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Effect of some rare earth elements on yield and quality of superior grapes

[1]EL-Kader N., N. Abd-el hamed[2], M. Fathi[2], N. Abd-el aziz[1] and G. M. Hussein[1]

[1]*Nuclear Materials Authority, Cairo, Egypt.*
[2]*Horticulture Department, Faculty of Agriculture, Ain Shams Univ., Shobra El-Kheima, Cairo, Egypt*

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ABSTRACT

This study was carried out during 2014 and 2015 seasons in a private farm, located at 64 Kilometers, Cairo-Alexandria desert road, on mature Superior grapevines (*Vitis vinifera* L) .The vines were 5 years old grown in sandy loam soil, spaced at 2×3 meters trained as Y shape system under drip irrigation system was used. The study aimed to investigate the effect of some rare earth elements and their mixture on the yield and quality of Superior grapes .The study included 13 treatments which were: lanthanum (La), cerium (Ce), neodymium(Nd) , and their mixture at 5, 10, 20 ppm in addition to control. Treatments were arranged in a complete randomized block design. The clusters of each treatment were dipped twice in the treatments, the first was at fruit set and the second during veriason stage .The obtained results indicated that 10 ppm of (Nd) recorded significant increments in yield/vine and berry length, While 10 ppm of (La) gave the highest values of weight and volume of 100 berries and Ca content. Moreover 5 ppm of (Ce) recorded the highest values of cluster length, firmness, Ca and P content, On the other side, 10 ppm (Ce) and 20 ppm Mixture gave the lowest values of berry shuttering percentage and the highest fruit potassium content.The study recommended that its important to apply Superior grapevine twice, frist at fruit set and second at vriason stage with low concentrations of REEs i.e.,(Ce),(La) and (Nd) or their mixture to increase yield and quality and decrease berry shuttering .

Key words: Grapes, Cerium, Lanthanum, Neodymium, Yield and Quality mineral contents

Introduction

Grape (*Vitis vinifera* L.) is considered the first major fruit crop in production all over the world. It is an important crop traditionally produced in Egypt. It's the most profitable fruit in Egypt. According to Ministry of Agriculture 2014, total fruiting area cultivated with grape reached to 171882 feddans. Most vineyard soils in the desert areas in Egypt contain insufficient amounts of the essential mineral elements to grow and produce.

Some grapes grown under sandy soil conditions have a problem of low productivity due to poor fertility of such soils. The productivity and quality of Superior cultivar mainly depends on the balance proportion of mineral elements, affects the fruit quality .Some of recent technologies for grape in improving yield and its components is the treatment with rare earth elements (REEs) i.e., Lanthanum (La), Cerium (Ce),Neodymium and mixture of their combination (Xie *et al*., 2002).

Pilon-Smits *et al*., (2009) mentioned that 92 elements presented in the earth ´s crust, but only 17 elements are known to be essential to all plants, and 12 elements have been proven to be potentially beneficial in trace amounts. These include Silver (Ag),Cerium (Ce),Chromium (Cr), Fluoride (F) , Iodine (I), Lanthanum (La) , Rubidium (Rb), Tin (sn), Strontium (Sr), Titanium (Ti), Vanadium (V) and Tungsten (W). Also lanthanum and cerium belong to the group of light rare earth elements are fairly abundant in nature and beneficial for plant growth. Yin *et al*. (2009) reported that .REEs have shown interesting biological effects on plants. Lanthanum and cerium are the main constituents of commercial REEs. They have been widely used in china since the 1970, REEs improve crop plant growth and yield due to REEs enhanced enzymatic activities (Hu *et al.,* 2004) .REEs might be involved, directly or indirectly, in the regulation of the biosynthetic metabolisms of some flavor compounds, ultimately affecting fruit quality and yield. However, the mechanism suggest that these elements regulate flavor metabolism remains unclear (Yang *et al*., 2010) Rare earth elements

Corresponding Author: EL-Kader N., Nuclear Materials Authority, Cairo, Egypt.
E-mail: naglaaabdelkader@gmail.com

increased yield of grape by about 10-15% also TSS were increased by application of REEs as found by Xiong (1995), also yield of orange increased by about 8-38% as reported by Wan *et al.,* (1997) . REEs have important effects on membrane stability and interact strongly with Ca.

