Journal of Experimental Agriculture International

Volume 46, Issue 10, Page 290-297, 2024; Article no.JEAI.123538
ISSN: 2457-0591
(Past name: American Journal of Experimental Agriculture, Past ISSN: 2231-0606)

Efficacy of *Ascophyllum nodosum* Seaweed Extracts on Growth, Yield and Quality Parameters in Thompson Seedless Grapes

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.9734/jeai/2024/v46i102949

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/123538

Original Research Article

Received: 15/07/2024
Accepted: 17/09/2024
Published: 08/10/2024

ABSTRACT

The experiment was conducted on Thompson Seedless grafted on Dogridge rootstock planted at ICAR- National Research Centre for Grapes, Pune during the year 2021-2022. The experiments was carried out in completely randomized block design. Standard cultural practices were followed during the experimentation. The *A. nodosum* was applied with different concentration varies from 0.25 kg/ha to 1.25 kg/ ha at 4-6 inch cane growth, 8-14 inch cane growth (14 days after 1st spray), 10 days after fruit set, 2 weeks after 3rd spray, 2 weeks after 4th spray and Version Stage. The result obtained from this study showed that the chlorophyll content index (44.30 µmol/m²), leaf area

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Cite as: *Ramteke, S. D., Amruta Langote, A. H. Gavali, Snehal Khalate, S. R. Bhagwat, and J. N. Kalbhor. 2024. "Efficacy of Ascophyllum Nodosum Seaweed Extracts on Growth, Yield and Quality Parameters in Thompson Seedless Grapes". Journal of Experimental Agriculture International 46 (10):290-97. https://doi.org/10.9734/jeai/2024/v46i102949.*

index (1.88 cm^2), bunch weight (216.16 g), berry diameter (14.83 mm), berry length (19.81 mm), yield/ha (16.86 ton), TSS (21.05^0 Brix) and Acidity (0.66%) were recorded higher in treatment treated with *A.nodosum* @ 0.75kg/ha. From this study, it is concluded that foliar application of *A. nodosum* @ 0.75 kg/ha recorded higher chlorophyll content in leaf and chlorophyll content index also helpful for improving and increasing yield and quality parameters in Grapes.

Keywords: A.nodosum; chlorophyll; growth; quality; yield.

1. INTRODUCTION

Grape (Vitis vinifera L.) is a fruit, botanically a berry, of the deciduous woody vines of the flowering plant genus Vitis and belongs to the family Vitaceae. Grape is one of the essential commercial fruit crops of temperate to tropical regions [1]. India's major grape growing states are Maharashtra, Karnataka, Andhra Pradesh, Telangana, and Tamil Nadu. Among the grape-growing states, Karnataka stands second in area after Maharashtra [2].

Most modern and traditional grape-growing regions are facing challenges due to the unpredictability of weather conditions and warming trends. Innovative and sustainable tools such as seaweed-based bio-stimulants may play a key-role in the development of environment-friendly viticulture strategies to improve yields, biotic/abiotic stress tolerance [3]. Seaweeds are used in agriculture to provide nutrients, bio stimulation and soil conditioning. Seaweed extracts contain several substances that promote plant growth, such as auxins, cytokines, betaines and gibberellins, as well as organic substances, such as amino acids, macronutrients and trace elements, which can improve crop yield and quality [4]. The quality of the grape is depend on berry size, colour and pulp content in the berries while, yield is governed by number of bunches per vine and bunch weight [5].

A. nodosum is an exclusive mixture of beneficial bioactive compound (alginic acid, oligosaccharides, betaines, mannitol, fructose containing polymer, other carbohydrates and nutrients) from *A. nodosum* seaweed. It is powered by Acadian BioSwitch^{tm}, an advanced technology which enhances natural processes within the plants by switching on gene expression and active compound production that stimulates plant growth and protects against environmental stresses. Hence the experiment was conducted to study the effect of *A. nodosum* seaweed extracts on growth, quality and yield of Thompson Seedless grapes in India.

2. MATERIALS AND METHODS

The experiment was conducted on Thompson Seedless grafted on Dogridge rootstock planted at ICAR- National Research Centre for Grapes, Pune during the year 2021-2022. The experiments were carried out in randomized block design. Standard cultural practices were followed during the experimentation. The *A. nodosum* was applied at various doses at different growth stages of grape development as per the protocol. Following treatments were applied by spraying using 1000 liter of water per hectare.

