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Growth and Productivity of Superior Grapevine in Relation to Spraying Seaweed Extract and Chitosan

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Abstract: The present investigation was conducted during two successive seasons 2018 and 2019 on own rooted 17 years old 'Superior Seedless' grapevine grown at Matay district El-Minia Governorate. This study aimed to investigate the response of growth and fruiting of Superior Seedless grapevine *cv.* to spraying seaweed extract or/and chitosan. It is clear from the obtained results that, using both examined materials (seaweed extract and chitosan) in combination was more effective than using each one alone. Non-significant differences between the two highest concentrations of both examined compounds (seaweed or/and chitosan) were observed, during the two experimental seasons. It is may be practical recommended to spray 'Superior Seedless' grapevines grown in clay soil conditions with seaweed extract at 0.2% + chitosan at 0.1% three times yearly in order to improve vegetative growth parameters, vines mineral status and productivity of 'Superiors Seedless' grapevines.

Key words: Superior grapevines, seaweed extract, chitosan, vegetative growth, nutrient status and yield

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INTRODUCTION

Botanical classification puts grapevines (*Vitis vinifera L.*) in Family *Vitaceae*, Genus Vitis, subgenera Euvitis and Muscadinia. Grapes (*Vitis vinifera L.*) consider as one of the major horticulture crops throughout the world. Grapevines are fairly adaptable fruit trees, growing in a wide range of soil types, from sand to heavy packed clay, and flourishing around the globe in the temperate and hot zones between 20°C and 50°C Latitude, north or south of the Equator (**Winkler *et al.*, 1974 and Reynier, 2000**). Superior Seedless grapevine is one of the most popular table grape cultivar successfully grown under Egyptian conditions. Under El-Minia region conditions Egypt it faces some problems such as poor yield and high percentage of shot berries on the clusters, which in turn negatively affect marketing of such grapevine *cv.* Many trials were

made for finding out the nontraditional methods for overcoming these problems and at the same time protecting the environment from pollution.

Seaweeds or seaweed extract are excellent source of highly bioactive secondary metabolites that could represent useful leads in the development of new functional ingredients. Many previous reports have been published regarding isolated compounds from seaweeds with various biological activities, demonstrating their ability to produce important metabolites unlike those found in terrestrial species (**Fan *et al.*, 1993; Laurence, 2006 and Zamani *et al.*, 2013**). However, Seaweed extracts are often classified as plant bio-stimulants (**Khan *et al.*, 2009 and Khan *et al.*, 2012**). Furthermore, it generally thought to contain trace amounts of macro- and micronutrient elements, amino acids, vitamins, cytokinins, auxins, abscisic acid-like compounds (**Reitz & Trumble, 1996; Stirk *et al.*, 2004 and Uwakiem, 2011**).

Chitosan had received much attention in fundamental science and industrial biotechnology due to their remarkable macromolecular structure, physical and chemical properties. Chitosan is a semi-synthetic commercial amino-polysaccharide, and so because of its particular macromolecular structure, biocompatibility, biodegradability and other intrinsic functional properties, chitosan has attracted major scientific and industrial interests for decades until now (**Kim & Thomas 2006; Sashiwa & Harding 2015; Dima *et al.*, 2017; Philibert *et al.*, 2017 and Ruano-Rosa *et al.*, 2022)**.

Chitosan derived by deacetylation of the naturally occurring biopolymer chitin. Chitin is the most abundant of the renewable polysaccharides in the marine environment and one of the most abundant on earth after cellulose (**Rinaudo 2006; Nechita, 2017; Philibert *et al.*, 2017;** and **Singh *et al.*, 2022**).

The present investigation aimed to study the effect of seaweed and chitosan, each one individually or both in combination, nutritional statues and productivity as well as fruit quality of superior grapevines grown under El-Minia Governorate conditions.

MATERIALS AND METHODS

The present investigation was conducted during two successive seasons 2018 and 2019 on thirty Superior vines uniform in vigor own rooted 17 years old grown in private vineyard located at Abwan village, Matay district El-Minia Governorate, where the soil texture is clay and water table depth is not less than two meters. Vines load was Leaving 84 eyes per vine (on the basis of six fruiting canes X 12 eyes plus six renewal spurs X two eyes), using the assistance of gable supporting system.