Therefore, they strongly affect ionic interactions with the cell (Brown *et al.,* 1995). Grapes at different developmental stages may acquire mineral nutrients differently. During the vriasion-to-ripeness stage, sugar content rapidly increases, acids sharply decrease, and secondary products such as aromatic compounds and polyphenolics also accumulate significantly as reported by Ollat *et al.* (2002).

Therefore, the aim of this study was to investigate the effect of lanthanum, cerium, neodymium and their mixture on yield and quality of Superior grapes.

Materials and methods

This study was carried out during 2014 and 2015 seasons, in a private farm, located at Kilo 64 Cairo-Alexandria desert road, on mature uniform Superior grapevines (*Vitis vinifera* L) , with 5 years old grown in sandy loam soil ,the chosen vines were planted at 2×3 meters apart grown using Y shape system. These vines were irrigated with well water. Fertilization programme was applied through drip irrigation system as recommended from Ministry of Agriculture .The total number of vines used in the experiment was 39 vines. Cane pruning system was followed at the first week of January for both seasons. leaving 84 eyes per vine (on basis of six fruiting canes × 12 eyes plus six renewal spurs × two eyes).This study aimed to investigate the effect of some rare earth elements (REEs) i.e. cerium, lanthanum, neodymium and their mixture at 5,10 and 20 ppm on yield and quality of Superior grapes .

All the chosen vines were received regular horticultural practices that already applied in the in the vineyard including those dealing with the application of dromex and chemical rest breakages .These practices included hoeing, pest control management, irrigation and fertilization with 20 m^3 farmyard manure, 200 Kg ammonium sulphate (20.6 % N),250 Kg calcium triple superphosphate (15.5 % P_2O_5) and 250 kg potassium sulphate (48% K_2O) .Farmyard manure was added once at the first week of Jan, in both seasons. The amounts of nitrogen and potassium were applied as follows:- 30% first stage from bud burst to flowering .40% from fruit set to maturity and harvest.30% after harvest. However, calcium triple super phosphate were applied with farm yard manure.

Thirteen treatments were carried out which were three individual rare earth elements in nitrate source i.e., Lanthanum (La), Cerium (Ce) and Neodymium in addition to the mixture of the three elements together, each at three concentrations i.e. 5,10 and 20 ppm in addition to control treatment. Three replicates were used each with three vines .Treatments were used by dipping the clusters tn the treatments twice during each season, the first was at fruit set and the second was at vriason stage. The rare earth elements solutions as nitrate source from above mentioned concentrations were prepared as the method described by Yin *et al.* (2009).

At harvesting time (June 10 first season, June15 second season),random samples of (3 kg) of ripe fruits from each treatment were taken and transferred immediately to the post harvest Lab ,in Faculty of Agric., Ain shams Univ., then kept in a refrigerator at 5 C° and the following data were recorded :

a. Average yield /vine (kg).
b. Cluster weight (g).
c. Berries shuttering % as the method of Christoudulou *et al.* (1968)
d. Cluster length (cm).
e. Berry width (cm).
f. Weight of 100 berries.
g. Titratable acidity was determined as grams of tartaric acid /100 ml of juice.
h. Total soluble solids (TSS) percentages were determined using a hand refractmeter.
i. T.S.S/ acid ratio was calculated from TSS and TA readings.
j. Total nitrogen was determined according to micro keldahl method as the method of Pregl, (1945), phosphorus was determined calorimetrically according to Jackson (1958). Potassium was determined with flame photometer (Piper, 1950). Calcium was determined as the methods in A.O.A.C., (1980). Data obtained from this study was statistically analyzed and Duncan multiple

range test at 5% level was used to verify differences among means of the treatments as the method of Duncan, (1955).

Results and Discussion

Total yield / vine (Kg):-

Results presented in table (1) show clearly that in the first season, the mixture of the three rare earth elements at 20 ppm showed significantly the highest yield /vine .On the other hand, lanthanum at the three tested concentrations, cerium with 5 or 10 ppm and neodymium at the lowest concentration (5ppm) gave the lowest yield. While in the second season, no significant differences were detected among control treatment and all tested treatments. Such results are similar, to those reported by Pang *et al*. (2002), Zeng *et al.* (2007) and Yang *et al.* (2010).