Yield and quality parameters: The mean bunch weight was derived by averaging the weight of ten bunches randomly from each treatment and was expressed in grams per bunch, while 50 berries were randomly selected from each treatment at harvest and their mean weight was recorded to determine the 50 berry weight in grams and calculated by using weighing balance (Adair Dutt, Mumbai, India). Pedicel thickness was derived by averaging the pedicel randomly from each treatment and measured using vernier caliper (RSK, China) and expressed in millimeter (mm). Berry length, berry diameter and berry skin thickness were derived by averaging the 10 berries randomly from each treatment and measured using vernier caliper (RSK, China) while expressed in millimeter (mm). Berry Skin thickness was measured using micro screw gauze (No. 103-101-10, Mitutoyo, Japan) and expressed in micrometer (mm). Total soluble solids and acidity were derived by the juice of 10 berries randomly from each treatment and measured by using hand refractometer (ERMA INC, Tokyo, Japan) and Acid-base titration method respectively. Total soluble solids (TSS) were expressed in degree brix (°β) and acidity was expressed in percentage (%). Total Chlorophyll content was determined by using DMSO method. Total Chlorophyll content index

Table 1. Treatment details

Treatments	Stages of Application					
	4-6 inch cane growth. 1-2 inch bunch	8-14 inch cane growth (14 days after 1st spray)	10 days after fruit set	2 weeks after 3rd spray	2 weeks after 4th spray	Version Stage
T_1	0.25 kg/ha	0.25 kg/ha	0.25 kg/ha	0.25 kg/ha	0.25 kg/ha	0.25 kg/ha
T_2	0.50 kg/ha	0.50 kg/ha	0.50 kg/ha	0.50 kg/ha	0.50 kg/ha	0.50 kg/ha
T_3	0.75 kg/ha	0.75 kg/ha	0.75 kg/ha	0.75 kg/ha	0.75 kg/ha	0.75 kg/ha
T_4	1.00 kg/ha	1.00 kg/ha	1.00 kg/ha	1.00 kg/ha	1.00 kg/ha	1.00 kg/ha
T_5	1.25 kg/ha	1.25 kg/ha	1.25 kg/ha	1.25 kg/ha	1.25 kg/ha	1.25 kg/ha
T_6	Control	-	-	-	-	-

measured with the help of SPAD instrument. LAI quantifies the amount of leaf material in a canopy. The total Leaf area was measured at 45 days after 1st application. LAI are calculated by using fallowing formula.

$$LAI = \text{leaf area } (cm^2) / \text{Ground area } (m^2)$$

LAI is a measure for the total area of leaves per unit ground area and directly related to the amount of light that can be intercepted by plants. The data was analysed using statistical software SAS (version 9.3).

Grape petioles were sampled by using standard method of IIHR [6]. The leaves present on the opposite of the first inflorescence of the cane were chosen for petiole sampling [7]. Petiole sampling was done in the morning hours at the rate of 3-4 leaves per plant and only the petioles were retained. Petiole sampling was done during the 45 days after Oct pruning.

3. RESULTS AND DISCUSSION

3.1 Effect of *A. nodosum* on Chlorophyll Contents in Leaf of Thompson Seedless Grapes

Effect of *A. nodosum* on Chlorophyll content in leaves and Chlorophyll content index (SPAD) was presented in Tables 2 and 3. Result showed that the chlorophyll content was increased due to application of *A. nodosum*. After 1st to 4th spray chlorophyll and Chlorophyll content index (SPAD) value show the increasing pattern but after 4th spray of application, chlorophyll and Chlorophyll content index (SPAD) value decreased. Maximum chlorophyll (mg/g) was found in treatment treated with T_3 (2.79 mg/g) after 7 days of application at 2nd weeks after 3rd spray followed by treatment T_2 (2.49 mg/g). Similar result obtained by [8].

3.2 Effect of *A. nodosum* after 7 Days of Application on Chlorophyll Content Index (µmol/m²) in Thompson Seedless Grapes

Effects of *A. nodosum* on Chlorophyll content index are presented in Table 3.