Soil analysis

The soil texture, where the present study carried out in Abwan village, Matay distract El-Minia Governorate, was shown in table (2). A composite sample was collected and subjected to physicochemical analysis according to the procedures outlined by **Wilde *et al.* (1985**) and **Buurman *et al.*** (**1996**).

Experimental work

In order to declare the effect and the suitable doses of seaweed extract and chitosan on 'Superior' grapevine, four doses of each material were examined, as well as the combined application of the two materials (seaweed and chitosan) were achieved, during this present experiment. Three frequencies of application were achieved for each treatment (starting of vegetative growth, and one moth intervals). Then, this study included ten treatments, as follow the ten treatments were arranged:

Control (vines sprayed with water), Spraying seaweed extract at 0.1%, Spraying seaweed extract at 0.2%, Spraying seaweed extract at 0.4%, Spraying chitosan at 0.05%, Spraying chitosan at 0.1%, Spraying chitosan at 0.2%, Spraying seaweed extract at 0.1% + chitosan at 0.05%, Spraying seaweed extract at 0.2% + chitosan at 0.1% and Spraying seaweed extract at 0.4% + chitosan at 0.2%. Each

treatment was replicated three times, one vine per each. Triton B compound "as a wetting agent" was added to all solutions.

Table (1). Physicochemical analysis of vineyard soils

Constituents	Values
Sand %	6.4
Silt %	15.8
Clay %	77.8
Texture	Clay
EC (1 : 2.5 extract) mmhos / cm / 25 C	0.99
Organic matter %	1. 2
pH (1 : 2.5 extract)	7.4
Total CaCO3 %	1.75
N %	0.09
Available P (Olsen, ppm)	7.12
Exch. K^+ (mg/100g)	415.1
Exch. Ca $^{++}$ (mg/100g)	19.9

Experimental design and statistical analysis

The treatments were arranged in a complete randomized block design (RCBD) and each treatment was replicated tree times, one vine per each. The obtained data were tabulated and subjected for statistical analysis by MSTATC Program. Comparisons between means were made by least significant differences (New L.S.D) at p= 0.05 (**Snedecore and Cochran 1990**).

Different measurements and determinations

The following parameters; vegetative growth, leaves pigments, leaves mineral content, yield and physicochemical characters of berries and physical properties of clusters were achieved during the two experimental seasons.

RESULTS AND DISCUSSION

1. Effect of seaweed extract and chitosan on on vegetative growth

Data in table (2) shows the effect of spraying seaweed extract and chitosan at different concentration on vegetative growth parameters of 'Superior' grapevine (in terms of shoot lengths, numbers of leaves/shoot, leaf area, wood ripening coefficient, pruning wood and can thickness), during the present trail (2018 and 2019 seasons).

1.1. Effect of seaweed and chitosan on shoot lengths, number of leaves/shoot and leaf area: Data obtained during the two experimental seasons as illustrated in Table (2) displayed that, regardless the concentration of seaweed, chitosan and their combinations, all sprayed trees present a significant higher values rather than those untreated (control). It is clear from this table that increasing the seaweed or chitosan concentration gradually was associated with significant increments. However, non-significant differences were observed between the two highest concentrations of seaweed and chitosan also. Regardless the concentration used, chitosan treatment shows a superiority effect rather than those of seaweed extract on Superior grapevine shoot length, number of leaves per shoot and leaf area (cm^2), this finding were true during the two seasons (2018 and 2019). In the other hand, the combined application

of seaweed extract and chitosan showed more effective in these three vegetative growth parameters rather than used each compound individually. The obtained data showed also that, the vines received seaweed at 0.4 % and chitosan at 0.2% present the highest shoot length, number of leaves per shoot and leaf area. While, untreated vines present the lowest shoot length, number of leaves per shoot and leaf area, during the two experimental seasons respectively.

