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(Original Article)

Effect of Potassium Silicate and Chitosan Spraying on Fruiting of Thompson Seedless Grapevines

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Abstract

The present study was conducted on 20-year-old Thompson seedless grapevines (*Vitis vinifera* L.) in the two consecutive seasons of 2023 and 2024. The purpose of this study was to examine the effects of K-silicate and chitosan foliar sprays on vine yield of Thompson seedless grapevines. The experiment included 10 single or combination treatments with K-silicate and chitosan as foliar application in a randomized complete block design (RCBD) with three replicates.

The effect on the yield of 'Thompson seedless' grapevine, assessed by percentage of berry set, number of bunches/vine, average bunch weight, yield/vine, average bunch length and width at different concentrations of potassium silicate and/or Chitosan foliar application compared to control treatment. Single applications of K-silicate or chitosan increased the physical quality of the berries and reduced the percentage of shoot formation, particularly at 0.1% and 0.2% compared to the control, with no significant difference between the two concentrations. Application of K-silicate and/or chitosan at different concentrations inhanced the average values of the chemical quality traits of the berries (TSS%, total acidity, TSS/acid ratio, juice% and total sugar) of the grapevine life cycle. Thompson seedless.

Keywords: *Chitosan, Foliar application, Potassium Silicate, Grapevine, Thompson seedless.*

Introduction

The old-world species Vitis vinifera is the grape of antiquity often mentioned in the Bible. Table, wine and raisin grapes are produced from varieties of such species. Grapes are used for curing of gastrointestinal diseases, urinary, respiratory diseases and cancer (Coombe and Dry, 1992 and Passingham, 2004).

According to the Ministry of Agriculture Statistics 2022 (Table 1), the total area dedicated for grapes attained 186404 feddans including 178485 feddans as fruitful vines producing about 1790734 tons with an average of 10.033 tons/feddans.

Foliar spray is merely an additional precaution to ensure that plants receive an appropriate amount of nutrients. Numerous efforts have been made to determine which horticulture techniques are most effective in enhancing the yield and berry quality of premium, well-liked, and long-lasting grapes meant for table use (El-Mehrat *et al.*,

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2018). Thus, any horticultural applications, like bio stimulants and nutritional elements, that might be made to enhance these qualities would be crucial.

The exorbitant cost of fertilizers is one of the biggest problems faced by farmers. Excessive use of chemical fertilizers not only causes serious problems such as soil salinization and groundwater pollution, but has also driven up the cost of mineral potassium fertilizer in Egypt. Therefore, scientists have focused on developing partially safe substitutes for mineral fertilizers that are harmless to the environment, humans and animals (Belal *et al*., 2017; Abd El Rahman and AlSharnouby, 2021). Large financial losses occur because an estimated 50 to 90% of the potassium in applied fertilizers is lost to the environment and not absorbed by plants (Solanki *et al*. 2015). According to (Inglese *et al*. In 2002), foliar spray is simply an additional precaution to ensure plants receive an adequate amount of nutrients. Although foliar fertilization does not replace soil fertilization for crops with broad leaf surfaces, it can improve the efficiency and absorption of nutrients supplied to the soil (Kannan, 2010).

Biodynamics relies heavily on silicon, known in the viticulture sector for its ability to alter enzyme levels, inducing stress resistance and altering grape quality characteristics (Losada *et al*., 2022). A very soluble source of silicon and potassium is potassium silicate. In addition to serving as a silica additive in agricultural production systems, it also provides trace amounts of potassium. Adequate potassium intake also improves fruit size, color, soluble solids, shelf life, ascorbic acid concentration, tree yields, and shipping quality in many horticultural crops (Kanai *et al*., 2007).

Chitosan is a linear polysaccharide with a random distribution of β-(1-4)-linked D-glucosamines (deacetylated units) and N-acetyl-D-glucosamines (acetylated units); it is a polysaccharide called 2-amino-2-deoxyβ-D-glucosamine; it is also known as chitosan, a highly aminated polysaccharide. Chitosan can be obtained from marine crustaceans such as shrimps, mussels and needlefish or from the exoskeletons of most insects, called chitin, which can be converted into chitosan by isolation and amination of acetyl groups (Sugiyama *et al*. 2001).

