

Effect of Nano Trace Elements and Nano Chitosan Foliar Application on Productivity and Fruits Quality of Grapevine CV. 'Superior Seedless'

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Abstract: This study was carried out during 2017 and 2018 seasons on 14 years-old Superior seedless grapevines grown in sandy in a private vineyard at Cairo-Alexandria desert road (Km 60), Egypt, to study the effect of foliar applications by Nano trace elements and Nano chitosan either in single or in combination at different fruits setting stages were investigated on the productivity and quality characteristics of grapes. Grapevines were sprayed with 0.5 g/ l Nano trace elements and 2.5 ml/ l Nano chitosan weekly and biweekly either in single or in combination between them at different fruit setting stages. Unsprayed grapevines were kept as control. Grapevines treated biweekly with the mixed Nano trace elements 0.5 g/ l and Nano chitosan 2.5 ml/ l exhibited significantly higher yield per vine (28.36 and 31.59%), cluster weight (23.3 and 28.54%), cluster length and width, berry number per clusters, berry length, berry firmness, berry attachment, total soluble solid (TSS), TSS/acid ratio as compared to other treatments in both seasons 2017 and 2018. In conclusion, multiple foliar applications of 0.5 g/ l Nano trace elements and 2.5 ml/ l Nano chitosan can be used effectively to improve productivity and fruits quality of grapevine cv. 'Superior Seedless'.

Key words: Grape • Superior seedless • Foliar application • Nano traces elements • Nano chitosan • Grapevines productivity and fruit quality

INTRODUCTION

European grapevines (*Vitis vinifera* L.) are one of the earliest fruit crop grown in the world [1]. In Egypt grapevines came in the second rank after citrus. Superior seedless grape is very important grape cultivar grown in Egypt and considered one of the most subtropical fruits.

The foliar fertilization by micro elements during growth and development may be improve the nutrient balance of crops, which, in turn, leads to increase yield and quality, also greater resistance to diseases and insect pests and may be improve drought tolerance [2].

Foliar spray of micronutrients is advantageous over soil application, because of rapid response, effectiveness and elimination of deficiency symptoms due to certain micronutrients. Application of micro nutrients through foliage can be from 10 to 20 times as efficient as a soil application [3, 4].

Many previous studies indicated that foliar application of micro nutrients and bio-stimulants is an important method of foliar feeding and in some cases these applications are more effective than soil application [5].

Improve the productivity and quality of many crops fertilized by spraying leaves with micro elements due to the important role played by these elements in plants, where Mousavi [6] indicated that Iron (Fe) has many essential roles in plant growth and productivity including chlorophyll synthesis and chloroplast development.

Moreover, Bybordi and Shabanov [7] reported that Zinc (Zn) is one of the essential elements for plants. Zn is required for the synthesis of aux ins, chlorophyll, starch and metabolism of carbohydrate. Also, production of clusters with undeveloped shot berries and generally poor fruit set are all characteristics of Zn deficiency.

Manganese (Mn) is involved in photosynthesis and metabolism of nitrogen and carbohydrate as indicated by El-Sheikh *et al.* [4].

Also, El-Sheikh *et al.* [4] indicated that Boron (Br) is responsible for activation of dehydrogenase enzymes, sugar translocation, nucleic acids and plant hormones. In addition to, is helpful in plant growth and productivity, fruit setting and yield in orchards. Also, has effect on cell wall structure cell elongation, root growth and transfer of sugar.

Adwiger [8] reported that the agricultural and horticultural uses of chitosan, primarily for plant defense and yield increase, are based on how this glucosamine polymer influences the biochemistry and molecular biology of the plant cell. Recently, some researchers reported that chitosan enhanced plant development such as Shehata *et al.* [9], Shiri *et al.* [10] and Wafaa *et al.* [11].

The deficiency of the previous elements has visual symptom on root and leaves growth, flower, cluster and berry development in grapevine. Also it may cause reduction in internodes and shoot length, shoot tip death, low fruit set and tiny berries are all common symptoms of boron deficiency. Few studies were focused on the foliar fertilization by Nano trace Elements and Nano Chitosan,

Therefore the aim of this study was improving productivity and quality of Superior Seedless table grape by the foliar application of a new combination of Nano trace elements and Nano chitosan under the conditions of this study.