Table (2). Response of shoot length, number of leaves, leaf area and wood ripening coefficient of 'Superior Seedless' grapevines to spraying seaweed and chitosan at different concentration, during 2018 and 2019 seasons

Treatments	Shoot length (cm)		No. of leaves per shoot		Leaf area (cm^2)		Wood ripening Coefficient	
	2018	2019	2018	2019	2018	2019	2018	2019
Control	90.4	91.5	10.0	15.5	90.5	90.7	0.65	0.64
Seaweed 0.1%	92.0	93.1	17.0	16.8	92.3	92.2	0.69	0.68
Seaweed 0.2%	93.5	94.6	18.0	18.1	93.8	93.9	0.75	0.73
Seaweed 0.4%	94.4	95.7	18.5	18.9	94.7	95.0	0.76	0.75
Chitosan 0.05%	95.9	97.1	20.0	20.2	96.1	96.5	0.81	0.80
Chitosan 0.1%	97.3	98.6	22.0	22.1	97.8	98.1	0.86	0.86
Chitosan 0.2%	98.7	99.8	22.7	23.0	98.8	99.3	0.89	0.89
Seaweed 0.1% + Chitosan 0.05%	99.7	101.5	25.0	25.2	100.2	100.9	0.92	0.93
Seaweed 0.2% + Chitosan 0.1%	102.3	103.2	26.2	26.6	101.8	102.6	0.94	0.95
Seaweed 0.4% + Chitosan 0.2%	102.1	104.4	27.0	27.5	102.7	102.9	0.98	0.99
New LSD at 5%	1.3	1.4	1.0	15.5	1.4	1.5	0.04	0.04

1.2. Effect of seaweed extract and chitosan on wood ripening, pruning wood and can thickness

It is clear from the data illustrated in Tables (2 & 3) that spraying seaweed weed extract and chitosan, individually or in combination, at different concentration has a significant effect on wood ripening coefficient, weight of one year pruning wood (kg) and can thickness (cm) of 'Superior Seedless' grapevines. These data were true during the two experimental seasons (2018 and 2019). In this concern, whatever the concentration used, spraying chitosan shows more effective in these three vegetative characters rather than spraying seaweed extract.

The response of ripening wood coefficient, one year pruning wood (kg) and can thickness (cm) of 'Superior Seedless' grapevines to increasing the concentration used from each compound individually or their combinations was gradual and significant in both experimental seasons (2018 and 2019). I this concern, non-significant differences were observed between the two highest concentrations (0.2% % 0.4% for seaweed and 0.1% & 0.2% for chitosan). It is clear from the same table that treated 'Superior Seedless' vines with the highest concentrations of the two examined materials (seaweed 0.4% and chitosan 0.2%) in combination present the highest ripening wood coefficient (0.98 % & 0.99 %), one year pruning wood weight (2.73 g & 2.74 kg) and highest can thickness (1.52 cm & 1.52 cm) during the two seasons respectively. On the opposite side, untreated 'Superior Seedless' vines present the lowest wood ripening coefficient (0.65 % & 0.64 %), weight of one year pruning wood (1.95 g & 1.99 kg) and can thickness (cm & cm), these data were true during both experimental seasons respectively.

It is well known that, in addition to containing many nutrient elements, seaweed extracts contain several growth promoter substances such as auxins, cytokinins, betaines and gibberellins. Furthermore, seaweed is also rich in organic substances, such as amino acids that promote plant growth (**Khan *et al.*, 2009; Craigie, 2011; Arioli *et al*., 2015; Battacharyya *et al.*, 2015**). This distinctive structure of seaweed extract advantage in exhibit growth and activity stimulating the vegetative growth parameters of fruit trees. Furthermore, the use of seaweed as bio-stimulants in fruit trees growth is well established (**Zhang** and **Chapman, 1993**). Seaweed extract is reach with macro- and microelement nutrients, amino acids, vitamins, cytokinins, auxins, and abscisic acid (ABA)-like growth substances affect cellular metabolism in treated plants leading to enhanced fruit trees growth when applied in small quantities and bioactive at low concentrations (**Gandhiyappan & Perumal, 2001 and Ali & Mohamed, 2016**). So, we can attribute the superiority of seaweed spraying treatments in increasing the growth (main shoot length, leaf area and number of leaves/shoot) of 'Superior' grapevine to seaweed extract contains of plant growth regulators and many essential major and minor nutrients, which will positively affect the growth. The results concerning the simulative effect of seaweed extract on vegetative growth are agreement with those obtained by: **Durand *et al.*, (2004); Abd El-Moniem & Abd-Allah (2008); Colavita *et al.*, (2010); Ganapathy & Sivakumar (2014); Ali & Mohamed (2016) and Abe El-Hakem (2019)**.

