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Article

Effect of Spraying Chitosan and Algae Extract on Fruiting and Quality of Banaty Grape Vines

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Abstract: This experiment utilized thirty 10-year-old Banaty grapevines throughout the 2022 and 2023 growing seasons, cultivated in a private vineyard located in West Abu Qurqas, El-Minia Governorate, Egypt. In a Completely Randomized Block design with three replicates per treatment, the effects of spraying algae extracts at (0.25, 0.50, and 0.75 g/L) and chitosan at (0.05, 0.1, and 0.2%) were evaluated, as well as their interactions with a total of 10 treatments. The results suggested that all treatments considerably improved the physical and chemical quality, cluster aspects, and yield of the berries. Moreover, the observed beneficial effects were generally in accordance with the increasing dosages of these interventions. The administration of chitosan as an individual was observed to yield the most substantial benefits more than algae extracts. The treatment that included three sprays of algae extracts (0.50 g/L) plus chitosan (0.1%) was the most economically treatment in improving yield, cluster parameters, physical and chemical qualities of berries with decreasing in shot berries and total acidity of Banaty grapevines under Minia conditions.

Key words: Algae extract, chitosan, yield, physical, chemical quality and Banaty grapevines.

1. Introduction

In Egypt, grapes are the third most produced fruit crop, after citrus and mangoes. The requirement for significant land to attain considerable fruit yields presents challenges for grapevines grown in high-temperature environments, especially concerning berry size, colouration, and overall quality. Grape producers in these areas utilize horticultural techniques to enhance grape quality. Numerous compounds are extensively utilized in grapevines, with specific nutrients and natural extracts categorized as biostimulants (**El-Saman and Refaai, 2025**). The grape cultivation area in Egypt spans 186735 feddans, with a productive segment of 175245 feddans, leading to a total production of 1715410 tonnes. The total cultivated land in Minia Governorate reached 21098 feddans, with a productive area of 20852 feddans, yielding a total of 205244 tonnes (**MALR, 2023**). The key factors facilitating the cultivation of table grapes across Egypt encompass climate, soil composition, and production techniques. **Dhekny (2016)** indicates that fresh grapes and grape products are rich in beneficial phenolic compounds, vitamins, and fibre. The White Banaty grape cultivar is highly regarded in Egypt for its versatility as both a source of fresh fruit and raisins.

Environmental regulations are driving the progress of sustainable strategies. Bio-stimulating agents such as algae extract are crucial in this context (**Omar *et al.*, 2017; Abou-Zaid and Eissa, 2019; Zarraonaindia *et al.*, 2023; Ibrahim *et al.*, 2024**). The agricultural sector is progressively emphasizing the use of natural resources, such as algal extract, in horticulture as a biostimulant for nutritional development in food (**Zarraonaindia *et al.*, 2023**). At present, there is significant application of natural compounds to improve the predictability and quality of grapevine fruit. Algae extract represents a significantly overlooked compound for enhancing plant growth. Algae extract, which is gaining traction in horticulture, is rich in vitamins, including those potentially sourced from bacteria that interact with marine plants, particularly vitamin B12. The algal extract includes vitamin C and fucoxanthin, which could act as a precursor to vitamin A, although vitamin A is not present in its precursor form (beta-carotene). The B group vitamins consist of B2 (riboflavin), B1 (thiamine), B12, folic acid, and pantothenic acid. Algal extract contains notable concentrations of vitamin K, vitamin E (tocopherol), and various growth-promoting compounds (**Selvam and Sivakumar 2014, Venkata *et al.*, 2015, and Zarraonaindia *et al.*, 2023**).

Chitosan is a natural biopolymer derived from chitin deacetylation that, when applied to plant surfaces, can perform three functions: film formation, antibacterial activity, and elicitation (**Romanazzi *et al.* 2018**). Chitosan is deemed non-toxic because it is widely used in various fields of application, such as medicine and the food industry, and it was one of the first basic compounds approved for plant protection by the European Union (**Marchand *et al.*, 2021**). In the United States, the Food and Drug Administration has classed it as GRAS (Generally Recognised as Safe) (**Romanazzi *et al.*, 2022**). According to **Sharif *et al.* (2018**), chitosan improves the physiological characteristics of plants and prolongs the shelf life of produce after harvest.

