



Quality and Yield of Table Grapes cv. "Early Sweet" as Affected by Humic Acid and Nano Calcium Carbonate

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ABSTRACT: This investigation was conducted in a private farm located at Khatatba, Monofaia Governorate, Egypt during two successive seasons (2018 and 2019) to study the effect of humic acid and nano calcium carbonate treatments on quality and yield of "Early sweet" table grapes using factorial randomized complete block design with three replicates for each treatment. Humic acid was added as a soil application at rates of control, 2.5, 5 and 7.5 g/tree, while, nano calcium carbonate (0.5%) applied as a foliar application (control, once; two weeks after fruit setting and twice; two and four weeks after fruit setting).

Results showed that humic acid (at 7.5 g/tree) and nano calcium carbonate foliar application (two times at two and four weeks after fruit setting) recorded the best values of cluster weight, number of clusters/tree, yield/tree, physical characters, i.e. cluster length, cluster width, juice of 100 berry and fruit firmness, and chemical composition, i.e. TSS, TSS/acidity, vitamin C content and carbohydrates percentage as compared with the control treatment which recorded the minimum values of these characters during both seasons.

Keywords: Early sweet table grapes, humic acid, nano calcium carbonate, yield, fruit quality, chemical composition.

INTRODUCTION: Grapes (*Vitis vinifera* L.) rank is the top fruit crop over the world and the second crop after citrus in Egypt. Vineyard has continuously increased especially in the new reclaimed land. Since the total area of grape in Egypt reached about 192934 feddans producing about 1686706 tons according to the Statistics of the Ministry of Agriculture (2017). Grapevines cultivation area in Egypt has progressively developed in recent years. The great of this area is concentrated in the new reclaimed soils where grapes have recently become a key component of Egyptian horticultural exports (Ali *et al.*, 2013).

Early sweet grapevine cultivar is considered a prime and outstanding grapevine cultivar grown under Egypt conditions. It ripens early especially when treated with breakages and easily marketing to most foreign countries. Early sweet grape is a large seedless berry with a creamy white color. The high sugar level gives this grape a sweet flavor with a hint of Muscat and an extremely high juice level (Ali and Mohamed 2016).

Fertilizers are important factors in agriculture since they provide essential nutrients for plant growth and development (Moraru *et al.*, 2003). The beneficial effects of humic substances for enhancing plant growth have been well-known since the 1980s, and they can be supportive to a circular economy (Agrawal and Rathore, 2014; Naderi *et al.*, 2011; Jindo *et al.*, 2020).

Humic acid significantly increased qualitative and quantitative parameters of table grape (Ferrara and Brunetti, 2010). Humic substances enhanced aerial part and root system of papaya seedling (Cavalcante *et al.*, 2011). Also, quantitative and qualitative characteristics of strawberry were improved by foliar application of humic acid at 1.5-3 mg l⁻¹ (Farahi *et al.*, 2013). Humic acid application significantly improved tree size, growth, yield, fruit quality and leaf nutrient contents of Egyptian lime trees (Ennab, 2016).

Nano fertilizers are aimed to make nutrients more available, consequently increasing nutrient use efficiency (Suppan, 2013). Some characteristics of nanoparticles, including the large specific surface area, unique magnetic/optical properties, electronic states, and catalytic reactivity confer nanoparticles a better reactivity than the equivalent bulk materials (Agrawal and Rathore, 2014).

Nano calcium carbonate (0.5 g/l) treatment alleviated the common negative effects on different plant growth parameters of tomato plants hybrid Super strain B irrigated with saline water compared to all other treatments. Also, fruit yield and nutritional status were significantly improved by nano calcium treatments (Tantawy *et al.*, 2014). Zaghoul date palms initial fruit of setting %, fruit retention %, bunch weight, yield/palm and fruit quality parameters were enhanced by three times of Zn, Fe and Mn in

chelated form at 25 to 100 ppm or via nano form at 2.5 to 20 ppm over the control treatment (El-Sayed *et al.*, 2017).