MATERIALS AND METHODS

This experiment was conducted in two successive seasons 2017 and 2018, on 14 years-old Superior seedless grapevines grown in sandy soil at 2 x 3 m apart (700 vines/fad.) in private vineyard at Cairo-Alexandria desert road (Km 60), Egypt, to study the effect of Nano trace elements and Nano chitosan on productivity and fruit quality of grapevines cv. Superior seedless. All selected vines were irrigated by drip irrigation system and trained according to the cane pruning system on arbors (Baron Type). Winter pruning system was carried out at the end of December in both seasons using cane pruning system leaving 120 buds (10 fruiting canes x 10 buds + 10 renewal spurs x two buds). The experimental vines received similar horticultural practices adopted in the orchard (i.e. irrigation pest and weed control... etc.) except those dealing with the present treatments. In addition, the best 30 clusters on each vine were left and the other small clusters were thinned during the two seasons.

The Tested Treatments: The Superior Seedless grapevines were sprayed with Nano trace Elements (NE) and / or Nano Chitosan (NC) from 1 April until 30 August

at weekly and biweekly intervals (20 or 10 sprays throughout 5 months/ weekly or biweekly, respectively). Each vine was received equal amounts of spray solution. Treatments were applied as follow:

T1: Without spraying control treatment.

T2: Spraying with NE at 0.5 g/ l weekly.

T3: Spraying with NE at 0.5 g/ l biweekly.

T4: Spraying with NC at 2.5 ml / l weekly.

T5: Spraying with NC at 2.5 ml/ l biweekly.

T6: Spraying with NE at 0.5 g/ l + NC at 2.5 ml/ l weekly.

T7: Spraying with NE at 0.5 g/ l + NC at 2.5 ml/ l biweekly.

Nano-Trace Elements and Nano Chitosan Sources: The source of Nano trace elements was a commercial product called "Magrow Nanomix" contains six essential substances for plant nutrition (Fe 6 %, Zn 6 %, Mn 5 %, Cu 1 %, Bo 2 % and Mo 0.1 %). Meanwhile, Nano chitosan was a commercial product "Chitomag" composed glucosamine, 2 – amino-2- deoxy– β - D-glucose obtained from the exoskeletons of crustaceans, all made by the Modern Agricide Company, Egypt.

Measurements: At the commercial harvesting time (first week of June), the clusters on each vine were picked and weighed in each season. The average yield per vine (kg/ vine) was registered. A sample of five clusters per each replicate (vine) were randomly taken for determination of some physical characteristics: average cluster weight (g), cluster length (cm), cluster diameter (cm), weight of 100-berry (g), berry length and berry diameter (cm).

Berry attachment force and berry firmness (g/ cm²) were estimated in twenty berries using a push pull dynamometer (model FD101, Tokyo, Japan; needle diameter = 1 mm). Moreover, the berry juice was extracted from 100 berries representing each replicate for estimate weight (g) and size (ml) of juice and determine some berry chemical constituents, i.e., total soluble solids percentage (TSS) using a hand refractometer, total acidity percentage (as g tartaric acid/ 100 ml juice) and the TSS/ acid ratio of the berry juice [12].

Statistical Analysis: This experiment was set in a completely randomized block design with seven treatments. Each treatment was represented by three replicates, each replicate comprised one vine. The obtained data was subjected to analysis of variances (ANOVA) according to Snedecor and Chochran [13] using SAS program. Differences between means were compared using Duncan's multiple range tests at 5 % level.

RESULTS AND DISCUSSION

Productivity Attributes: Data in Table 1 demonstrate that, the tested foliar spraying treatment with NE and/or NC exhibited significant effect on cluster yield / vine (kg), cluster weight (g) and cluster dimensions (Length and width) of Superior seedless grapevines as compared to the control in both tested seasons.

As for cluster yield / vine, was significantly highest in vines sprayed with (T7) (NE at 0.5 g/l + NC at 2.5 ml/l) biweekly (17.56 and 17.83 Kg), which is greater than the control by 28.36% and 31.59% in both tested seasons, respectively and without significant differences with those treated by (T3) (NE at 0.5 g/l) biweekly, in both seasons.

Regarding the average cluster weight (g), it was significantly highest also in vines treated by (T7) (NE at 0.5 g/l + NC at 2.5 ml/l) biweekly (555.33 and 557.00 g), which exceed the control by 23.13% and 28.54% in both tested seasons, respectively and without significant differences with those treated by (T3, T4 and T5) in the first season only.

Concerning cluster length, it was significantly highest in vines treated by (T4) (NC at 2.5 ml/l) weekly (27.20 and 27.60 cm) in both tested seasons, respectively and without significant differences with those treated by (T3 and T7) in the first season.