Grapevines in the west El-Minia region are experiencing some issues as a result of the hot climate. Under such hot temperatures, the vines experience some stress. The previously mentioned issues are further exacerbated by the yield depression, inconsistent cluster colouration, and poor berry quality cluster compactness of certain grapevine cultivars, such as Banaty grapevines. Consequently, the present investigation has been conducted to enhance the yield and fruiting of grapes by utilizing antioxidants such as chitosan and algae extracts at varying concentrations.

2. Materials and Methods

2.1. Vineyard location and conditions

Thirty 10-year-old Banaty grapevines were used in this investigation during 2022 and 2023 growing seasons cultivated in a private vineyard in West Abu Qurqas center, El-Minia Governorate, Egypt.

The soil analysis indicated a well-drained sandy composition. Table (A) presents the soil characteristics as outlined by **Wilde *et al.* (1985**). Vines are arranged 2.0 m apart inside rows, while the inter-row gap is 3.0 m.

During the second week of January, a head pruning system was used in both seasons, resulting in 68 eyes per vine (15 fruiting spurs × 4 eyes per spur + 4 replacement spurs × 2 eyes). The thirty vines that were chosen were uniformly vigorous and robust, showing no outward symptoms of nutrient deficiencies, with routine fertilization and surface irrigation system utilizing water from the Nile Rivier was implemented.

Table (A). Analysis of the mechanical, physical, and chemical properties of the examined orchard soil

Soil characters		2022/2023
Particle size distribution (%)	**Sand**	4.08
	Silt	34.90
	Clay	61.02
	Texture class	Clay
EC ppm (1:2.5 extract)		288
pH (1:2.5 extract)		7.97
Organic matter %		2.33
$CaCO_3$ %		2.54
Soil nutrients	**Total N (%)**	0.22
	Available P (ppm)	5.18
	Available K (ppm)	505.0
	Zn (ppm)	2.6
	Fe (ppm)	2.4
	Mn (ppm)	4.2
	Cu (ppm)	0.13

2.2. Experimental work

The study design included ten treatments of foliar sprays of chitosan and algae extract at varying concentrations, together with their interactions and control, arranged in a Completely Randomized Block design with three replicates per treatment.

1. Control (spray with tap water).
2. Algae extract at 0.25 g/L.
3. Algae extract at 0.50 g/L.
4. Algae extract at 0.75 g/L.
5. Chitosan at 0.05%.
6. Chitosan at 0.1%.
7. Chitosan at 0.2%.
8. Algae extract at 0.25 g/L+ Chitosan at 0.05%.
9. Algae extract at 0.50 g/L+ Chitosan at 0.1%.
10. Algae extract at 0.75 g/L+ Chitosan at 0.2%.

The foliar treatments utilizing varying quantities of chitosan and algae extract were administered thrice: at the commencement of vegetative growth, post-fruit set, and one month following the second application. A wetting agent was incorporated into all solutions of algae extract at a concentration of 0.1%. The chemical analyses of the brown algae extract utilized in this study are presented in Table B, as referenced in **Ibrahim *et al.* (2024).**

Table (B). The chemical analysis of the brown algae extract utilized in the present investigation.

Compound	Concentration
Organic Matter	42 ~ 57%
Total Nitrogen	0.6 ~ 1.6%
Phosphorus (P_2O_5)	7 %
Potassium	17 ~ 20%
Mg	0.49 ~ 0.62%
Ca	0.44 ~ 1.70 %
Fe	0.15 ~ 0.30 %
Alginc acid	10 – 14%
Soluble in water	100%
Appearance	Flake or Particle

2.3. Data collection

Yield and physical attributes of clusters

Ten clusters per vine were selected as representative random samples, the subsequent parameters were established: Clusters number/vine**,** weight (g)**,** yield (kg)/vine, cluster dimensions (length and shoulder in (cm) and berry setting (%) was computed as the following: packed 5 flower clusters per vine in perforated paper bags before bloom, which are discharged during berry set which computed as follows:

$$\text{berry Setting\%} = \frac{\text{Number of berries /cluster}}{\text{Total number of flower /cluster}}$$

Physical characteristics of berries

The calculation of the shot berry proportion involved dividing the percentage of berries in each cluster by the total number of berries across all clusters, followed by multiplying the result by 100. Berry weight (g) and berry dimensions (longitudinal and equatorial).