Chitosan is a chemical biopolymer derived from crustaceans and is soluble in organic acids. Chitosan is considered environmentally friendly for use in agriculture because it breaks down easily in the environment and is non-toxic to humans. Chitosan and its derivatives have been reported to induce a natural defense response in plants and are used as natural compounds to combat pathogenic diseases before and after harvest. Antimicrobial activity of chitosan against various plant pathogens has been reported (Rahman *et al*. 2014).

In order to enhance yields in Thompson seedless vineyards, this study investigated the impacts of potassium silicate and/or Chitosan at different concentration on berry setting, yield, and berry quality in Thompson seedless grapevines cultivated under Assiut governorate conditions.

Table 1. Area, Yield and Production of Grapevines in Egypt, 2022

Governorates	Total			
	Production	Yield (Ton/fed)	Fruitful Area	Total Area
Behera	98169	10.614	9249	10868
Gharbia	105011	9.395	11177	11217
Dakahlia	73658	13.329	5526	6533
Sharkia	37145	9.897	3753	6858
Ismailia	14985	6.874	2180	2252
Lower Egypt	**349246**	**10.113**	**34534**	**40555**
Giza	31714	8.969	3536	3581
Beni Suef	44750	8.795	5088	5296
Menia	204136	9.845	20734	21087
Middle Egypt	**287775**	**9.557**	**30113**	**30727**
Assuit	27634	12.776	2163	2255
Luxor	3887	6.489	599	1001
Upper Egypt	**40926**	**10.529**	**3887**	**4638**
Inside the valley	**677947**	**9.892**	**68534**	**75920**
Outside the valley	**1112787**	**10.121**	**109951**	**110484**
Total	**1790734**	**10.033**	**178485**	**186404**

Area: Fedden, Yield: Ton / Fed., Production (Ton.)
Source: Agriculture Directorates of Governorates.
Publisher: Economic Affairs Sector.

Materials and Methods

1. Trial Grapevines and their cultivation circumstances

The present study was conducted on 20-years old Thompson seedless grapevines (*Vitis vinifera* L.), throughout two successive seasons of 2023 and 2024 seasons.

The purpose of this study was to examine the effects of potassium silicate and chitosan foliar sprays on the growing and yield of Thompson seedless grapevines in a private vineyard situated west of El-Wasta Zone, Assiut Governorate, Egypt. Thirty vines were nearly identical in terms of growth vigor.

Grape vines are grown on clay soil and cultivated at a distance of 3 m between rows and 2 m between vines (700 vines/fed) under a surface irrigation system with Nile water (water table depth > 1.5 m). In both seasons, winter pruning was done with typical heads in the second week of January, with each vine having 60 eyes.

2. Treatments and experimental design:

The experiment included 10 treatments individual or combined of the potassium silicate and chitosan as foliar application in Randomized complete block design (RCBD) with three replicates as following

1-Control (sprayed with tap water).

2-Spraying Potassium silicate (0.05 %)

3-Spraying Potassium silicate (0.1 %)

4-Spraying Potassium silicate (0.2 %)

5-Spraying chitosan at (0.05%).

6-Spraying chitosan at (0.1 %).

7-Spraying chitosan at (0.2%).

8-Spraying Potassium silicate (0.05 %) + chitosan (0.05%)

9-Spraying Potassium silicate (0.1%) + chitosan (0.1%)

10-Spraying Potassium silicate (0.2 %) + chitosan (0.2 %)

The treatments were sprayed shoots of seedlings with both of K-silicate and Chitosan three times, the first at the beginning of growth, the second after berry setting, while the third one-month later.

3. Data collection

The effects spraying K-silicate and/or Chitosan at varying concentrations on berry quality, yield, and growth were assessed using the following metrics.

A-Yield and cluster characteristic

During the two seasons under study, harvesting took place during the second week of July, which is the typical commercial harvest date

1-Berry setting (%) was computed as the following: Following the initial spraying, two bunches were placed in white cheese bags with holes in them.

$$\textbf{Berry Setting\%} = \frac{\textbf{Berries number /cluster}}{\textbf{Total flower number /cluster}}$$

2-Cluster number/vine.

3-Cluster weight (g).

4-Cluster length (cm).

5-Cluster width (cm).

6-Yield/vine (kg).

B-Physical characteristics of the berry

1-Shoot berry%

2-Average berry weight (g).

3-Average berry longitudinal (cm).

4-Average berry equatorial (cm).

C-Chemical characteristics of the berry according to (A.O.A.C, 2000)

1-Hand refractometer readings for total soluble solids% in juice

2-Total acidity as a tartaric acid/100 ml juice).