The distinguished effect of chitosan on vegetative growth parameters of fruit trees may be attributed to an increase in the key enzymes activation of nitrogen metabolism (nitrate reductase, glutamine synthetase and protease) as well as enhancing the photosynthesis which increase the vegetative growth of these trees (**Gornik *et al.*, 2008** and **Ibrahiem & Mohsen, 2015**). In addition, chitosan enhances synthesize of some plant growth hormones such as gibberellins and some signaling pathways of auxin biosynthesis via a tryptophan independent pathway (**Ferguson and Oneill (2011**). Also, may be attributed to an increase in the availability and absorption of water and essential elements through adjusting cell osmotic pressure, and reducing the accumulation of harmful free radicals by increasing antioxidants and enzyme activities (**Jail *et al.* (2014) and Ibraheim & Mohsein, 2015**).

Tale (3). Response of pruning wood (kg), can thickness (cm) and chlorophylls a & b contents (mg/100g F.W.) of 'Superior Seedless' grapevines to spraying seaweed and chitosan at different concentration, during 2018 and 2019 seasons

Treatments	Pruning wood (kg)		Can thickness (cm)		Chlorophyll a (mg/100g FW)		Chlorophyll b (mg/100g FW)		Total Chlorophylls (mg/100g FW)	
	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
Control	1.95	1.99	0.95	1.00	1.12	1.15	0.95	1.00	2.07	2.15
Seaweed 0.1%	2.05	2.10	1.08	1.08	1.20	1.20	0.99	1.05	2.19	2.31
Seaweed 0.2%	2.16	2.21	1.16	1.17	1.28	1.35	1.06	1.08	2.34	2.43
Seaweed 0.4%	2.20	2.26	1.20	1.20	1.30	1.37	1.08	1.09	2.38	2.46
Chitosan 0.05%	2.31	2.33	1.23	1.27	1.42	1.50	1.14	1.16	2.56	2.66
Chitosan 0.1%	2.41	2.44	1.31	1.33	1.50	1.60	1.18	1.21	2.68	2.81
Chitosan 0.2%	2.46	2.50	1.34	1.36	1.54	1.62	1.20	1.23	2.74	2.85
Seaweed 0.1% + Chitosan 0.05%	2.55	2.59	1.41	1.41	1.70	1.76	1.27	1.29	2.97	3.05
Seaweed 0.2% + Chitosan 0.1%	2.69	2.71	1.48	1.49	1.83	1.87	1.31	1.35	3.14	3.22
Seaweed 0.4% + Chitosan 0.2%	2.73	2.74	1.52	1.52	1.86	1.89	1.32	1.37	3.18	3.26
New LSD at 5%	0.06	0.07	0.05	0.04	0.05	0.03	0.03	0.04	0.07	0.05

2. Effect of seaweed extract and chitosan on leaves pigments

Concerning the effect of spraying seaweed extract or/and chitosan at different concentrations on leaves chlorophyll a, chlorophyll b, and total chlorophylls (mg/100g F.W.) during the two experimental seasons are illustrated in Table (3). The data shows that all seaweed extract and chitosan treatments caused a significant increase in chlorophyll contents (a, b and total chlorophylls) in 'Superior Seedless' grapevines leaves compared to untreated vines, these findings were true during both experimental seasons. This increment was gradual and parallel with increasing the concentration used of seaweed extract and chitosan either individually or in combination. Whereas, increasing the concentration of seaweed extract from 0.2% to 0.4% or/and chitosan from 0.1% to 0.2% was not capable to cause a significant increment of leaf chlorophyll contents significantly, during the experimental seasons. It is clear from the same Table that the vines treated with chitosan present superiority in chlorophylls contents rather than those treated with seaweed extract. Foliar application of both examined materials (seaweed extract and chitosan) in combination showed more effective of leaves chlorophyll contents rather than using each material alone. Whereas, the vines received seaweed extract at 0.4% and chitosan at 0.2% produced the highest concentrations of chlorophylls pigments in their leaves, during the two experimental seasons. On the opposite side, untreated vines produced the lowest concentrations of chlorophylls pigments in their leaves. These findings were true during both experimental seasons.