With regard to cluster width, most of the tested treatments (T1, T2, T4, T5 and T7) recorded significantly highest cluster width without significant differences among them in both tested seasons. In the second rank those treated by (T3 and T6).

These results go in line with those reported in others crops by Beede *et al.* [14]; Malakouti [15]; Abd El-Aal *et al.* [16] and Akbar *et al.* [17] they indicated that foliar application of micronutrients leads to improve yield and fruit quality. Increasing yield per vine may be due to improvement of photosynthesis in the treated vines.

Moreover, Norrie and Keathley [18] reported that application of seaweed extract as a source of Fe and Mn on 'Thompson Seedless' grape increased the number of clusters per vine and thus total yield per vine. As Fe and Mn could enhance chlorophyll production and photosynthesis processes which led to positive effects on growth parameters. The increase in cluster weight is ascribed to the increased of chlorophyll contents of leaves, which increased photosynthesis and ultimately overall health of vine. Also increasing of cluster weight which sprayed with B and Zn could be attributed to increase berry set, number of berries per cluster and cell

size or cell number resulting hence competition of photosynthetic substance between berries on the cluster as indicated by Ebadi *et al.* [19]. Moreover the NC had positive effect of the total yield per vine and the weight of bunches, this results may be due to that NC could reduce the loss of water of the outer membrane of berries. Shiri *et al.* [10] reported that chitosan coatings help to reduce transpiration and control weight loss and slow down ripening and extend shelf life by controlling respiration rate and ethylene production

Quality Attributes: Data in Table 2 show that spraying Superior Seedless grapevines with NE and/or NC was significantly increased 100 berries weight, juice weight and volume of 100 berries and berry dimensions as compared with the control in both seasons. In this respect, vines sprayed with (T7) (NE at 0.5 g/l + NC at 2.5 ml/l) biweekly, recorded significantly highest values for all tested parameter in both seasons except berry length in the first season.

These results are in harmony with those reported by Rana and Sharma [20]; Hayat *et al.* [21] and Marzouk and Kassem [22]. They explained that increasing berry volume was linked by increasing leaf chlorophyll content which responsible for the high production of photosynthesis and thus increasing berry volume and yield.

Berries Firmness and Attaching: Data in Table 3 clear that spraying Superior Seedless grapevines with NE and/or NC significantly increased berry firmness and attaching force as compared with the control. In this respect, vines sprayed with (T7) (NE at 0.5 g/l + NC at 2.5 ml/l) biweekly, recorded significantly highest berry firmness and attaching force, in both seasons. This may be due to that NE and/or NC affecting activities of prime cell wall degrading enzymes such as xylanase, cellulose, polygalacturonase and promotes cell division and cell enlargement [21].

Chemical Properties (TSS, Acidity, TSS/ Acid Ratio): The obtained results in (Figure 1) revealed that, the tested foliar spraying treatments with NE and/or NC exhibited significant effect on total soluble solids (TSS), acidity and TSS/acid ratio of Superior seedless grapes as compared to the control in both tested seasons. As such, T6 and T7 were recorded significantly highest TSS and TSS/acid ratio and lowest acidity as compared with the control and most of other treatments in both seasons. These results proved that treatments involving both NE and NC are given higher TSS and TSS/acid ratio than those contained only one of them.

Table 1: Response of yield and cluster characteristics of Superior Seedless grapevines to some nano trace elements and nano chitosan sprays treatments (2017 and 2018 seasons)

Treatments (Foliar spray)	2017 seasons						2018 seasons					
	Yield/ vine		Cluster weight		Cluster		Yield/ vine		Cluster weight		Cluster	
	(Kg)	±%	(g)	±%	length (cm)	width (cm)	(Kg)	±%	(g)	±%	length (cm)	width (cm)
T1 Control (water spray)	13.68f	-	451.00c	-	21.92c	15.48abc	13.55d	-	433.33d	-	22.95d	15.85abc
T2 NE at 0.5 g/ L weekly	14.22ef	+3.95	451.67c	+0.15	25.60ab	15.40abc	14.70c	+8.49	438.67d	+1.23	25.80c	15.90abc
T3 NE at 0.5 g/ L biweekly	16.88ab	+23.39	518.33ab	+14.93	25.50ab	15.10bc	17.17ab	+26.71	531.67b	+22.69	27.35ab	15.45bc
T4 NC at 2.5 ml/ L weekly	16.41bc	+19.96	519.67ab	+15.23	27.20a	16.50a	16.75b	+23.62	521.33b	+20.31	27.60a	16.05abc
T5 NC at 2.5 ml/ L biweekly	15.84cd	+15.79	509.00ab	+12.86	24.30b	16.20ab	16.38b	+20.88	508.67b	+17.39	25.20c	16.30ab
T6 NE at 0.5 g/ L + NC at 2.5 ml/ L weekly	14.91de	+8.99	489.67bc	+8.57	25.00b	14.50c	15.50c	+14.39	470.67c	+8.61	26.10bc	15.10c
T7 NE at 0.5 g/ L + NC at 2.5 ml/ L biweekly	17.56a	+28.36	555.33a	+23.13	25.90ab	15.40abc	17.83a	+31.59	557.00a	+28.54	27.30ab	16.90a