3-Ratio between TSS/acidity.

4-Total sugar%.

5-Juice %.

Statistical analysis: Comparing between the treatments were set as mentioned by Mead *et al*., (1993), using new LSD at 5

Results and Discussion

During the seasons of 2023 and 2024, the following data showed effect of individual or combine application of K-silicate and Chitosan at varying concentrations on the certain aspects of physical and chemical state of berries, yield and its components of Thompson seedless grapevines.

1. Yield and cluster characteristic

The impact of K-silicate or/and chitosan at different concentrations as foliar spraying on the yield of "Thompson seedless " grapevines, as measured in berry setting percentage, shoot berries percentage, clusters number/vine, average cluster weight, yield/vine, average cluster length and width, when compared to the untreated vines are indicated in Tables (2 & 3).

Berry setting%

Table 2 shows the effect of spraying different rates with K-silicate and/or chitosan on the percentage of berry set. The results showed that all treatments significantly increased percentage berry set values compared to control vines. As the concentration of single application of K-silicate or chitosan increased, the percentage of berry formation increased, while the concentration of 0.1 and 0.2% potassium silicate or chitosan did not show significant fluctuations ($P \leq 0.05$), the highest with the measured values Vines were sprayed with chitosan at a concentration of 0.2% and then with K-silicate at a concentration of 0.2%, with no noticeable difference between them could be seen. With the combined application of potassium silicate and chitosan in different concentrations, the result indicated an increase in berry set in %, with the highest average values achieved with the foliar spray with K-silicate (0.2%) + chitosan (0.2%), followed by the lower concentration was 0.1% for each of the applications with no significant difference between them. The same pattern occurred in season 2.

Table 2. Effect of spraying K-silicate and chitosan on berry setting, number of cluster/vine and yield/vine of Thompson seedless grapevines during 2023 and 2024 seasons.

Characteristics / Treatments	Berry setting %		Number of cluster/vines		Yield/vine (kg)	
	2021	2022	2021	2022	2021	2022
Control	8.2	8.5	27.4	28.8	9.2	9.8
Potassium silicate (0.05%)	8.8	9.2	27.5	30.1	9.6	10.7
Potassium silicate (0.1%)	9.3	9.8	27.7	31.5	10.0	11.5
Potassium silicate (0.2%)	9.6	10.2	27.8	32.6	10.3	12.2
Chitosan (0.05%)	9.4	9.9	28.0	31.5	10.2	11.6
Chitosan (0.1%)	9.9	10.4	28.0	32.7	10.6	12.4
Chitosan (0.2%)	10.1	10.7	28.1	33.7	10.8	13.0
Potassium silicate (0.05) + Chitosan (0.05%)	10.0	10.4	27.7	32.7	10.4	12.3
Potassium silicate (0.1%) + Chitosan (0.1%)	10.5	11.1	27.8	34.1	10.8	13.0
Potassium silicate (0.2%) + Chitosan (0.2%)	10.8	11.5	27.8	34.9	11.0	13.6
New LSD at 5%	**0.4**	**0.5**	**N.S**	**1.1**	**0.4**	**0.7**

Number of cluster/vines

From the data in Table 2, it is clear that no statistically significant variation was observed in the number of clusters/vines between all applications in the first season, either for single or mixed applications. While in 2024 all treatments significantly increased the number of clusters/vines, even single and mixed applications. No significant difference was found for potassium silicate or chitosan individually or in combination when the concentration increased from 0.1% to 0.2%. In general, the high average values of clusters number were measured in the mixed application of 0.2% K-silicate + 0.2% chitosan, followed by the lower concentration for both, and the lowest average values were obtained in the untreated vines.

Yield/vine (kg)

The impact of various applied treatments on yield/vine (kg) of Thompson seedless grapevines was tabulated in Table (2). The results showed that during the 2023 and 2024 seasons, comparing to the untreated treatment, every treatment significantly increased yield per vine ($P \leq 0.05$). However, no significant differences were seen between the foliar applications of K-Si or chitosan single treatments at 0.1 and 0.2% during either season.

The same results were found by (Masoud and Ibrahim, 2017) on Red Globe grape vines: spraying a mixture of barley seed sprouts and potassium silicate three times, each at 0.05%, improved yield and quality. The present results are consistent with those of Mostafa (2017), who reported that percentage yield, berry set, vine weight, number of clusters and cluster dimensions (length and shoulder) were improved compared to the control treatment when Superior grapevine K-Si was treated with in concentrations of 0.05 to 0.4% once, twice, three or four times. The same results were reported by Abdel Aal *et al*. (2017) for seedless Crimson grapevines and Eisa *et al*. (2023) found for Thompson seedless grapevines.