The positive effects of seaweed extract on chlorophylls (a, b and total chlorophyll), which observed during the present investigation may be due to their high level of hormones, antioxidant and nutrient elements (gibberellins and cytokinins, vitamins, NPK and micro elements "especially Mn and Fe"). The obtained results in term of effect of seaweed on enhancing leaves chlorophylls content are in harmony with those obtained by **Benjama & Masniyom (2012); Rombola *et al.* (2001) Durand *et al.* (2004); Norrie & Keathley (2006); Abdel-Mawgoud *et al.* (2010); Arun *et al.* (2014) and Ali & Mohamed (2016)**.

The role of chitosan in improving leaves chlorophyll contents has been proven recently by many authors such as (**Khan *et al.,* 2009** and **Crimi & Lichtfause, 2019**). They confirmed that Chitosan has been classified as an important regulator of plant photosynthesis, and metabolic aspects. **Petriccione *et al.,* 2015** mentioned that in Bananas plants (identifier a highly perishable fruit and deteriorate faster than other fruits) that, chitosan can be used to delay fruit ripening and retain fruits green colour (by enhancing chlorophyll pigments), then it can increase fruit shelf-life. Additionally, chitosan treatments can also improve the antioxidant activity and increasing vitamin C content in fruits (**Anraku *et al.,* 2018; Rahman *et al.,* 2018; Suseno *et al.,* 2014**; **and Chen *et al.,* 2003**).

3. Effect of seaweed extract and chitosan on leaves macro and micro nutrients

3.1. Effect of seaweed extract and chitosan on leaves N, P and K (%): Changing in leaves macro elements contents (N, P and K percentages on dry weight basis) of 'Superior Seedless' grapevines during 2018 and 2019 seasons in relation to spraying seaweed extract and chitosan, individually or in combination, at different concentrations are illustrated in Table (4). It is obvious that spraying 'Superior Seedless' grapevines with the two examined materials was capable to enhancing leaves N, P and K percentages, during the two experimental seasons.

It's clear from this Table that, treating 'Superior Seedless' vines with a gradual increasing concentration of seaweed or/and chitosan was parallel to a gradual and significant increment of leaves nitrogen, phosphorus and potassium percentages compared to the check treatments. However, spraying chitosan shows more effective in these three macro elements rather than spraying seaweed extract. It is worth to mention that non-significant differences were observed between the two highest concentrations of seaweed (0.2% & 0.4%) or/and chitosan (0.1% & 0.2 %), in both experimental seasons. Furthermore, the vines received the highest concentration of seaweed extract (0.4%) and chitosan (0.2%) in

combination present the higher content of macro nutrients in their leaves. On opposite side, untreated vines present the lowest macro mineral nutrients content in their leaves. These data were true during both experimental seasons.

Table (4). Response of leaves N%, P% and K% of 'Superior Seedless' grapevines to spraying seaweed and chitosan at different concentration, during 2018 and 2019 seasons

Treatments	Leaves N %		Leaves P%		Leaves K %	
	2018	2019	2018	2019	2018	2019
Control	1.60	1.55	0.15	0.13	1.16	1.14
Seaweed 0.1%	1.66	1.64	0.18	0.17	1.22	1.18
Seaweed 0.2%	1.79	1.78	0.22	0.20	1.30	1.22
Seaweed 0.4%	1.82	1.82	0.23	0.21	1.33	1.24
Chitosan 0.05%	1.89	1.88	0.24	0.25	1.41	1.40
Chitosan 0.1%	1.99	1.97	0.28	0.28	1.50	1.45
Chitosan 0.2%	2.01	2.00	0.29	0.30	1.53	1.46
Seaweed 0.1% + Chitosan 0.05%	2.11	2.11	0.34	0.33	1.57	1.50
Seaweed 0.2% + Chitosan 0.1%	2.21	2.21	0.40	0.36	1.61	1.57
Seaweed 0.4% + Chitosan 0.2%	2.25	2.26	0.41	0.37	1.63	1.59
New LSD at 5%	0.05	0.06	0.02	0.03	0.04	0.03