Therefore, the main objective of this study was to investigate the effect of different levels of humic acid and nano calcium carbonate on quality and yield of "Early Sweet" table grapes.

MATERIALS AND METHODS

This investigation was conducted in a private

Table (1): The initial physical and chemical properties of the experimental soil in 2018 season.

Parameter	Value	Unit
Mechanical Analysis		
Sand	85.52	%
Silt	-	%
Clay	14.48	%
Textural class		Loamy sand
pH (1:1)	7.2	-
Ca Co ₃	2.7	%
EC(1:1, water extract)	0.56	dS/m
O.M	5.2	%
Soluble cations		
Ca ²⁺	5.2	meq/l
Mg ²⁺	2.2	meq/l
Na ⁺	13.7	meq/l
K ⁺	0.7	meq/l
Soluble anions		
HCO ₃ ⁻	8.2	meq/l
Cl ⁻	11.2	meq/l
SO ₄ ²⁻	17	meq/l
Available nutrients		
Nitrogen (N)	14	mg/l
Phosphorus (P)	15	mg/kg
Potassium (K)	12.35	mg/kg

Experimental Design

The experiment was arranged in a factorial randomized complete block design on 72 trees as 12 treatments were represented with three replicates and each replicate included two trees.

Humic acid treatments included control, 2.5, 7.5 and 5 g/tree as a soil application. Nano calcium carbonate (foliar application 0.5%) treatments were control, once (two weeks after fruit setting) and twice (two and four weeks after fruit setting).

Data recorded

A) Yield (kg/vine)

At harvesting date when TSS % of berries reached about 16-17 % in control, average yield/vine, (kg) and cluster weight (g).

B) Physical properties

Hundred berries/cluster were used to determine the average of berry length (mm), berry diameter (mm), juice volume of 100 berries (cm³) and berry firmness (lb/inch²) by using a texture analyzer instrument; fruit hardness tester, no 510-as.

farm located at Khatatba, Monofaia Governorate, Egypt on 6-year-old "Early sweet" table grapevines during two successive seasons (2018 and 2019). Physical and chemical properties of the experimental soil are shown in Table (1). The trees were spaced at 2x3 m apart and irrigated by drip irrigation system and received similar cultural practices.

A sample of 5 clusters/vine was taken for determining cluster length (cm), cluster width (cm) and number of berries/cluster.

C) Chemical fruit characteristics

Total soluble solids (TSS %) was measured by using hand refractometer (ATAGrO Co. LTD, Tokya, Japan). Total acidity (%) was determined by direct titrating of 0.1 N sodium hydroxide using phenolphthalein 1% as an indicator and expressed as citric acid percentage according to the **AOAC (1985)**. TSS/acid ratio was calculated by dividing the values of TSS with the corresponding values of titratable acidity. Vitamin C was determined by titration with 2, 6 dichloro phenol-endo-phenol (**AOAC, 1985**) and calculated as mg/100 ml juice. Total carbohydrates (%) were determined according to **Mahadevan and Sridhar (1986)**

Statistical analysis:

Results of the measured parameters were subjected to computerized statistical analysis using MSTAT package for analysis of variance

(ANOVA) and means of treatments were compared using LSD at 0.05 according to **Snedecor and Cochran (1990)**.

RESULTS AND DISCUSSION

A) Yield

Results presented in **Table (2)** revealed the effect of humic acid application on average cluster weight, number of clusters/vine and yield/vine (kg) of table grapes cv. "Early sweet". The results showed that the highest values of cluster weight (455.67 and 510.35 g), number of clusters/vine (36.77 and 40.85) and yield/vine (16.73 and 20.81 kg) were recorded with humic acid at 7.5 g/vine, while control treatment recorded the lowest values of cluster weight (347.70 and 389.42 g), number of clusters/vine

(24.27 and 38.74) and yield/vine (12.11 and 15.07 kg) during both seasons.