Cluster weight (g)

The data in Table 3 illustrate that with increasing concentration of 0.05, 0.1, and 0.2% potassium silicate and/or chitosan, the cluster weight increased significantly. From the data, the vines sprayed with 0.2% potassium silicate or chitosan recorded the highest values, followed by the lower concentration of 0.1% each with no significant difference in the 2023 and 2024 seasons. Furthermore, vines sprayed with K-silicate and chitosan at the highest concentration (0.2%) recorded the highest value of the trait, followed by 0.1% for each application, which is unremarkable compared to each other. Mean cluster weight values were determined for the other treatments.

Cluster length (cm)

Regarding the cluster length shown in Table 3, it was found that all applied spray treatments (0.05, 0.1 and 0.2% for potassium silicate or chitosan) increased the cluster length of the Thompson seedless vines compared to the control treatment. Application of K-silicate or chitosan alone improves cluster length with an increase in concentration of 0.05, 0.1, and 0.2%, with no significant difference between the two higher concentrations. The highest average values were given for chitosan at 0.2%.

Furthermore, Thompson seedless grapevines sprayed with the combination treatment (0.05, 0.1, and 0.2% for potassium silicate and chitosan) yielded increased cluster length compared to the control. The higher values were measured with 0.2% potassium silicate + 0.2% chitosan, followed by the lower concentration for both, which were unremarkable compared to each other. In contrast, vines treated with a control spray had the lowest value. The other treatments showed intermediate values in both seasons.

Table 3. Effect of spraying K-silicate and chitosan on cluster weight, cluster length and cluster width of Thompson seedless grapevines during 2023 and 2024 seasons.

Treatments \ Characteristics	Cluster weight (g)		Cluster length (cm)		Cluster width (cm)	
	2021	2022	2021	2022	2021	2022
Control	366.8	372.3	22.4	22.8	11.0	11.4
Potassium silicate (0.05%)	383.3	389.8	25.4	26.0	11.5	11.8
Potassium silicate (0.1%)	395.3	400.8	25.7	26.4	11.9	12.4
Potassium silicate (0.2%)	405.2	407.3	26.0	26.6	12.3	12.6
Chitosan (0.05%)	399.7	401.9	26.0	26.4	12.0	12.3
Chitosan (0.1%)	412.8	413.9	26.4	26.9	12.6	12.7
Chitosan (0.2%)	420.5	421.6	26.5	27.3	12.8	13.0
Potassium silicate (0.05) + Chitosan (0.05%)	410.6	410.6	26.3	26.9	12.5	12.8
Potassium silicate (0.1%) + Chitosan (0.1%)	424.9	419.4	26.7	27.4	13.0	13.2
Potassium silicate (0.2%) + Chitosan (0.2%)	431.4	427.1	26.9	27.6	13.4	13.5
New LSD at 5%	9.0	8.0	0.3	0.4	0.4	0.4

Cluster width (cm)

Table 3 shows that the groups treated with K-silicate and chitosan, either alone or in combination, had significant cluster width compared to the control group. The increase was found to be concentration dependent and when used together, the applications outperformed their stand-alone counterparts. The concentrations of 0.1 and 0.2% of both applications showed no significant differences. Higher grape breadth was achieved when the vines were treated with 0.2% K-silicate + 0.2% chitosan. Under such promising treatment, the grape width reached 13.4 and 13.5 cm in both seasons, respectively, followed by the lower concentration for each application with no significant differences between them.

Potassium silicate stimulation, which in turn increases the average weight and number of clusters (Tables 2 and 3), improves yield characteristics through photosynthesis production. The positive effects of potassium silicate as a foliar spray could be due to it increasing photosynthesis, decreasing transpiration, increasing energy compounds, stabilizing cell membranes, promoting cell division and elongation, increasing antioxidant levels, and increasing leaf water potential and nutrient bioavailability through potassium silicon role. Nutrient content is increased by potassium silicate, resulting in high levels of gibberellic acid and indoleacetic acid. These acids promote cell division and elongation, which in turn causes a cluster to grow in both length and width. In addition to potentially increasing the synthesis of indoleacetic acid and gibberellic acid, silica induces the release of excessive amounts of abscisic acid. The present results are consistent with those of Mostafa (2017), who reported that percentage yield, berry set, vine weight, number of clusters and cluster dimensions (length and shoulder) were improved compared to the control treatment when Superior grapevine K-Si was treated with in concentrations of 0.05 to 0.4% once, twice, three or four times. The same results were reported by Abdel Aal *et al*. (2017) for seedless Crimson grapevines and Eisa et al. (2023) found for Thompson seedless grapes.