Chemical characteristics of berries according to (**A.O.A.C, 2000**)

TSS% in berry juice measured with a handheld refractometer. Titrating 5 ml of berry juice against 0.1 N NaOH with phenolphthalein determined the titratable acidity percentage. TSS/acidity ratio of berry juice was calculated. Juice% and total sugar%.

3.3. Data analysis

Data analysis was conducted utilizing the new L.S.D. technique at a significance level of 5%, as outlined by **Mead *et al.* (1993).**

3. Results and Discussion

3.1. Yield and physical attributes of clusters

It is clear from the obtained data in Table (1) that the berry setting %, cluster number per vine, yield in kg / vine, cluster weight, cluster length, and shoulder was significantly affected by varying concentrations of algae extracts and/or chitosan foliar application. The application of both materials on the vines three times resulted in a notable increase in the traits compared to the control treatment. A gradual enhancement of this traits was observed with rising concentrations. The yield and cluster parameters remained largely unchanged with increasing concentrations from 0.50 to 0.75 g/L for algae extract and from 0.1 to 0.2% for chitosan. On the vines treated with chitosan, the highest values were seen at 0.2 %, followed by 0.1 %. Nevertheless, when the treatments were combined, the vines' yield and cluster parameters increased in comparison to the control and other treatments. During the research seasons, there were no significant differences between the highest two concentrations. The highest mean values were recorded with the combination of algae extract (0.75 g/L) and chitosan (0.2%), followed by algae extract (0.50 g/L) and chitosan (0.1%). Foliar applications of chitosan (0.2%) and algae extract (0.75 g/L) yielded an average of (9.8%, 25.0, 9.6 kg/vine, 388.0 g, 25.2 cm and 12.1 cm) in the first season and (9.810.1%, 33.0, 13.0 kg/vine, 394.0 g, 25.8 cm and 12.6 cm) in the second season for berry setting %, cluster number per vine, yield in kg / vine, cluster weight, cluster length, and shoulder, respectively. The lowest levels observed in the untreated plants. These findings were valid throughout both seasons.

Table (1). Foliar spray with algae extracts and chitosan on Banaty grapevines yield and cluster parameters in 2022 and 2023 growing seasons

Characteristics / Treatments	Berry setting %		Cluster number/vine		Yield/vine (kg)		Cluster weight (g)		Cluster length (cm)		Cluster shoulder (cm)	
	2022	2023	2022	2023	2022	2023	2022	2023	2022	2023	2022	2023
Control	7.1	7.6	25.0	26.0	8.5	9.0	340.0	345.0	21.0	21.4	10.3	10.5
Algae extract (0.25 g/L)	7.9	8.3	25.0	27.0	8.8	9.9	353.0	357.0	23.5	24.0	10.8	11.0
Algae extract (0.50 g/L)	8.4	8.8	25.0	29.0	9.2	10.6	363.0	368.0	23.9	24.4	11.1	11.4
Algae extract (0.75 g/L)	8.8	9.1	25.0	30.1	9.3	11.3	370.0	376.0	24.2	24.6	11.3	11.7
Chitosan (0.05%)	8.5	8.9	25.0	29.1	9.1	10.7	364.0	367.0	24.0	24.5	11.2	11.5
Chitosan (0.1%)	9.1	9.5	25.0	30.4	9.3	11.5	373.0	377.0	24.6	24.9	11.5	11.9
Chitosan (0.2%)	9.4	9.9	25.0	31.6	9.4	12.2	380.0	385.0	24.8	25.2	11.7	12.2
Algae extract (0.25 g/L) + Chitosan (0.05%)	8.9	9.4	25.0	30.5	9.3	11.5	374.0	376.0	24.4	24.9	11.7	11.9
Algae extract (0.50 g/L) + Chitosan (0.1%)	9.4	9.9	25.0	31.8	9.5	12.3	382.0	386.0	24.9	25.5	12.0	12.4
Algae extract (0.75 g/L) + Chitosan (0.2%)	9.8	10.1	25.0	33.0	9.6	13.0	388.0	394.0	25.2	25.8	12.1	12.6
New LSD at 5%	0.5	0.5	N.S	1.3	0.1	0.8	8.0	9.0	0.4	0.4	0.3	0.4