Cluster weight:-

Data shown in table (1) indicate clearly that in the first season, cerium application at 5 ppm resulted in a significant increase in cluster weight (625 g).On the other side, no significant differences were detected between all other tested treatments and control. Regarding the second season, results show also that no significant differences were detected among all used REEs treatments .Our results confirm those found by Zeng *et al.,* (2007) and Yang *et al*. (2010) .

Table 1: Effect of different concentrations with some rare earth elements on yield, cluster characteristics and berry shutter of Superior grapes in 2014 &2015 seasons.

Treatments (ppm)	Yield and cluster characteristics			
	First season			
	Yield/vine (Kg)	Cluster weight (g)	Berry shutter (%)	Cluster length (cm)
Control	16.5 b	365.0 bc	4.5 a	21.0 ab
5 lanthanum	10.5 d	393.3 bc	4.0 a	19.3 b
10 lanthanum	11.3 d	465.33 abc	4.0 a	22.5 ab
20 lanthanum	12.7 d	343.3 c	4.9 a	20.0 ab
5 cerium	12.8 d	625.0 a	3.9 a	22.3 ab
10 cerium	11.0 d	418.33 bc	3.9 a	20.0 ab
20 cerium	15.7 c	361.6 bc	3.2 a	25.6 a
5 neodymium	13.0 d	435.33 abc	4.1 a	22.0 ab
10 neodymium	17.2 b	518.0 abc	3.7 a	18.5 b
20 neodymium	16.0 b	546.0 ab	3.6 a	21.2 ab
5 mixture	17.0 b	318.6 bc	5.2 a	22.7 ab
10 mixture	14.7 c	406.0 bc	3.8 a	22.5 ab
20 mixture	22.7 a	546.6 ab	3.9 a	25.3 a
	Second season			
Control	10.5 ab	425.0 ab	4.5 a	20.0 b
5 lanthanum	11.3 ab	399.0 ab	2.0 bc	25.6 a
10 lanthanum	11.3 ab	388.3 ab	2.0 bc	23.2 ab
20 lanthanum	11.7 ab	447.3 a	1.6 bc	26.0 a
5 cerium	11.0 ab	384.0 ab	1.7 bc	26.7 a
10 cerium	11.0 ab	307.7 ab	1.0 c	28.0 a
20 cerium	9.7 ab	383.7 a	1.5 bc	28.5 a
5 neodymium	12.0 a	364.7 a	2.0 bc	27.0 a
10 neodymium	11.0 ab	364.7 a	3.0 ab	27.0 a
20 neodymium	9.8 ab	276.3 bc	1.5 ac	26.7 a
5 mixture	11.3 ab	384.0 ab	1.5 bc	26.7 a
10 mixture	9.7 b	307.7 a	1.3 bc	28.0 a
20 mixture	10.3 ab	386.7 ab	1.0 c	28.7 a

Means in each Colum with the same letters are not significantly different at 5% .

Berry shutter:-

It is clear form results tabulated in table (1) that no significant differences were detected between all used REEs treatments and control in the first season. While in the second season, control treatment showed the highest significant values of berry shatter percentage .On the other hand, using lanthanum, cerium and neodymium at the three used concentrations i.e; 5, 10 and 20 ppm decreased significantly the berry shutter % as compared with control .In the second season, the mixture of the three REEs reduced the berry shatter % .Such results may be due to the high Ca content in fruits and membrane stability as mentioned by Brown *et al*. (1995).

Cluster length:-

Data presented in table (1) indicate clearly that there was a significant positive effect for the application of REEs on grapevine cluster length .Whereas, control treatment showed significant decrement in cluster length as compared with all used REEs treatments . In this regard, no significant differences were detected among these tested treatments .Such results are in the same line with those obtained by Hu *et al.* (2004) who reported that REEs had enhanced enzymatic activities in plants which reflect a great increase in plant growth in different plant organs.

Berry width:-

Results presented in table (2) clearly indicate that the REEs had a positive effect on increasing the berry width in grapevine while control treatment showed the lowest values as compared with all tested treatments .Our results agree with those found by Zeng *et al.* (2007) and Yang *et al*. (2010). Such results may be attributed to the role of REEs in plant biosynthetic metabolisms.