Results in larger clusters and weights may be due to the effects of chitosan on cell division, endogenous levels of growth promoters, macro- and micronutrients, carbohydrates and hormones, particularly cytokinins (Khan *et al*., 2012). For Ruby Seedless vines, the best treatments in this regard were chitosan extract; Algae extract and fulvic acid, while salicylic acid recorded the best results in this regard (Masoud *et al* 2023). Additionally, it may have increased the fruit's natural maximum polyamine concentration. Our results are consistent with those of previous field experiments that showed an increase in yield and its components due to chitosan. Abo-Zaid *et al*. (2019) found that spraying algae four times was more effective than the control group.

The recommendations were as follows: once in April at the beginning of growth after flowering, once in mid-April shortly after the berries set, once in mid-May a month later and once at the end of May two weeks later.

This would improve grape characteristics and increase fruit production. Increasing chitosan concentration from 0.05 to 0.2% improved yield (bunch number, yield/vine, bunch weight, length and width), as Omar *et al*. (2020) on Flame Seedless, Mohamed *et al*. (2021) on Early Sweet, El-Senosy (2022) on Flame Seedless and Al-Sagheer *et al*., (2023) on Thompson seedless. For ruby red seedless vines, spraying with yeast combined with algae and fish oil resulted in the highest cluster number, heaviest clusters, and highest yield/vine compared to the other spray treatments and the unsprayed ones. (Masoud and Abou-Zaid, 2017)

2. Natural properties of berries

Table 4 shows the morphological parameters of the “Thompson seedless” grapevine, including shoot berry, average berry weight, longitudinal and equatorial direction, and how these parameters are influenced by foliar application of K-silicate and/or chitosan at different concentrations compared to the untreated treatments during the 2023 and 2024 seasons. These parameters are important for successful marketing locally, regionally or globally.

Shoot berries %

Results on the effectiveness of K-silicate and chitosan, applied individually or in combination to the leaves, on the percentage of shoot berries of “Thompson seedless” vines in the two seasons 2023 and 2024 are shown in Table (4). All treatments significantly reduced the proportion of shoot berries compared to the control ($P \leq 0.05$), corresponding to the average values of the two experimental seasons. However, when tested over two seasons, foliar sprays containing 0.1 and 0.2% potassium silicate and chitosan showed no noticeable differences. The proportion of shoot berries was higher in the control and decreased in single or mixed applications. When used in combination with shoot berry reduction %, the lowest reduction was found with 0.2 potassium silicate + 0.2 chitosan, with no significant difference when applying 0.1% potassium silicate + 0.1% chitosan.

Average berry weight (g)

The data in Table 4 showed that individual applications of potassium silicate or chitosan specifically increased average berry weight by 0.1% and 0.2% over the control, with no significant difference between the two concentrations. In contrast to the other treatments, where there was no noticeable change between the vines sprayed with 0.1% and 0.2% potassium silicate and chitosan, respectively, the combined application of these two substances had a much greater impact on improving this quality. However, the highest mean values recorded at the highest concentration for both application and control vines showed the lowest values for these traits over two seasons.

Table 4. Effect of spraying K-silicate and chitosan on Shoot berries %, average berry weight (g), berry longitudinal and berry equatorial of Thompson seedless grapevines during 2023 and 2024 seasons