The Chlorophyll content index was increased due to the application of *A. nodosum*. The highest Chlorophyll content index was recorded in treatment treated with T_3 (44.30 µmol/m²) after 7 days of application at 2nd weeks after 3rd spray followed by treatment T_2 (42.28 µmol/m²). The Chlorophyll content index also enhanced with the application of *A. nodosum* in grapes. Similar result were also reported by [3].

The data presented in Table 4, showed that the leaf area index was increased due to the application of *A. nodosum.* The highest leaf area index was recorded in treatment T_3 (1.88 cm^2) followed by treatment T_2 (1.60 cm^2) after 7 days of application at 2 weeks after 3rd spray. Similar results were reported by [9], they reported that the maximum leaf area reported by using *A. nodosum* in grapes and also reported by [10] in Thompson Seedless grapes [8], they reported that the *A. nodosum* (4 g/l) treatment resulted in significantly the largest leaf area (169.24 cm^2 and 173.97 cm^2) in Flame Seedless.

3.3 Effect of *A. nodosum* on Yield Parameters in Thompson Seedless Grapes

The data on yield and quality parameters was depicted in Tables 5 & 6. Data presented in table showed that, the application of *A. nodosum* increases berry length, berry diameter, average bunch weight, 50 berries weight, TSS, acidity and yield/vine. The data showed that the application of Acadian Gold star significantly

Table 2. Effect of *A. nodosum* after 7 days of application on Chlorophyll content (mg/g) in leaves of thompson seedless grapes

Treatments	Stages of Application					
	4-6 inch cane growth. 1-2 inch bunch	8-14 inch cane growth (14 days after 1st spray)	10 days after fruit set	2 weeks after 3rd spray	2 weeks after 4th spray	Version Stage
T_1	1.01	1.01	1.01	2.37	1.45	1.42
T_2	1.08	1.08	1.08	2.49	1.74	1.89
T_3	1.40	1.40	1.40	2.79	2.17	2.43
T_4	0.98	0.98	0.98	2.07	1.27	1.34
T_5	0.94	0.94	0.94	2.01	1.15	1.17
T_6	0.86	0.86	0.86	0.99	0.92	1.00
SEm(±)	**0.01**	**0.15**	**0.26**	**0.35**	**0.20**	**0.14**
C.D.@ 5 %	**0.03**	**0.46**	**0.77**	**1.05**	**0.59**	**0.40**

Table 3. Effect of *A. nodosum* after 7 days of application on Chlorophyll content index (µmol/m²) (SPAD) in thompson seedless grapes

Treatment	Stages of Application					
	4-6 inch cane growth. 1-2 inch bunch	8-14 inch cane growth (14 days after 1st spray)	10 days after fruit set	2 weeks after 3rd spray	2 weeks after 4th spray	Version Stage
T_1	35.40	36.00	39.62	40.90	40.80	38.51
T_2	37.00	38.80	41.94	42.28	41.70	40.14
T_3	38.40	40.00	42.14	44.30	43.60	41.69
T_4	33.60	34.80	39.30	40.70	39.80	37.64
T_5	33.00	33.20	39.28	39.60	39.40	36.90
T_6	32.20	28.60	32.82	38.60	38.40	34.14
SEm(±)	**1.09**	**0.91**	**1.42**	**0.62**	**0.70**	**0.84**
C.D.@ 5 %	**3.24**	**2.71**	**4.22**	**1.83**	**2.07**	**2.50**

Table 4. Effect of *A. nodosum* after 7 days of application on leaf area index (cm²) in Thompson Seedless Grapes

Treatment	Stages of Application					
	4-6 inch cane growth. 1-2 inch bunch	8-14 inch cane growth (14 days after 1st spray)	10 days after fruit set	2 weeks after 3rd spray	2 weeks after 4th spray	Version Stage
T_1	1.01	1.35	1.23	1.58	1.41	1.35
T_2	1.08	1.41	1.30	1.60	1.42	1.38
T_3	1.40	1.55	1.35	1.88	1.69	1.69
T_4	0.98	1.34	1.20	1.42	1.35	1.33
T_5	0.94	1.24	1.16	1.34	0.99	0.92
T_6	0.86	0.89	0.89	0.98	0.88	0.90
SEm(±)	**0.11**	**0.13**	**0.08**	**0.15**	**0.09**	**0.06**
C.D.@ 5 %	**0.33**	**0.39**	**0.23**	**0.45**	**0.26**	**0.18**