Table 2: Effect of different concentrations with some rare earth elements on berry characteristics of Superior grapes in 2014&2015 seasons.

Treatments (ppm)	berry and cluster characters, TSS and TSS/acid ratio			
	First season			
	Berry width (cm)	TSS (%)	TSS /acidity %	Weight of 100 berries (g)
Control	1.3 c	12.7 cd	19.3 ab	297.5 b
5 lanthanum	1.7 a	14.1 bc	24.1 a	449.0 ab
10 lanthanum	1.7 a	14.9 ab	25.6 ab	466.2 a
20 lanthanum	1.7 a	15.9 a	22.5 ab	390.0 ab
5 cerium	1.7 a	13.0 cd	22.1 ab	461.6 a
10 cerium	1.4 ab	11.9 d	21.3 ab	465.0 a
20 cerium	1.3 c	13.7 bcd	21.7 ab	389.7 ab
5 neodymium	1.5 ab	12.6 cd	24.0 ab	362.8 ab
10 neodymium	1.6 ab	13.0 cd	22.8 ab	433.3 ab
20 neodymium	1.4 bc	13.6 bcd	20.7 ab	388.3 a
5 mixture	1.4 bc	13.2 bcd	20.2 b	325.0 ab
10 mixture	1.4 bc	12.6 cd	17.8 ab	341.7 ab
20 mixture	1.2 c	14.3 abc	17.0 ab	375.0 ab
	Second season			
Control	1.4 c	14.1 ab	19.3 ab	350 ab
5 lanthanum	2.1 a	14.3 ab	24.1 ab	404.0 ab
10 lanthanum	2.0 ab	14.7 ab	25.6 a	478.6 a
20 lanthanum	2.0 ab	13.2 ab	22.5 ab	358.6 ab
5 cerium	1.6 bc	12.5 bc	22.1 ab	419.5 ab
10 cerium	1.3 bc	13.9 ab	24.2 ab	417.6 ab
20 cerium	1.3 c	13.6 ab	24.0 ab	396.33 ab
5 neodymium	1.6 bc	13.3 ab	22.8 ab	433.3 ab
10 neodymium	1.6 abc	14.6 ab	20.8 ab	433.3 ab
20 neodymium	1.7 abc	13.0 ab	20.7 ab	355.3 ab
5 mixture	1.5 bc	13.0 ab	20.1 ab	419.7 ab
10 mixture	1.7 abc	13.0 ab	19.8 ab	417.6 ab
20 mixture	1.4 c	15.1 a	22.5 ab	395.3 b

Means in each Colum with the same letters are not significantly different at 5% .

Total soluble solids (TSS) %:-

Regarding the effect of REEs and their mixture on total soluble solids, results shown in table (2) clearly indicate that there were no significant differences among all tested treatments .In this connection, the mixture of the three REEs at 20 ppm gave the highest value while this increment was insignificant as compared with control. Our results agree with those reported by Xin *et al.* (2002) and Yang *et al*. (2010).

T.S.S / acidity ratio:-

Concerning the effect of REEs and their mixture on total soluble solids /acid ratio, data in table (2) show clearly that all used concentrations increased TSS/acidity ratio while this increment did not reach the significant level between all used treatments in this character .The same trend was noticed by Yang *et al*. (2010).

Weight of 100 berries:

All used REEs and their mixture with all tested concentrations increased the weight of 100 berries as compared with control treatment in the two tested seasons except La at 10, Ce at 5 and Nd at 10 ppm in the first season which increased significantly the weight of 100 berries than control (table 2) .However, no clear differences, was detected among the other tested treatments. These results agree with those mentioned by Pang *et al*. (2002) and Xin *et al*. (2002).

Nitrogen percent:-

Results in table (3) indicate clearly that nitrogen percent was significantly increased by the application of lanthanum (La), neodymium (Nd) each at 5 ppm and control in the two tested seasons, In addition to the lowest concentration of the ixture
(5 ppm) in the second season. On the other hand, the medium and the high concentrations i.e., 10, 20 ppm of La, Ce and the mixture showed the lowest nitrogen percent in the two tested years. These results are in agreement with those of Wang (1994) and Pang *et al*. (2002), who suggested the effects of REEs in improving the absorption of nutrient elements.