Characteristics / Treatments	Shoot berries %		Average berry weight (g)		Average berry longitudinal (cm)		Average berry equatorial (cm)	
	2021	**2022**	**2021**	**2022**	**2021**	**2022**	**2021**	**2022**
Control	10.18	10.40	1.53	1.57	1.59	1.64	1.42	1.48
Potassium silicate (0.05%)	8.98	9.20	1.65	1.68	1.66	1.70	1.54	1.58
Potassium silicate (0.1%)	8.21	8.43	1.76	1.80	1.72	1.74	1.61	1.64
Potassium silicate (0.2%)	7.67	7.88	1.84	1.88	1.75	1.76	1.64	1.70
Chitosan (0.05%)	8.10	8.32	1.75	1.77	1.71	1.73	1.60	1.65
Chitosan (0.1%)	7.45	7.45	1.85	1.91	1.77	1.77	1.66	1.72
Chitosan (0.2%)	7.01	6.79	1.92	1.98	1.80	1.78	1.71	1.76
Potassium silicate (0.05) + Chitosan (0.05%)	7.34	6.57	1.86	1.88	1.76	1.77	1.66	1.73
Potassium silicate (0.1%) + Chitosan (0.1%)	6.57	5.69	1.98	2.00	1.82	1.81	1.72	1.81
Potassium silicate (0.2%) + Chitosan (0.2%)	6.13	5.04	2.06	2.09	1.85	1.83	1.75	1.86
New LSD at 5%	**0.6**	**0.7**	**0.08**	**0.09**	**0.04**	**0.03**	**0.05**	**0.06**

Average berry longitudinal

Regarding the data in Table 4, it was found that the highest berry length values were obtained in Thompson seedless vines sprayed with chitosan than when using K-silicate at different concentrations, while the concentrations for K-silicate or chitosan were 0.1 and 0.2%, no significant differences were found. The combination of potassium silicate with chitosan was more effective in improving berry longitudinal shape. However, when plants were sprayed with the control, the berry elongation value was lowest. Meanwhile, vines treated with 0.1% in each application or 0.2% in each application combined recorded the highest average berry longitudinal values in both seasons with no significant difference between them.

Average berry equatorial

As for the equatorial berries, the data presented in Table 4 indicate that with increasing concentrations tested for both potassium silicate and chitosan, there was an increase in the equatorial berries compared to the untreated plant. The highest values were measured with 0.2% chitosan versus the application of 0.2% potassium silicate with no significant difference between them. However, the combined applications achieved higher values than the single application, with the highest average values achieved at 0.2% potassium silicate + 0.2% chitosan, followed by 0.1 potassium silicate + 0.1% chitosan, in each of the two seasons, if there was no discernible difference between them. The effects of K-silicate on the physical quality of berries are consistent with the reports of Abdel Aal *et al*. (2017) who found that foliar application of K-silicate at 0.1% resulted in an increase in berry weight in the longitudinal and equatorial directions. Eisa *et al*. (2023) stated that 2000 ppm potassium silicate in leaf form improved berry number/cluster as well as both berry length and berry width.

The results of Omar *et al*. (2020), Mohamed *et al*. (2021), El-Senosy (2022) on Flame Seedless, Al-Sagheer *et al*. (2023) on Thompson seedless and other studies support this High average values of physical properties of berries caused by the increase in chitosan. These studies all showed that vines treated with higher amounts of algae resulted in an increase in physical berry parameters such as berry weight, length, diameter and shape index.

3. Berry chemical quality characteristics:

Table 5 show the average values of berries chemical quality characters (TSS%, total acidity, TSS/acidity ratio, juice%, and total sugar) of grapevine cv. Thompson seedless as a result of foliar application of K-silicate and/or chitosan at different concentrations during the 2021 and 2022 growing seasons.

Table 5. Effect of spraying K-silicate and chitosan on TSS%, total acidity, TSS/acidity, juice % and total sugar% of Thompson seedless grapevines during 2023 and 2024 seasons.

Characteristics / Treatments	TSS%		Total		TSS/acidity		Juice %		Total	
	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022
Control	19.82	20.37	0.51	0.50	42.16	44.76	82.23	83.00	17.63	18.07
Potassium silicate	20.48	21.13	0.46	0.44	48.99	52.31	84.86	85.08	18.29	18.72
Potassium silicate (0.1%)	21.02	21.57	0.42	0.41	54.32	57.67	85.41	85.52	18.83	19.16
Potassium silicate (0.2%)	21.35	21.79	0.40	0.39	59.15	61.90	85.74	85.63	19.16	19.38
Chitosan (0.05%)	21.13	21.68	0.42	0.41	54.47	57.82	85.30	85.41	18.72	19.27
Chitosan (0.1%)	21.57	22.01	0.39	0.38	59.92	63.06	85.74	85.85	19.27	19.82
Chitosan (0.2%)	21.79	22.12	0.37	0.36	65.04	67.64	85.96	86.07	19.49	20.15
Potassium silicate (0.05)	21.79	22.12	0.39	0.36	60.70	68.05	85.85	85.85	19.27	19.71
Potassium silicate (0.1%)	22.34	22.67	0.36	0.33	67.48	75.56	86.40	86.18	19.71	20.26
Potassium silicate (0.2%)	22.67	22.89	0.34	0.31	74.08	77.06	86.72	86.40	19.93	20.59
New LSD at 5%	0.4	0.3	0.028	0.025	6.1	4.0	0.4	0.3	0.4	0.4