Algae extract serves as an effective and environmentally sustainable method to enhance the cluster weight (g) and yield (kg/vine) of ‘Banaty’ grapevines. This enhancement occurs through an increase in fruit cell number early in the growth season and an increase in fruit cell volume during the berry growth period **(Samuels *et al.*, 2022; Zarraonaindia *et al.*, 2023**). In this study, the application of algae extracts significantly improved the percentage of berry set over two seasons, which consequently resulted in an increased yield (kg/vine). Additionally, it may have increased the concentration of natural polyamines at the fruit's apex. Our research findings are consistent with the applications of algae extract, which have been shown to increase crop production and its components in previous field experiments. **Ibrahim *et al.* (2024)** discovered that after three applications, the algal extract was more effective than the control group. This would improve fruit output and cluster traits. Cluster weight, length, and width of grapevines were all improved when the concentration of algal extract was increased from 0.25 to 0.75 g/L. **Sharma *et al.* (2023), Al-Sagheer *et al.* (2023), Ali *et al.* (2024), and Waseel *et al.* (2024**) reported these findings as a result of experiments conducted on a variety of grapevine varieties.

Chitosan positively influenced the total yield per vine and the clusters aspects. This is likely attributable to chitosan's capacity to diminish water loss from the outer membrane of berries. **Shiri *et al.* (2013**) asserted that chitosan coatings facilitate the regulation of respiration rate and ethylene production, hence diminishing transpiration, managing weight loss, decelerating maturation, and prolonging shelf life. The increase in cluster characteristics and yield linked to chitosan application, as revealed by **Ali *et al.* (2023)** and **Masoud *et al.* (2024).**

3.2. Physical characteristics of berries

The impact of varying concentrations of algae extracts and/or chitosan on the percentage of shot berries, berries equatorial, longitudinal, and average berry weight in 'Banaty' grapevines cultivated in clay under the conditions of El-Minia Governorate during the 2022 and 2023 seasons is presented in Table 2. The data obtained indicate that the application of 'Banaty' grapevine with algae extract or chitosan at varying levels, administered three times, resulted in a notable reduction in the percentage of shot berries and raise in average berry weight berries equatorial, and longitudinal compared to the control treatment. Nevertheless, the percentage of shot berries, average berry weight berries equatorial, and longitudinal considerably unaffected as the levels of both materials were raised from medium to high. The most successful treatment was foliar application of 0.2% chitosan, followed by 0.1%, with no significant difference between the two. The Table clearly demonstrates that the highest dose (0.75 g/L algae extracts+0.2% chitosan) significantly decreased shot berries% and increased berries equatorial, values of (5.8-6.1%), (1.88-1.94 g), (15.8 -6.1 cm) and (1.88-1.94 cm) in the 2022 and 2023 seasons, respectively. The lowest concentration (0.50 g/L algae extracts+0.1% chitosan) recorded (6.3-6.6%), (1.82-1.87 g), (6.3 – 6.6 cm) and (1.82-1.87 cm) without any discernible change, while the control vines recorded the highest significant values. This information is relevant to the effect of the dual combination between algae extracts and chitosan on physical berries quality.

Table (2). Foliar spray with algae extracts and chitosan on Banaty grapevines physical berries quality in 2022 and 2023 growing seasons

Characteristics / Treatments	Shot berries %		Average berry weight (g)		Average berry longitudinal (cm)		Average berry equatorial (cm)	
	2022	2023	2022	2023	2022	2023	2022	2023
Control	9.1	9.4	1.47	1.50	9.1	9.4	1.47	1.50
Algae extract (0.25 g/L)	8.3	8.5	1.59	1.61	8.3	8.5	1.59	1.61
Algae extract (0.50 g/L)	7.7	7.8	1.68	1.70	7.7	7.8	1.68	1.70
Algae extract (0.75 g/L)	7.3	7.3	1.74	1.77	7.3	7.3	1.74	1.77
Chitosan (0.05%)	7.7	7.9	1.66	1.69	7.7	7.9	1.66	1.69
Chitosan (0.1%)	7.0	7.2	1.70	1.77	7.0	7.2	1.70	1.77
Chitosan (0.2%)	6.5	6.8	1.75	1.83	6.5	6.8	1.75	1.83
Algae extract (0.25 g/L) + Chitosan (0.05%)	6.9	7.2	1.74	1.78	6.9	7.2	1.74	1.78
Algae extract (0.50 g/L) + Chitosan (0.1%)	6.3	6.6	1.82	1.87	6.3	6.6	1.82	1.87
Algae extract (0.75 g/L) + Chitosan (0.2%)	5.8	6.1	1.88	1.94	5.8	6.1	1.88	1.94
New LSD at 0.05	0.6	0.6	0.07	0.08	0.6	0.6	0.07	0.08