Table 5. Effect of *A. nodosum* on yield parameters of thompson seedless grapes

Treatment	Bunch weight (g)	50 berry weight (g)	Berry length (mm)	Berry diameter (mm)	Yield/ha (t/ha)	Benefit Cost ratio
T_1	193.90	112.66	18.30	13.10	15.12	1:1.51
T_2	213.94	120.60	19.00	14.60	16.69	1:1.67
T_3	216.16	125.78	19.80	14.80	16.86	1:1.69
T_4	194.82	114.50	18.30	13.60	15.20	1:1.52
T_5	192.56	106.76	18.70	13.80	15.02	1:1.50
T_6	174.86	95.72	17.80	13.10	13.64	1:1.36
SEm(±)	**4.77**	**1.25**	**0.03**	**0.03**	**0.37**	**-**
C.D.@ 5 %	**14.16**	**3.70**	**0.09**	**0.08**	**1.10**	**-**

increases the yield and quality parameters. Among the treatments, treatment T_3 (*A. nodosum* @ 0.75Kg/ha) recorded significantly highest bunch weight (216.16 g) and yield/ha (16.48 t/ha) compared to rest of the treatment. The application of *A. nodusum* increases berry weight, Berry size and yield of grapes. Similar results was recorded by [11] and bunch weight by [12]. The maximum berry length (19.80 mm) and berry diameter (14.80 mm) were recorded with the application of Acadian gold star @ 0.75Kg/ha (T_3).

The maximum yield /ha reported in treatment treated with T_3 (*A. nodosum* @ 0.75Kg/ha (16.86 t/ha) fallowed by treatment T_2 (16.69 t/ha). The foliar application of *A. nodosum* increases the yield, similar result reported by [13] in Hamlin, Washington Navel, Pineapple orange and Ruby Red grape fruit. [14] reported same result on grapevines of the cv. Black Magic. [15] Investigated that the foliar application of Acadian seaweed increased yield in Thompson Seedless grapes. Similar result were reported by [16,17] in tomato.

The quality parameters such as T.S.S. and acidity are greatly influenced by the application of *A. nodosum* and presented in Table 6. Among the quality parameters the highest total Soluble Solid (21.05°B) was recorded in treatment treated with T_3 (*A. nodosum* @ 0.75 Kg/Ha). Yield per hectare (16.86 Ton) and Benefit Cost Ratio (1.69) were recorded higher in treatment treated with T_3 (*A. nodosum* @ 0.75Kg/ha). Other quality parameters like Pedicel thickness (0.66 mm) was recorded maximum in treatment treated with T_3 (*A. nodosum* @ 0.75 kg/ha). Among the treatments, the treatment treated with T_3 (*A. nodosum* @ 0.75 kg/Ha) was found to be highly significant for most of the characters i.e. total bunch weight, 50 berry weights, berry length and berry diameter whereas treatment T_3 (*A. nodosum* @ 0.75 kg/Ha) showed significant values for the parameters like pedicel thickness, skin thickness and TSS. From the observations it was observed that the treatment (T_3) *A. nodosum* @ 0.75Kg/ha was effective for enhancement of length and diameter of grapes berry. Similar result found by (11). The different doses of *A. nodosum* have showed effects on yield and quality parameters in grapes. Similar result obtained by (12). The TSS acidity ratio were reported higher in treatment treated with T_3 (*A. nodosum* @ 0.75 kg/Ha) i.e. 31.86. The application of sea weed extract (*A. nodosum*) increases TSS acidity ratio. Similar result were reported in Thompson Seedless by [8,18,19].

3.4 Correlation between Different Parameters of Thompson Seedless Grapes

The correlations between different parameters are studied present in Table 7. The positive and negative correlations between different yields and quality parameters are found due to use of different concentration of *A. nodosum.*

The bunch weight are positively correlated with yield per ha. The berry length and berry diameter showed very strong positive relationship with each other. The Acidity was negatively correlated with bunch weight, 50 berry weight, berry length, berry diameter and yield. Berry length, berry diameter and berry weight found positive relation with each other. Similar result reported by [20].