Results in the same table indicated that foliar application of nano calcium carbonate twice (two and four weeks after fruit setting) recorded the highest mean values of cluster weight (447.53 and 501.24g), number of clusters/vine (34.79 and 38.65), and yield/vine (15.60 and 19.41kg), while control treatment recorded the lowest values of cluster weight (362.50 and 406.00g), number of clusters/vine (36.15 and 40.16) and yield/vine (13.14 and 16.35 kg) during both seasons.

The interaction between humic acid and nano calcium carbonate was significant on cluster weight, yield/vine and number of clusters/vine in most cases.

Table (2): Effect of humic acid and nano calcium carbonate on cluster weight, number of clusters/vine and yield/vine of "Early sweet" table grapes during 2018 and 2019 seasons.

Treatments	Cluster weight (g)		No. of clusters/ vine		Yield/vine (kg)		
	2018	2019	2018	2019	2018	2019	
A) Humic acid (HA)							
Control	347.70d	389.42d	34.27d	38.74c	12.11d	15.07d	
2.5 g	395.82c	443.32c	34.86c	38.08d	13.55c	16.86c	
5 g	417.9b	468.05b	36.08b	40.09b	15.05b	18.73b	
7.5 g	455.67a	510.35a	36.77a	40.85a	16.73a	20.81a	
LSD_(0.05)	3.85	4.31	0.32	0.36	0.02	0.03	
B) Nano CaCO₃							
Control	362.50c	406.00c	34.79c	38.65c	13.14c	16.35c	
Once	402.78b	451.12b	35.56b	39.51b	14.35b	17.85b	
Twice	447.53a	501.24a	36.15a	40.16a	15.60a	19.41a	
LSD_(0.05)	3.33	3.73	0.28	0.31	0.02	0.02	
Interaction (AXB)							
HA	**	**	ns	ns	**	**	
Nano CaCO₃							
Control	Control	311.77	349.18	35.11	39.02	10.95	13.62
Control	Once	346.41	387.98	35.12	39.02	12.16	15.14
	Twice	384.90	431.09	34.36	38.17	13.23	16.46
	Control	354.92	397.51	35.03	38.92	12.43	15.47
2.5 g	Once	394.36	441.68	34.27	38.08	13.52	16.82
	Twice	438.18	490.76	33.53	37.25	14.69	18.28
	Control	374.72	419.69	36.87	40.96	13.81	17.19
5 g	Once	416.36	466.32	36.07	40.08	15.02	18.69
	Twice	462.62	518.14	35.29	39.21	16.33	20.32
	Control	408.59	457.62	37.58	41.75	15.35	19.10
7.5 g	Once	453.99	508.47	36.77	40.85	16.69	20.76
	Twice	504.43	564.97	35.97	39.96	18.14	22.57
	LSD_(0.05)	3.85	4.31	0.32	0.36	0.02	0.03

B) Physical characteristics:

It is evident from the obtained results in Table (3) that, increasing humic acid concentrations increased cluster length, cluster width, number of berries/cluster, juice volume/100 berries and fruit firmness of "Early sweet" table grapes. The results revealed that humic acid application up to

7.5 g/vine recorded the highest mean values of cluster length (25.27 and 28.30 cm), cluster width (18.63 and 20.86 cm), number of berries/cluster (112.60 and 126.11), juice volume/100 berries (144.92 and 162.31 cm³), and fruit firmness (13.77 and 15.42 Lb/inch²) as compared with

control treatments which recorded the lowest values in this respect during both seasons.

In addition, foliar application of nano calcium carbonate twice (two and four weeks after fruit setting) recorded the highest mean values of cluster length (23.56 and 26.38 cm), cluster width (17.37 and 19.45 cm), number of berries/cluster (104.98 and 117.57), juice volume/100 berries (135.11 and 151.33 cm³) and fruit firmness (12.87 and 14.41 Lb/inch²) as compared with

control treatment which recorded the lowest significant values during 2018 and 2019 seasons.

The interaction between humic acid and nano calcium carbonate gave the highest values of cluster length, cluster width, number of berries/cluster, juice volume/100 berries and fruit firmness by humic acid at 7.5 g with foliar application of nano calcium carbonate (twice) during both seasons

Table (3): Effect of humic acid and nano calcium carbonate on cluster length, width and no. of berries/cluster of "Early sweet" table grapes during 2018 and 2019 seasons.