Phosphorus percent:-

As for phosphorus_percent in fruits, data presented in table (3) show that the treatments of REEs increased significantly phosphorus percent as compared with control in the two tested seasons. Whereas, cerium at 10 and 20 ppm gave significant increase in the two tested years in addition to La at 5ppm, Ce at 5 and 20 ppm, Nd at 5 or 20 ppm and the mixture at 5 ppm in the first season. Such results are similar to those obtained by Wang, (1994) and Pang *et al*. (2002).

Potassium percent:-

It is clear from results tabulated in table (3) that the highest mixture concentration of the REEs used (20 ppm) resulted in the highest potassium percent in the two tested seasons in addition to the application of La at 10 and 20 ppm, Ce at 10 ppm in the second season and control treatment in the first season .Our results confirm with Pang *et al*. (2002).

Calcium percent:-

Data presented in table (3) show clearly that using mixture of the three used REEs i.e; La, Ce and Nd at 5 and 10 ppm in the two experimental seasons significantly increased Ca percent in the fruits in addition to La, at 5and 20ppm and the mixture at 20 ppm in the first season .Also, La and Nd at 10 ppm showed the highest significant values of calcium in fruits. On the other side, control treatment gave the lowest values in the two tested years .These results are similar to those found by

Wang, (1994) and Pang *et al.,* (2002).Such results for the effect of REEs in increasing N, P, K and Ca contents in fruits may be due to its direct or indirect role in enhancing enzymatic activities and finally plant metabolism as reported by Hu *et al*. (2004).

Table 3: Effect of different concentrations with some rare earth elements treatments on nitrogen, phosphorus, potassium and calcium contents of Superior grapes during 2014 and 2015 seasons.

Treatments (ppm)	Fruit mineral content			
	First season			
	N %	P%	K %	Ca %
Control	0.55 a	0.28 b	0.95 ab	2.8 a
5 lanthanum	0.34 de	0.44 ab	0.55 b	1.6 bcd
10 lanthanum	0.33 bcde	0.26 b	0.53 b	2.4 ab
20 lanthanum	0.35 bcd	33.0 b	0.69 b	1.3 ab
5 cerium	0.34 bcd	0.35 ab	0.57 b	2.4 bcd
10 cerium	0.38 bc	0.57 a	0.63 b	1.8 ab
20 cerium	0.26 de	0.38 ab	0.68 b	2.7 abc
5 neodymium	0.40 b	0.41 ab	0.58 b	1.5 abc
10 neodymium	0.23 d	0.24 b	0.57 b	2.1 ab
20 neodymium	0.29 de	0.38 ab	0.60 b	2.1 abc
5 mixture	0.29 cde	0.48 ab	0.58 b	1.6 bcd
10 mixture	0.27 de	0.30 b	0.54 b	1.7 bcd
20 mixture	0.31 cde	0.36 ab	1.57 a	2.2 ab
	Second season			
Control	0.41 ab	0.36 cd	0.71 bcde	2.3 bcd
5 lanthanum	0.30 c	0.45 b	0.96 e	2.2 fg
10 lanthanum	0.35 bc	0.33 d	0.90 abc	2.9 a
20 lanthanum	0.35 bc	0.31 de	0.93 ab	1.2 g
5 cerium	0.29 c	0.33 d	0.51 e	2.2 bcd
10 cerium	0.30 c	0.52 a	0.86 abcd	2.0 cde
20 cerium	0.36 bc	0.46 ab	0.71 bcde	2.3 bc
5 neodymium	0.45 a	0.41 bc	0.62 de	1.8 def
10 neodymium	0.28 c	0.29 de	0.51 e	2.7 ab
20 neodymium	0.32 c	0.30 de	0.51 cde	2.3 bcd
5 mixture	0.41 ab	0.44 b	0.70 bcde	2.5 a
10 mixture	0.30 c	0.23 e	0.57 e	2.1 a
20 mixture	0.32 c	0.29 de	1.10 a	2.4 bc

Means in each Colum with the same letters are not significantly different at 5% .

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