Total soluble solids (TSS%)

The effect of foliar application to grapevines with K-silicate and/or chitosan content on the TSS percentage is shown in Table 5. Total soluble solids content in grapevine berries increased when the amounts of K-silicate or chitosan increased compared to untreated plants. The most extreme average values of total soluble solids % were recorded with 0.2% chitosan (21.79% and 22.12%) in 2023 and 2024, respectively, with no significant difference with 0.2% potassium silicate. The combined foliar application significantly increases the TSS percentage compared to other treatments and the highest mean values were recorded with 0.2% potassium silicate + 0.2% chitosan (22.67 and 22.89% respectively) in 2023 and 2024, followed by the lower concentration for each application mixed together. The same pattern emerged in two seasons.

Total acidity%

Either potassium silicate alone or in combination with chitosan in rates at 0.05, 0.1 and 0.2% compared to the untreated treatment showed a statistically significant reduction in total acidity (Table 5). There was no apparent change in total acidity when the concentration of each substance was increased from medium to high (0.1 to 0.2%). Treating vines with a combination of 0.2% K-silicate and 0.1% chitosan resulted in the greatest overall acid reduction, with no apparent difference between concentrations. Total acid levels were highest in control treatments. These results held true in both years.

TSS/acidity ratio

The data in Table 5 indicate the average mean values of the TSS/acid ratio for the berries of grapevines produced by the application of K-silicate and/or chitosan at the level of 0.05, 0.1 and 0.2% on the leaves were affected in 2023 and 2024. According to the results, the ratio of total solids content to acidity in the berries was significantly increased in all treatments. Furthermore, the highest mean values were recorded for plants sprayed with 0.2% chitosan, which was superior to K-silicate application at 0.2% with no significant difference. The effect of the combination of potassium silicate and chitosan significantly increased the TSS/acid ratio compared to the control. The maximum average was recorded with 0.2% potassium silicate + 0.2% chitosan, followed by the lower concentration of 0.1% each as there was no noticeable difference between them. The other treatments recorded intermediate values in both seasons.

Juice %

The data from Table 5 showed that vines sprayed with potassium silicate and chitosan individually or in combination significantly increased the juice percentage. Foliar application with different concentrations of 0.05, 0.1 and 0.2% for each application increased the sap percentage over the control, with the high increase with 0.2% chitosan followed by 0.2% potassium silicate with no significant difference between them was achieved. However, a significantly higher level of berry juice was observed in vines sprayed with 0.2% for each combined application, followed by a lower concentration of 0.1% for each application, with no discernible difference between them. This trend was clearly visible in two seasons.

Total sugar%

The results reported in Table (5) represent the leaf-level effect of single or mixed treatments with K-silicate and chitosan on total sugars in berries of Thompson seedless grapevines. The results showed that in the 2023 and 2024 seasons, each treatment Total sugar significantly increased compared to the control treatment ($P \leq 0.05$). Nevertheless, no significant differences were found in foliar application of single 0.1 and 0.2% potassium silicate or chitosan in both seasons. Although 0.2% chitosan was better than 0.2% potassium silicate. The combination of K-silicate and chitosan in different concentrations also increased total sugar in both seasons. Nevertheless, the highest average value of total sugar was obtained by applying 2% K-silicate and 2% chitosan on the leaves. Next came the lower concentration (0.1%) from each treatment, with no apparent difference between them. Both seasons showed the same general pattern.

An increase in fruit weight and length resulted in an improvement in fruit yield and fruit quality. This may be caused by potassium, which regulates a range of enzyme activities in plants by altering the pace of photosynthesis and accelerating the movement of leaves through the phloem and into storage tissue (Doaa *et al*., 2019; Kumaran *et al*., 2019). According to previous studies (Amiri and Fallahi, 2007; Ashraf *et al*., 2010; and Upadhyay *et al*., 2019), fruit quality was improved by potassium spraying, which increased chlorophyll concentration and promoted an increase in photosynthetic products and juice content, Fruit size, flavor and color have all been improved. These results are consistent with Abdel Aal *et al*. (2017) who indicated that spraying potassium silicate at a concentration of three times 0.1% improved the TSS percentage, acidity, TSS/acidity of berries, sugar reduction and total anthocyanin content of seedless Crimson grape vines. Furthermore, Awad *et al*. (2023) reported that applying a dose of 5 g/L K-Si to grapevines improved the TSS/acid ratio and the T.A. reduced. in the juiced berries.