Treatments	Cluster length (cm)		Cluster width (cm)		No. of berries/cluster		Juice volume/100 berries (cm ³)		Fruit firmness (Lb/inch ²)		
	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	
A) Humic acid (HA)											
Control	18.42d	20.63d	13.52d	15.14d	82.08d	91.93d	105.65d	118.32d	10.20d	11.43d	
2.5 g	20.46c	22.92c	15.08c	16.89c	91.20c	102.15c	117.38c	131.47c	11.18c	12.52c	
5 g	22.74b	25.47b	16.76b	18.78b	101.33b	113.49b	130.42b	146.07b	12.42b	13.91b	
7.5 g	25.27a	28.30a	18.63a	20.86a	112.60a	126.11a	144.92a	162.31a	13.77a	15.42a	
LSD_(0.05)	0.07	0.07	0.07	0.08	0.11	0.13	0.38	0.43	0.04	0.4	
B) Nano CaCO₃											
Control	19.94c	22.33c	14.65c	16.41c	88.85c	99.52c	114.36c	128.08c	10.99c	12.31c	
Once	21.67b	24.27b	15.98b	17.89b	96.58b	108.17b	124.30b	139.22b	11.83b	13.24b	
Twice	23.56a	26.38a	17.37a	19.45a	104.98a	117.57a	135.11a	151.33a	12.87a	14.41a	
LSD_(0.05)	0.06	0.06	0.06	0.07	0.10	0.11	0.33	0.37	0.03	0.04	
Interaction (AXB)											
HA	Nano CaCO₃	**	**	**	**	**	**	**	**	**	
Control	Control	16.91	18.93	12.28	13.75	75.34	84.38	96.97	108.61	9.66	10.82
	Once	18.38	20.58	13.55	15.17	81.89	91.72	105.40	118.05	10.04	11.24
	Twice	19.97	22.37	14.72	16.49	89.01	99.69	114.57	128.31	10.91	12.22
2.5 g	Control	18.78	21.03	13.84	15.51	83.71	93.76	107.74	120.67	10.26	11.49
	Once	20.41	22.86	15.05	16.85	90.99	101.91	117.11	131.17	11.15	12.49
	Twice	22.19	24.86	16.36	18.32	98.90	110.77	127.30	142.57	12.12	13.58
5 g	Control	20.87	23.37	15.39	17.32	93.01	104.17	119.71	134.07	11.40	12.77
	Once	22.69	25.41	16.72	18.73	101.10	113.23	130.12	145.74	12.39	13.88
	Twice	24.66	27.62	18.18	20.36	109.89	123.07	141.44	158.41	13.47	15.08
7.5 g	Control	23.19	25.97	17.10	19.15	103.35	115.75	133.02	148.98	12.62	14.14
	Once	25.21	28.24	18.59	20.82	112.33	125.81	144.58	161.94	13.72	15.37
	Twice	27.40	30.69	20.20	22.62	122.10	136.76	157.16	176.02	14.97	16.76
LSD_(0.05)	0.07	0.07	0.07	0.08	0.11	0.13	0.38	0.43	0.04	0.4	

These results are in agreement with those of Concheri *et al.*, 1994; Nardi *et al.*, 1996; Chen *et al.*, 2004; Ferrara and Brunetti, 2008 who demonstrated that increases in total yield were probably related to the effect of humic acid fertilization as it helped in stimulating plant growth and consequently yield by acting on mechanisms involved in: cell respiration, photosynthesis, protein synthesis, water and nutrients uptake, increase of microbial population, and enzyme activities. Also, foliar application of humic acid causes a considerable increase in berry size, weight and width and thus,

increased cluster weight compared with the control treatment. This probably ascribes to the functions of humic acid, which have the same effects of some kinds of hormones such as auxin, gibberellin and cytokinin which their activities affect the volume and weight of berries.