±% = increase or decrease % in relation to control, NE: Nano trace elements and NC: Nano chitosan.

- The largest 30 clusters/ vines were left on each vine and the others were removed (thinned) on mid-March.

Table 2: Response of some berry physical characteristics of Superior Seedless grapevines to some nano trace elements and nano chitosan sprays treatments (2017 and 2018 seasons)

Treatments (Foliar spray)	2017 seasons					2018 seasons				
	100- berries		Berry		Berry width (cm)	100- berries		Berry		Berry width (cm)
	weight (g)	Weight (g)	Size (ml)	length (cm)		weight (g)	Weight (g)	Size (ml)	length (cm)	
T1 Control (water spray)	343.33 e	275.57 e	284.50 e	1.91 e	1.71 e	345.00 e	274.24 e	283.50 e	1.87 d	1.71 f
T2 NE at 0.5 g/ L weekly	452.50 b	335.35 c	346.00 c	2.34 a	1.91 a	442.50 bcd	335.25 c	350.50 c	2.28 a	1.89 bc
T3 NE at 0.5 g/ L biweekly	447.50 b	353.44 b	359.50 bc	2.26 b	1.84 b	450.00 b	359.87 b	368.00 b	2.25 ab	1.84 e
T4 NC at 2.5 ml/ L weekly	422.50 c	316.61 d	326.50 d	2.20 c	1.84 b	420.00 d	322.83 d	338.00 d	2.23 ab	1.87 cd
T5 NC at 2.5 ml/ L biweekly	400.00 d	332.93 c	343.50 cd	2.18 c	1.88 ab	422.50 cd	335.27 c	345.00 cd	2.18 bc	1.90 b
T6 NE at 0.5 g/ L + NC at 2.5 ml/ L weekly	440.00 b	354.25 b	365.50 b	2.11 d	1.84 b	445.00 bc	360.19 b	365.00 b	2.14 c	1.85 de
T7 NE at 0.5 g/ L + NC at 2.5 ml/ L biweekly	477.50 a	406.59 a	419.50 a	2.28 b	1.93 a	482.50 a	415.07 a	429.00 a	2.29 a	1.93 a

- NE: Nano trace elements and NC: Nano chitosan.

- The largest 30 clusters/ vines were left on each vine and the others were removed (thinned) on mid-March.

Table 3: Response of berry firmness and attaching force of Superior Seedless grapevines to some nano trace elements and nano chitosan sprays treatments (2017 and 2018 seasons)

Treatments	2017 seasons		2018 seasons	
	Berry firmness (g/ cm ²)	Berry attaching force (g/ cm ²)	Berry firmness (g/ cm ²)	Berry attaching force (g/ cm ²)
T1 Control (water spray)	280.00 d	388.50 c	327.00 d	405.50 c
T2 NE at 0.5 g/ L weekly	311.50 c	455.50 bc	327.00 d	443.50 c
T3 NE at 0.5 g/ L biweekly	364.00 ab	454.50 bc	369.50 b	443.00 c
T4 NC at 2.5 ml/ L weekly	359.00 ab	499.00 b	359.50 bc	503.50 b
T5 NC at 2.5 ml/ L biweekly	325.50 c	440.50 bc	333.50 d	500.00 b
T6 NE at 0.5 g/ L + NC at 2.5 ml/ L weekly	355.00 b	380.00 c	351.50 c	404.50 c
T7 NE at 0.5 g/ L + NC at 2.5 ml/ L biweekly	379.83 a	629.50 a	395.50 a	647.50 a

- NE: Nano trace elements and NC: Nano chitosan

This may be due to using a high rate of NE and NC in both studied seasons. These results are in accordance with those found by Meng *et al.* [23] and Ghasemnezhad *et al.* [24] they found chitosan increase in total soluble solids (TSS) and decreased acidity. Also, Abada [25] reported that foliar application of yeast extract and some micronutrients increased the total sugars percentage of 'Red Roomy' grapevines.