This role of algae extract in reducing this undesirable characteristic (shot berries %) and increasing the average berry weight, longitudinal, and equatorial may be attributed to its higher concentrations of plant growth regulators, such as GA3 and citokinens, as well as its greater effect on amino acids and mineral elements (**Abd El-Hakem 2018 and Samuels *et al.*, 2022**). Moreover, algae extracts are frequently categorized as plant bio-stimulants (**Khan *et al.*, 2012; Correia *et al.*, 2015**), and are generally believed to possess elevated levels of macro- and micronutrients, amino acids, vitamins, cytokinins, auxins, and abscisic acid (**Stirk *et al.*, 2004; Samuels *et al.*, 2022**). Consequently, this may elucidate the notable reduction in the percentage of shot berries and the enhancement in other physical qualities.

The influence of chitosan on the physical characteristics of berries, as evidenced by the findings of **Refaai and Silem (2021), El-Senosy (2022),** and **Ali *et al.* (2023**), indicates that foliar application of chitosan resulted in enhancements in the physicochemical parameters of superior grapevines, including berry setting percentage, weight, and dimensions.

3.3. Berry chemical characteristics

Data concerning the effect of different algae extract and chitosan at different concentrations on berries TSS% of 'Banaty' grapevines, during 2022 and 2023 seasons (Table 9 and Fig 26) showed that, spraying 'Banaty' three times with algae extract or chitosan significantly increased the TSS%, TSS/total acidity ration, juice%, and total sugar% and decreased total acidity% rather than the control treatment, in the both experimental seasons. It is clear from the obtained data that the enhancement of chemical berries quality was gradual and parallel to gradual increasing of chitosan concentrations. However, the vines received three sprays with the highest concentration (0.2%) present the highest TSS% (19.5-20.0%), TSS/total acidity ration (53.59-55.0), juice% (77.2-78.1 %), and total sugar (18.1-18.5%), with a reduction in total acidity (0.362-0.360%), followed by chitosan at 0.1% with values of TSS% (18.9-19.4%), TSS/total acidity ration (48.74-49.74), juice% (76.7-77.7 %), and total sugar (17.6-18.0%), with values of total acidity (0.390%), during the two seasons respectively. Contrary, untreated vines present the lowest TSS%, TSS/total acidity ration, juice%, and total sugar% and highest total acidity%. The data presented in the Table indicate that the dual application of algae extracts and chitosan through foliar spray on Banaty vines, at various concentrations, significantly enhanced the chemical quality of the berries in comparison to the untreated vines. The highest mean values were recorded with algae extract (0.75 g/L) combined with chitosan (0.2%), followed by algae extract (0.50 g/L) with chitosan (0.1%), with no significant difference observed between the two.

The application of algae extract modulated the carbohydrate metabolism in fruit trees. The hydrolysis of sucrose by invertase modulates the concentrations of certain plant hormones and vitamins, which are components of algae extract (**Cook *et al.*, 2018; Belal *et al.*, 2023; Ibrahim *et al.*, 2024**). Previous studies confirm the relationship between algae extract and the chemical concentration of berries (**Cataldo *et al.*, 2022; Kara *et al.*, 2022)**. Increasing the intensity of photosynthesis and enzyme activation can lead to the accumulation of reducing, non-reducing, and total sugars. This may result from enhanced synthesis and translocation of photosynthetic assimilates to the fruits, as well as the breakdown of starch during the ripening stage.