C) Chemical fruit characteristics:

Results in Tables (4 and 5) indicated that humic acid had a positive effect on TSS, acidity percentage, TSS/acidity, vitamin C content and carbohydrates percentage as compared to control treatment during both seasons. However, humic acid up to 7.5 g/vine recorded the highest mean values of TSS (16.54

and 18.53 %), TSS/acidity (35.67 and 38.05), vitamin C (50.54 and 56.61 mg/100ml juice) and carbohydrates (29.51 and 33.05%) as compared with control treatments which recorded the

highest acidity (0.64 and 0.67 %) but gave the lowest mean values of TSS, TSS/acidity, vitamin C content and carbohydrates percentage during both seasons.

Table (4): Effect of humic acid and nano calcium carbonate on TSS, acidity and TSS/acidity of "Early sweet" table grapes during 2018 and 2019 seasons.

Treatments		TSS (%)		Acidity (%)		TSS/Acidity	
		2018	2019	2018	2019	2018	2019
A) Humic acid (HA)							
	Control	14.14d	15.84d	0.64a	0.67a	22.25d	23.73d
	2.5 g	15.24c	17.07c	0.58b	0.61b	26.64c	28.42c
	5 g	15.69b	17.57b	0.52c	0.55c	30.46b	32.49b
	7.5 g	16.54a	18.53a	0.47d	0.49d	35.67a	38.05a
LSD_(0.05)		0.17	0.19	0.001	0.001	0.31	0.34
B) Nano CaCO₃							
	Control	14.62c	16.38c	0.60a	0.63a	24.98c	26.64c
	Once	15.39b	17.23b	0.55b	0.58b	28.57b	30.48b
	Twice	16.20a	18.15a	0.51c	0.53c	32.72a	34.90a
LSD_(0.05)		0.15	0.17	0.001	0.001	0.27	0.29
Interaction (AXB)		ns	ns	**	**	**	**
HA	Nano CaCO₃						
Control	Control	13.43	15.05	0.70	0.73	19.33	20.62
	Once	14.12	15.81	0.64	0.67	22.10	23.57
	Twice	14.88	16.67	0.59	0.62	25.32	27.00
2.5 g	Control	14.47	16.20	0.63	0.66	23.14	24.68
	Once	15.23	17.06	0.58	0.60	26.47	28.24
	Twice	16.03	17.96	0.53	0.56	30.31	32.33
5 g	Control	14.89	16.68	0.56	0.59	26.45	28.22
	Once	15.67	17.55	0.52	0.54	30.28	32.30
	Twice	16.50	18.48	0.48	0.50	36.65	36.96
7.5 g	Control	15.70	17.58	0.51	0.53	30.99	33.05
	Once	16.53	18.51	0.47	0.49	35.44	37.80
	Twice	17.40	19.49	0.43	0.45	40.59	43.30
LSD_(0.05)		0.17	0.19	0.001	0.001	0.31	0.34

Table (5): Effect of humic acid and nano calcium carbonate on vitamin C (mg/100 ml juice) and carbohydrates (%) of "Early sweet" table grapes during 2018 and 2019 seasons.

Treatments	Vitamin C (mg/100 ml juice)		Carbohydrates (%)		
	2018	2019	2018	2019	
A) Humic acid (HA)					
Control	36.84d	41.26d	21.21d	23.76d	
2.5 g	40.94c	45.85c	23.91c	26.77c	
5 g	45.49b	50.94b	26.34b	29.50b	
7.5 g	50.54a	56.61a	29.51a	33.05a	
LSD_(0.05)	0.21	0.23	0.32	0.35	
B) Nano CaCO₃					
Control	39.88c	44.67c	22.83c	25.57c	
Once	43.35b	48.55b	25.37b	28.41b	
Twice	47.12a	52.78a	27.54a	30.84a	
LSD_(0.05)	0.18	0.20	0.27	0.31	
Interaction (AXB)					
HA					
	Nano CaCO₃				
	Control	33.81	37.87	19.02	21.31
Control	Once	36.76	41.17	21.13	23.67
	Twice	39.95	44.75	23.49	26.30
	Control	37.57	42.08	21.16	28.89
2.5 g	Once	40.84	45.75	24.01	29.23
	Twice	44.40	49.72	26.10	24.20
	Control	41.75	46.76	24.01	26.89
5 g	Once	45.38	50.82	26.68	29.87
	Twice	49.33	55.25	28.33	31.73
	Control	46.39	51.96	26.68	29.88
7.5 g	Once	50.43	56.48	29.64	33.20
	Twice	54.81	61.39	32.22	36.08
LSD_(0.05)		0.21	0.23	0.32	0.35

