar application of citric acid at (1000 ppm), macro-elements at (0.5 ppm) and micro-elements at (0.1 ppm) had the best results for yield, bunch quality attributes, vegetative growth aspects, leaf content of nitrogen, phosphorus and potassium and buds content of gibberellic acid and indole acetic acid of Red Globe grapevines.

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