3.2. Effect of seaweed extract and chitosan on leaves micro-nutrients (Fe, Zn and Mn ppm)

Contents of 'Superior Seedless' grapevine leaves micro-elements (ppm on basis of dry weight) during 2018 and 2019 seasons in relation to spraying seaweed extract or/and chitosan at different concentrations are shows in Table (5). It is clear from this table that spraying 'Superior Seedless' grapevines with seaweed extract and chitosan was capable to enhancing Fe, Zn and Mn contents (ppm) in their leaves.

It is clear from this table that increasing the concentration used from seaweed (from 0.0 to 0.4%) and chitosan (from 0.0% to 0.2%) caused a gradual and significant increment in Fe, Zn and Mn concentrations (ppm) of 'Superior Seedless' adult leaves. However, chitosan treatments showed more effective in these three micro elements rather than those of seaweed extract. The same table declared that, regardless the concentration used, spraying these two examined materials (seaweed and chitosan) in combination shows more effective than using each one alone. However, the vines received the highest concentrations of seaweed (0.4%) and chitosan (0.2%) in combination produced the highest Fe, Zn and Mn in their adult leaves. Contrary, the control vines present the lowest Fe, Zn and Mn in their adult leaves. These findings were true in both experimental seasons.

The positive effect of seaweed extract on improving leaves macro and micro nutrients contents (N, P, K, Fe, Zn and Mn) might be attributed to its higher content in mineral nutrients such as nitrogen, phosphorus, potassium, zinc and iron as well as its favorable effect on enhancing the mineral nutrients and water uptake. Furthermore, seaweed has a positive effect on bio-stimulation enzymes that can positively improve the photosynthesis and mineral uptick. It maybe leads to increase macro (N, P & K) and micro (Fe, Zn & Mn) nutrients in adult leaves of 'Superior Seedless' grapevines. The role of seaweed extract in improving adult leaves mineral contents are in harmony with those obtained by

Rombola *et al.* (2001); Durand *et al.* (2004); Spinelli *et al.* (2009); Abdel-Mawgoud *et al.* (2010); Benjama & Masniyom (2012); Arun *et al.* (2014) Omar (2014) and Ali & Mohamed (2016).

The favorable effect of chitosan on enhancing leaves mineral contents (N, P, K, Fe, Zn and Mn) of 'Superior Seedless' grapevines adult leaves may be attributed to their higher content of mineral nutrients such as nitrogen, phosphorus, potassium, zinc and iron, also its benefits effect on nutrient and water uptake as well as the favorable positive role in bio-stimulation, that may be lead to improving photosynthesis and mineral elements uptick. All these roles can have explained the enhancing mineral nutrients concentration in adult leaves of 'Superior Seedless' grapevines (**Petriccione *et al.*, 2015; Ahmed *et al.*, 2016; Agbodjato *et al.*, 2016; El-Kenawy, 2017** and **Ayed, 2018).** It was also reported that chitosan improved the transportation of some elements such as nitrogen (**Chibu *et al.*, 2002; Gornik *et al.*, 2008**). Chitosan also enhancing the activity of some important enzymes in plant tissues (**Ortmann & Moerschbacher, 2006 and Kafagy (2019**). More interesting studs reported that chitosan enhanced plant growth and development (**Khan *et al.*, 2002; Chibu *et al.*, 2003; Gornik *et al.*, 2008**) through enhancing key enzymes activity such as these of nitrogen metabolism (nitrate reductase, glutamine synthetase and protease).