On the other side, foliar application of nano calcium carbonate twice (two and four weeks after fruit setting) recorded the highest mean values of TSS (16.20 and 18.15 %), TSS/acidity (32.72 and 34.90), vitamin C (47.12 and 52.78 mg/100ml juice) and carbohydrates (27.54 and 30.84 %) as compared to control treatment which recorded the highest acidity percentage (0.60 and 0.63 %), but it recorded the lowest mean values of TSS, TSS/acidity, vitamin C content and carbohydrates percentage during both seasons.

The interaction between humic acid and nano calcium carbonate was highly significant on acidity percentage, TSS/acidity, vitamin C content and carbohydrates percentage, while not significant on TSS percentage during both seasons.

These results are confirmed by the findings of Liu *et al.* (2005) who found higher soluble sugars and proteins of the aerial parts of the plants treated with calcium. As was observed in this study, Liu *et al.*, (2005) observed an improvement in the absorption of nutritional elements in the contents in the shoots. The improvements in the contents of soluble sugars, proteins and nutritional elements may explain the high contents of the total soluble solids recorded in the tomato fruits (Tantawy *et al.*, 2014). Also, EL Ghayaty *et al.* (2019) showed that humic acid treatment improved total soluble solids, total soluble solids/total acidity of grapevine varieties.

CONCLUSION:

It could be concluded that humic acid as a soil application at 7.5 g/tree and nano calcium carbonate as a foliar application two times (two and four weeks after fruit setting) maybe improve fruit quality and yield of "Early sweet" table grapes under study conditions.

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الملخص العربي

جودة ومحصول عنب المائدة صنف "إيرلي سويت" المتأثرين بحامض الهيوميك

ونانو كربونات الكالسيوم

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أجريت هذه الدراسة في مزرعة خاصة في الخطاطبة، محافظة المنوفية، مصر خلال الموسمين المتتاليين ٢٠١٨، ٢٠١٩ لدراسة تأثير معاملات حامض الهيوميك ونانو كربونات الكالسيوم على محصول وجودة عنب المائدة صنف "إيرلي سويت" في تصميم عاملي قطاعات كاملة العشوائية بثلاث مكررات لكل معاملة. تمت إضافة حامض الهيوميك إلى التربة بمعدل كنترول، ٢.٥، ٥، ٧.٥ جم/شجرة ومعاملة الأشجار بنانو كربونات الكالسيوم (٠.٥%) رش ورقي (كنترول، رش مرة واحدة بعد أسبوعين من العقد، رش مرتين بعد أسبوعين وأربع أسابيع من العقد).

أوضحت النتائج أن إضافة حمض الهيوميك (بمعدل ٧.٥ جم/شجرة) والرش بالنانو كربونات الكالسيوم (مرتين بعد أسبوعين وأربع أسابيع من العقد) أعطت أعلى القيم لكل من وزن العنقود، عدد العناقيد/شجرة، المحصول/شجرة، والصفات الطبيعية مثل طول العنقود، عرض العنقود، حجم عصير ١٠٠ حبة والصلابة، والمكونات الكيميائية مثل % للمواد الصلبة الذائبة الكلية، المواد الصلبة الذائبة الكلية/الحموضة، فيتامين سي، % للكربوهيدرات مقارنة بمعاملة الكنترول التي سجلت أقل القيم لهذه الصفات خلال كلا الموسمين.