The data obtained regarding the impact of chitosan on the chemical quality of grapevines, including total sugar, total acidity, TSS/TA, and total sugar, are consistent with those obtained by **Abd El-Rahman (2021).** The foliar application of chitosan once, twice, or thrice resulted in an increase in TSS %, sugars %, and TSS/acid ratio, while the total acidity % was decreased. In comparison to the untreated vines, foliar sprinkling with chitosan at 2% resulted in an increase in TSS, a reduction in sugar, acidity, and TSS/TA on Ruby Seedless grapevines, as discovered by **Masoud *et al.* (2024).**

Table (3). Foliar spray with algae extracts and chitosan on Banaty grapevines chemical berries quality in 2022 and 2023 growing seasons

Characteristics / Treatments	TSS%		Total acidity%		TSS/acidity ratio		Juice %		Total sugar%	
	2022	2023	2022	2023	2022	2023	2022	2023	2022	2023
Control	18.0	18.4	0.465	0.450	38.71	40.89	74.5	75.0	16.5	16.8
Algae extract (0.25 g/L)	18.5	18.9	0.420	0.420	44.05	45.60	76.3	77.2	17.2	17.4
Algae extract (0.50 g/L)	18.9	19.3	0.390	0.391	48.46	49.36	76.8	77.8	17.7	18.0
Algae extract (0.75 g/L)	19.1	19.6	0.365	0.364	52.33	53.85	77.0	78.0	18.0	18.4
Chitosan (0.05%)	18.9	19.4	0.390	0.390	48.46	49.74	76.7	77.7	17.6	18.0
Chitosan (0.1%)	19.4	19.8	0.362	0.360	53.59	55.00	77.2	78.1	18.1	18.5
Chitosan (0.2%)	19.5	20.0	0.336	0.334	58.04	59.88	77.3	78.4	18.3	18.8
Algae extract (0.25 g/L) + Chitosan (0.05%)	19.3	19.9	0.361	0.361	53.46	55.12	77.1	78.2	18.1	18.6
Algae extract (0.50 g/L) + Chitosan (0.1%)	19.8	20.3	0.334	0.333	59.28	60.96	77.5	79.7	18.5	19.1
Algae extract (0.75 g/L) + Chitosan (0.2%)	20.0	20.5	0.309	0.306	64.72	66.99	77.7	79.9	18.8	19.4
New LSD at 0.05	0.3	0.4	0.027	0.028	5.50	6.10	0.3	0.4	0.4	0.5

4. Conclusion

Previous findings indicate that optimal economic outcomes regarding yield and berry quality were attained by applying a mixture of 0.50 g/L algae extracts and 0.1% chitosan to Banaty grapevines in the Minia region. So, its recommended to use this treatment was administered three times: at the onset of vegetative growth, after fruit set, and one month later.

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تأثير الرش بالشيتوسان و مستخلص الطحالب البحريه على الإثمار و صفات الجوده لكرمات العنب البناتى

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الملخص العربى

إستخدمت ٣٠ كرمة من العنب البناتى بعمر ١٠ سنوات فى مزرعه خاصة غرب أبو قرقاص بمحافظة المنيا خلال عامى ٢٠٢٢ و ٢٠٢٣ لدراسه تأثير الرش الورقى بتركيزات مختلفه من مستخلص الطحالب البحريه (٠,٢٥، ٠,٥٠، ٠,٧٥ جم/لتر) و الشيتوسان (٠,٠٥، ٠,١، ٠,٢%) و تفاعلاتهما بإجمالى ١٠ معاملات صممت فى تصميم قطاعات كامله العشوائية فى ٣ مكررات. أشارت النتائج تحت الدراسه إلى تحسن بشكل كبير فى جميع صفات المحصول و العناقيد و صفات الجوده الفيزيائية و الكيميائية للتوت، حيث لوحظت أفضل القيم عند إستخدام الرش الورقى بالكيتوزان أفضل من مستخلص الطحالب البحريه. ووجد أن التحسن فى الصفات يعتمد على زياده التركيز مع عدم ملاحظة أى فرق معنوى بين التركيز المتوسط و الأعلى منه. و كانت المعامله الأكثر إقتصاديه فى الحصول على أفضل محصول و أفضل صفات جوده للتوت مع إنخفاض فى نسبة الحبات الصغيره و الحموضه الكليه لكروم العنب البنات تحت ظروف محافظة المنيا هى الرش ثلاث مرات بتركيز ٠,٥٠ جم/لتر مستخلص طحالب بحريه مع ٠,١% شيتوسان .

الكلمات المفتاحيه: مستخلص الطحالب البحريه، شيتوسان، محصول، صفات جوده كيميائيه و فيزيائية، عنب بناتى.