Table (5). Response of leaves Zn, Fe and Mn (ppm) of 'Superior Seedless' grapevines to spraying seaweed and chitosan at different concentration, during 2018 and 2019 seasons

Treatments	Leaf Zn (ppm)		Leaf Fe (ppm)		Leaf Mn (ppm)	
	2018	2019	2018	2019	2018	2019
Control	50.1	50.5	70.0	70.2	51.3	51.6
Seaweed 0.1%	53.3	53.1	73.1	73.4	53.5	53.6
Seaweed 0.2%	55.4	55.1	75.1	75.4	55.4	55.6
Seaweed 0.4%	57.0	56.8	76.8	77.2	57.0	57.3
Chitosan 0.05%	55.5	55.2	75.2	75.4	55.3	55.5
Chitosan 0.1%	57.5	57.1	77.1	77.3	57.1	57.3
Chitosan 0.2%	59.3	58.7	78.7	79.0	58.7	59.0
Seaweed 0.1% + Chitosan 0.05%	57.8	57.0	77.0	77.5	57.0	57.3
Seaweed 0.2% + Chitosan 0.1%	59.7	58.9	78.9	79.5	58.8	59.1
Seaweed 0.4% + Chitosan 0.2%	61.4	60.6	80.6	81.3	60.4	60.7
New LSD at 5%	1.9	1.8	1.8	1.7	1.7	1.8

4. Effect of seaweed extract and chitosan on berry setting%

It is clear from Table (6) that spraying seaweed extract and chitosan individually or in combination significantly increased the percentage of berries setting of 'Superior Seedless' grapevine rather than control treatment. These data were true during the two experimental seasons. However, this increment was more remarkable for chitosan treatments rather than those of seaweed treatments in both experimental seasons. It is clear from the same Table that all combined treatments produced a higher percentage of berries setting of 'Superior Seedless' grapevines rather than spraying each compound individually. Furthermore, 'Superior Seedles' vines received the highest concentrations from the two examined materials in combination (seaweed at 0.4% + chitosan at 0.2%) present the highest berry setting percentages (13.0 % and 13.0%), during both experimental seasons respectively. On the opposite side, the control vines (untreated vines) present the lowest percentages of berry setting (8% and 7%), during both experimental seasons respectively. The remarkable increasing in berry setting % as a result

of spraying seaweed extract or/and chitosan at different concentrations, which obtained during this experimental, may be explained by the role of these two material in improving the nutritional status of vines by increasing the availability and uptake of macro and micro mineral nutrients, increasing some key enzymes of photosynesis and some increasing antioxidant contents in plant cells.

5. Effect of seaweed extract and chitosan on yield and its components

5.1. Effect on cluster numbers and cluster weight

Data illustrated in Table (6) shows the effect of spraying seaweed extract and chitosan, each one individually or both in combination, at different concentration on the number of clusters per vine and average cluster weight of 'Superior Seedless' grapevine growing in clay soil under El-Minia governorate conditions, during 2018 and 2019 seasons. It is clear from Table (8) that spraying seaweed extract (at 0.0% t0 0.4%) or/and chitosan (at 0.0% 0.2%) significantly improved these two characters, except the case of cluster numbers on the first year (2018). Whatever the concentration used, the two examined materials failed to varying the cluster number significantly during the first seasons, it same be logic, whereas the fruiting bud obviously differentiated during the previous summer. This positive effect was clearer when the vines received the two examined materials at highest concentrations, either individually or in combination. It is clear from this table that increasing the concentration used of seaweed extract or/and chitosan gradually was accompanied with gradual and significant increment in cluster numbers per vine (during the second season only) and average cluster weight (g). However, non-significant differences were observed between the two highest concentrations of seaweed (0.2% and 0.4%) and/or chitosan (0.1% and 0.2%) neither in the clusters number per vine nor in cluster weight (g), during both experimental seasons. Regardless the concentration used, spraying chitosan shows more effective on the cluster numbers/vine (only in the second season) and average cluster weight of 'Superior Seedless' grapevines rather than those of seaweed extract, during both experimental seasons. It worth to mention that, the vines received the higher concentration of seaweed (0.4%) and chitosan (0.2%) in combination present the highest cluster numbers per vine in the second year (39.0 cluster) and average cluster weigh (397.0 g and 385.0 g), during the two experimental seasons respectively. On the other hand, the control vines (untreated vines) present the lowest cluster number per vine (22 clusters) and average cluster weight (327.0 g and 325.0 g), during the two experimental seasons respectively.