Results are in harmony with those stated by Moustafa *et al.* [26]; Sourour [27] and Malakouti and Rezaei [28] as they reported that grapevines treated with Fe significantly increased TSS, sugars and decreased acidity. As Fe plays a key role in carbohydrate metabolism and improving fruit quality. Moreover, foliar application

of grapevines with Mg and Zn increased TSS. Where, Zn had also an important role in photosynthesis and related enzymes which decreased acidity and increased the sugars. A favorable effect of foliar application of Br may be due to its role in sugar metabolism and accumulation of carbohydrates.

The beneficial effect of NC and NE on enhancing chemical properties of the berries may be interpreted to its role in achieving a good balance between vegetative growth and fruiting through nutrients availability which is reflected its turn on increasing the accumulation of total carbohydrate and stimulation of ripening, the same results were indicated by Abada [25].

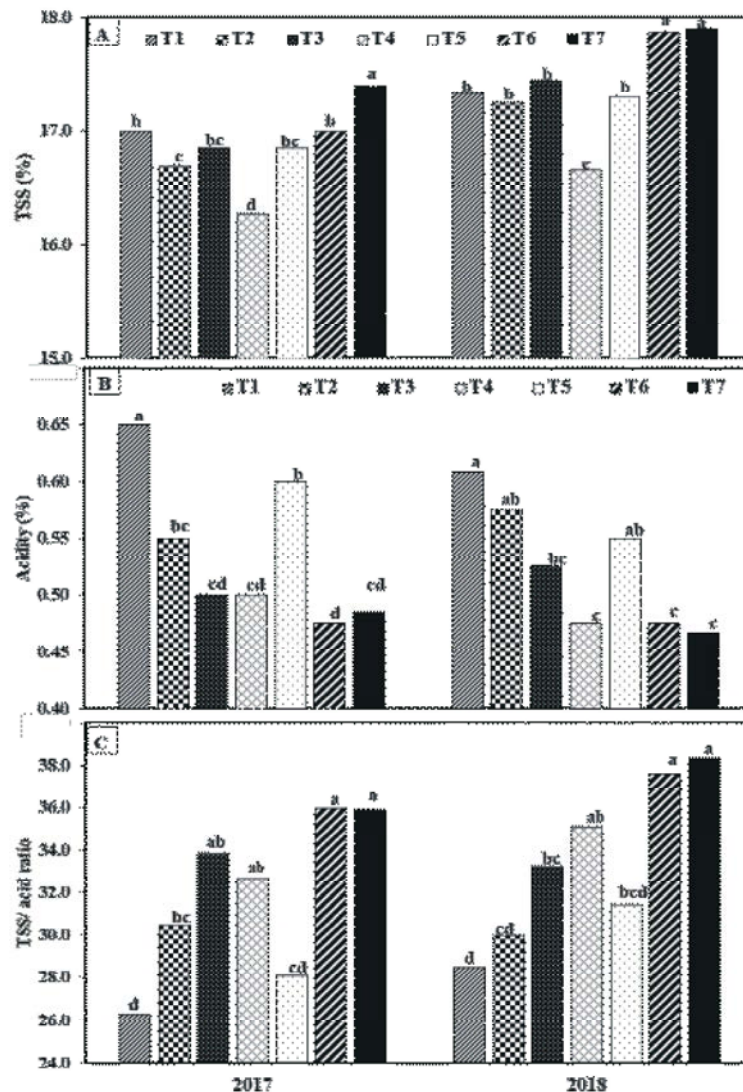


Fig. 1: Effect of NE and NC foliar application on (A) Total Soluble Solids (TSS %), (B) Acidity % and (C) TSS/acid ratio in both seasons 2017 and 2018, values are the average of 3 trees per treatment. a, b, c are statistically different at 0.05 levels

Generally, to get high quality table grapes in domestic and for exportation to external markets, there are some characteristics for the cluster of grapes such as large berries, compactness of cluster, berries firmness and sweetness. Foliar treatments by NE+NC gave positive effects on these parameters and enhanced physical properties of cluster and berries.

CONCLUSION

In conclusion, the application of Nano trace elements at 0.5 g/l and Nano chitosan 2.5 ml/l in combination and biweekly led to increase the yield production and

improvement the physical and chemical qualities of Superior Seedless table grape. It is therefore possible to recommend using the previous concentration for the commercial farms to get high quality table grape fruits for exportation to external markets.

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