According to Khan *et al*. (2012) and Petoumenou and Patris (2021), some enzymes contained in chitosan support the production of proteins, certain phytohormones, amino acids and carbohydrates. This is accompanied by an increase in total sugar content (%TSS) and a decrease in TA (%) in grape juice. The data obtained are also consistent with the findings of Masoud *et al*. (2023) and Mohamed *et al*. (2021) on Early Sweet, El-Senosy (2022) on Flame Seedless and Al-Sagheer *et al*. (2023) agree Thompson seedless. These studies found that as chitosan concentration increased, TSS%, TSS/acid, sugar percentage, and total acid content increased compared to the control.

Conclusion

Foliar treatment of 0.2% potassium silicate + 0.2% chitosan yielded the greatest mean values across the board, with no discernible variation at lower concentrations. From an economical perspective, treating the vines with a medium quantity of potassium silicate (0.1%) and chitosan (0.1%) yielded the greatest outcomes in terms of berry quality and increased quantitative production of "Thompson seedless " grapevines. Therefore, according to the research, a mixed medium concentration of 0.1% is best used under the same conditions.

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تأثير رش سيليكات البوتاسيوم والشيتوزان على إثمار كروم العنب طومسون سيدلس

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الملخص

أجريت الدراسة الحالية على كروم العنب طومسون سيدلس (*Vitis vinifera* L.) التي يبلغ عمرها 20 عامًا، على مدار موســمين متتاليين 2023 ،2024. وكان الغرض من هذه الدراســة هو دراســة تأثيرات الرش الورقي بالشيتوزان على إنتاجية كروم العنب طومسون سيدلس

وكان تأثير الرش الورقي بتراكيز مختلفة من سـليكات البوتاسـيوم و/أو الشـيتوزان خلال موسـمي النمو على نســبــة العقــد، عــدد العنــاقيــد/الكرمــة، وزن العنقود، طول العنقود، عرض العنقود، المحصــول/الكرمه (بالكجم) مقارنة بمعاملة الكنترول. ومع زيادة التركيز عند التطبيق المنفرد لسـليكات البوتاسـيوم والشـيتوزان زادت قيمة متوسـط جميع صـفات العناقيد والمحصـول وسـجلت أعلى القيم عند الرش الشيتوزان بنسبة 0.2% يليها سليكات البوتاسيوم بنسبة 0.2% دون وجود فرق معنوي بينمها.

أدى الرش الورقي للمعاملات المختلفة سـواء من سـليكات البوتاسـيوم أو الشـيتوزان إلى زيادة في الصــفات الطبيعية لحبات العنب مقارنة بمعاملة الكنترول وســجلت أعلى القيم عند الرش الورقي بتركيز 0.2% من الشـيتوزان يليها 0.2% من سليكات البوتاسـيوم لجميع الصـفات ماعد نسـبة الحبات الصـغيرة للعنقود التي انخفضت بالزيادة في التركيز مع عدم وجود فرق معنوي بين التركيزين.

لوحظ زيادة معنوية في جميع الصــفات بزيادة التركيز مع انخفاض معنوي في الحموضــة الكلية حيث سـجلت أعلى القيم عند الرش الورقي بمعدل 0.2% الشـيتوزان يليه 0.2% من سـليكات البوتاسـيوم مع عدم وجود فرق معنوي بينهم. وسـجل ارتفاع في القيم لصـفات الجودة وانخفاض في الحموضـة الكلية عند الرش بخليط من سـليكات البوتاسـيوم والشـيتوزان حيث سـجلت أعلى القيم عند الرش بمعدل 0.2% سليكات بوتاسيوم +0.2% شيتوزان يليها التركيز الأقل منهم (0.1%) مع عدم وجود فرق معنوي بينهم خلال كلا الموسمين وسجلت باقي المعاملات قيماً متوسطة.

الكلمات المفتاحية: الشيتوزان، الرش الورقي، العنب، سيليكات البوتاسيوم، طومسن سيدلس.