Table 6. Effect of *A. nodosum* on quality parameters of thompson seedless grapes

Treatment	TSS (^{0}Brix)	Acidity (%)	TSS/Acidity ratio	Skin thickness (mm)	Pedicel thickness (mm)
T_1	19.36	0.74	26.37	0.30	0.17
T_2	20.57	0.69	29.87	0.30	0.13
T_3	21.05	0.66	31.86	0.26	0.16
T_4	20.68	0.67	30.94	0.32	0.14
T_5	19.56	0.72	27.33	0.28	0.12
T_6	18.65	0.77	24.40	0.33	0.16
SEm(±)	**0.34**	**0.02**	**0.95**	**0.01**	**0.01**
C.D.@ 5 %	**1.02**	**0.07**	**2.81**	**0.04**	**0.03**

Table 7. Correlation between different parameters of Thompson Seedless grapes

	Bunch weight (g)	50 berry weight (g)	Berry length (mm)	Berry diameter (mm)	Yield/ha (t/ha)	TSS (^{0}Brix)	Acidity (%)	TSS/ Acidity ratio
Bunch weight (g)	1							
50 berry weight (g)	0.965	1						
Berry length (mm)	0.909	0.852	1					
Berry diameter (mm)	0.907	0.803	0.924	1				
Yield/ha (t/ha)	1.000	0.965	0.908	0.908	1			
TSS (^{0}Brix)	0.874	0.916	0.780	0.818	0.875	1		
Acidity (%)	-0.817	-0.870	-0.753	-0.777	-0.817	-0.990	1	
TSS/Acidity ratio	0.834	0.887	0.762	0.791	0.835	0.996	-0.998	1

Table 8. Nutrient contents in petioles of thompson seedless grapes at 45 DAP

Treatment	N %	P %	K %	Ca %	Mg %	S %	Fe ppm	Mn ppm	Cu ppm	Boron ppm	Mo %	Na %
T_1	1.53	0.23	2.51	0.58	0.31	0.09	98	111	61	82.01	0.58	0.2
T_2	1.77	0.55	3.22	0.83	0.36	0.18	101	65	38	50.65	0.39	0.25
T_3	1.83	0.68	3.65	0.99	0.47	0.21	126	48	29	43.42	0.56	0.41
T_4	1.65	0.67	2.48	0.75	0.34	0.14	54	68	37	48.24	0.44	0.26
T_5	1.53	0.52	2.85	0.68	0.33	0.13	87	77	40	47.44	0.49	0.28
T_6	1.48	0.51	3.12	0.78	0.29	0.17	56	43	79	53.81	0.48	0.3

3.5 Nutrient Contents in Petioles of Thompson Seedless Grapes

The recorded on nutrient status in leaf petioles presented in Table 8. Plant petioles (50–60) at 5th Node position were collected during fruit bud differentiation stage after October pruning following the procedure described by [21]. The nitrogen content in grape petioles reported higher (1.83 %) in treatment treated with T_3 (*A. nodosum* @ 0.75Kg/ha) fallowed by T2 (1.77%). Similar result reported by [22]. They reported that the highest petiole nitrogen (2.96 and 2.12%) was observed in high yielding vineyards. The phosphorus (0.68 %) and potassium content (3.65%) in grape petioles reported higher in treatment treated with T_3 (*A. nodosum* @ 0.75Kg/ha) fallowed by treatment T_2. Similarly the calcium (99%), magnesium (0.47 %) and sulphur content (0.21%) in grape petioles reported maximum in treatment treated with T_3 (*A. nodosum* @ 0.75Kg/ha) [23], they reported that the highest nitrogen, phosphorus, potassium, calcium, magnesium and sulphur content was recorded higher in table purpose white type grape varieties.

4. CONCLUSION

The present study illustrated that the all treatments of *A. nodosum* increases chlorophyll content index in leaf, yield and quality parameters as compared to untreated control. The application of *A. nodosum* @ 0.50kg/ha and 0.75 kg/ha found to increases the chlorophyll content in leaf. The Berry length, diameter, yield per vine, yield per acre, yield per ha and TSS (Brix) was recorded higher in treatment treated with *A. nodosum* @ 0.75kg/ha. Hence, it can concluded from this study, that the application of *A. nodosum)* @ 0.75 kg/ha is better for yield and quality parameters.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

ACKNOWLEDGEMENT

The authors are thankful to the Director, Pune for providing all the field and laboratory facilities for conducting this experiment and also thankful to Acadian sea plant company for providing *Ascophyllum nodosum* as a brand name of product i.e. Acadian Golstar.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/123538