5.2. Effect on yield (kg/vine)

Data presented in Table (6) shows that subjected 'Superior' grapevines to spraying different concentrations of seaweed or/and chitosan significantly enhancing the yield per vine during both experimental seasons. This may be confirmed the positive correlation previously conducted in different grapevines cultivars, by different authors.

It is clear from this table that increasing the concentration used from each material (individually or in combination) was parallel to gradual and significant increment in yield per vine. Regardless the concentration used, this increment was more remarkably for chitosan treatments rather than those of seaweed extract treatments. However, the combined application of both materials (seaweed and chitosan) was superior than using any one individual. The same table shows also that, the vines received the highest concentration from both compounds in combination (0.4% for seaweed and 0.2% for chitosan) produced the highest yield (10.3 & 14.6 kg/vine). In the contrary, the untreated vines produced the lowest yield (7.2 & 7.2 kg/vine), during the two seasons respectively.

The obtained data concerning the effect of seaweed extract or/and chitosan on clusters number per vine, average cluster weight and yield (kg/vine) as well as yield (kg/vine) are in harmony with those obtained by: **Durand et al., 2004; Spinelli et al., 2009; Abdel-Mawgoud 2010; Benjama &**

Masniyom, 2012; Arun et al., 2014 Omar 2014; Ali & Mohamed 2016; Abd El-Hakem, 2018; and Arioli *et al.*, (2021) on seaweed. In this concern, the effect of chitosan on cluster numbers, cluster weight (g) and yield (kg) was also illustrated by **Petriccione *et al.*, 2015**; **Ahmed *et al.*, 2016; Abd El-Fattah *et al.*, (2016); Agbodjato *et al.*, 2016; El-Kenawy, 2017; Ayed, 2018; Abd El-Aziz, 2020 and Artem *et al.*, (2021)** on some grapevines cultivars.

Table (6). Response of berry setting %, number of clusters per vine, cluster weight (g) and yield per vine (kg) of 'Superior' grapevines to spraying seaweed and chitosan at different concentration, individually or in combination, during 2018 and 2019 seasons

Treatments	Berry setting %		No. cluster per vine		Cluster weight (g)		Yield per vine (kg)	
	2018	2019	2018	2019	2018	2019	2018	2019
Control	8.0	7.7	22.0	22.0	327.0	325.0	7.2	7.2
Seaweed 0.1%	8.6	8.2	23.0	24.0	340.0	332.0	7.8	8.0
Seaweed 0.2%	9.4	9.9	24.0	26.0	349.0	340.0	8.4	8.8
Seaweed 0.4%	9.7	10.2	24.0	27.0	355.0	345.0	8.5	9.0
Chitosan 0.05%	10.4	10.5	25.0	29.0	361.0	351.0	9.0	10.2
Chitosan 0.1%	11.2	11.1	25.0	33.0	370.0	359.0	9.3	11.8
Chitosan 0.2%	11.6	11.5	25.0	33.0	376.0	363.0	9.4	12.0
Seaweed 0.1% + Chitosan 0.05%	12.2	12.1	26.0	35.0	384.0	373.0	10.0	13.1
Seaweed 0.2% + Chitosan 0.1%	12.8	12.7	26.0	38.0	391.0	382.0	10.2	14.5
Seaweed 0.4% + Chitosan 0.2%	13.0	13.0	26.0	39.0	397.0	385.0	10.3	14.6
New LSD at 5%	**0.5**	**0.4**	**NS**	**2.0**	**8.0**	**6.0**	**0.2**	**0.3**

Conclusion

Based on obtained results we can confirm that, using both examined materials (seaweed extract and chitosan) in combination was more effective than using each one alone. Non-significant differences between the two highest concentrations of both examined compounds (seaweed and chitosan) were observed, during the two experimental seasons. From these standpoints it is strongly recommended to spray 'Superior Seedless' grapevines grown in clay soil under El-Minia Governorate and resembling conditions with seaweed extract at 0.2% + chitosan at 0.1% three times yearly in order to improve vegetative growth parameters, vines mineral status and productivity of 'Superiors Seedless' grapevines.

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