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EFFECT OF BUNCH LOAD AND FOLIAR APPLICATION OF MICRONUTRIENTS ON QUALITY OF GRAPES CV. THOMPSON SEEDLESS

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ABSTRACT

Grape (*Vitis vinifera* L.), traditionally a temperate region fruit crop, faces challenges such as uneven ripening, poor bunch development and susceptibility to abiotic stresses when cultivated in India's tropical or subtropical belts. To address these issues, the present study "Effect of bunch load and foliar application of micronutrients on the quality of grapes cv. Thompson Seedless" was conducted during the year of 2023-24 at Horticulture Research and Extension Centre (HREC), Tidagundi, Vijayapura, under the University of Horticultural Sciences, Bagalkot. The experiment was laid out in a Factorial Randomized Block Design (FRBD) with eight treatments and three replications. Among different treatments, B_1M_3 (35 bunches/vine) with foliar application combination of [Si (1 g/L) + Ca-EDTA (0.5 g/L) + B (0.05 %)] resulted in highest TSS (22.50 °Brix), ascorbic acid (4.26 mg/100g), berry firmness (4.58 N), juice content (76.22 %), TSS: acid ratio (56.25) and lowest titratable acidity (0.40 %) and physiological loss of weight (PLW) at 2nd, 4th and 6th day (6.13, 11.25 and 17.78 %) was recorded respectively.

***Keywords*:** Grapes, bunch load, micronutrients, quality

Introduction

Grapes (*Vitis vinifera* L.) belonging to the vitaceae family, are globally cherished for their flavour and nutritional benefits. As non-climacteric fruits, they do not ripen after harvest and grow on perennial vines. Originating from the Black and Caspian Sea regions, they are rich in sugars, vitamins, minerals and tannins, making them a valuable part of diets worldwide.

The best grapes are produced when there is a balance between vegetative growth and crop yield (Dry *et al.,* 2004). Gladstones defined vine balance as the equilibrium between vegetative vigor and fruit load, which is crucial for high fruit quality. Balanced pruning is commonly used to regulate this balance. However, maximizing bunches per vine can lower fruit quality (Somkuwar and Ramteke, 2006). Bunch regulation, which limits the number of bunches per vine, improves quality by increasing total soluble solids (TSS). Excessive bunches lead to reduced berry set and drying at the cluster tips, highlighting the importance of bunch load management for enhancing berry quality.

Micronutrients are crucial for enhancing fruit quality, profitability and overall plant health with foliar application being an effective way to boost nutrition. Minerals like boron, calcium and silicon play key role in grapevine growth and quality. Boron aids in pollination and sugar translocation, while calcium strengthens cell walls and improves fruit firmness and shelf life. Silicon enhances resistance to pests, stress tolerance and fruit quality by increasing sugar content (Khilari *et al.*, 2020). This study focuses on the effects of bunch load and micronutrient application on the quality of Thompson Seedless grapes.

Material and Methods

The present investigation "Effect of bunch load and foliar application of micronutrients on the quality of grapes cv. Thompson Seedless" was conducted during 2023-2024 at Horticultural Research and Extension Centre (HREC) Tidagundi, Vijayapura district, Karnataka. The ten-year-old experimental vineyard featured medium black soils with a pH of 7.5 to 8.5 and was planted with grapevines grafted onto Dogridge rootstock at a spacing of 3.1 × 1.5 meters using the Y-trellis training system. The vineyard was irrigated through a drip system, with backward pruning practiced on April 10th, 2023 and fore pruning on October 13th, 2023.

No. of treatments	: 08
No. of replications	: 03
No. of vines/ treatment	: 05
Design	: FRBD

Treatment details

Treatment		Bunch load (B) and micronutrients (M)
T_1	:	B_1M_1
T_2	:	B_1M_2
T_3	:	B_1M_3
T_4	:	B_1M_4
T_5	:	B_2M_1
T_6	:	B_2M_2
T_7	:	B_2M_3
T_8	:	B_2M_4

Total soluble solids (°Brix)

The total soluble solid content was measured using a digital hand refractometer. The ripened berries from all treatments were squeezed and the TSS percentage was directly read and recorded in degrees Brix.

Titratable acidity (%)

The estimation of titratable acidity in fresh juice followed the procedure outlined by Ranganna (1979). Acidity was assessed in terms of tartaric acid by diluting the juice extracted from a five-gram sample. The juice was filtered through muslin cloth, further diluted with distilled water to a total volume of 100 ml and an aliquot was taken for titration. This aliquot was titrated with standard 0.1 N NaOH using phenolphthalein as an indicator until a bright pink endpoint was achieved. The percentage of titratable tartaric acid in the fruit was then calculated to represent the acidity values.

$$\text{Acidity \%} = \frac{\text{Titrable value} \times \text{Normality of NaOH} \times \text{volume made up} \times \text{Equivalent weight of acid}}{\text{Volume of sample for estimation} \times \text{weight or volume of sample taken}}$$

TSS to acid ratio

The TSS to acid ratio was calculated by dividing the total soluble solids (°Brix) by the titratable acidity (%) of the fruits.

Ascorbic acid content (mg/100g of fresh weight)

The ascorbic acid or vitamin C content of the juice was determined using the dye solution (dichlorophenolindophenol) binding method. The results were expressed as milligrams per 100 grams of sample fresh weight (Anon., 1980).

$$\text{Ascorbic acid} = \frac{0.5\,\text{mg} \times V_2 \times 100\,\text{m}}{1 \times 5\,\text{ml} \times \text{weight of sample}}$$

Berry firmness (N)

The firmness of the grape berries was measured using a TAXT plus texture analyzer (Make: Stable Micro System, Model: Texture Export Version 1.22). The force applied to cut the sample was recorded and the peak force value from the graph was used to determine the texture value in Newtons (N). The following instrument settings were used during the experiment.

Type of probe used	: 2 mm Piercing probe
Test option used	: Return to start
Test Speed	: 5.0 mm/s
Post-test speed	: 10.00 mm/s
Distance	: 10 mm
Load cell	: 5 kg

Juice content (%)

The berry juice content was determined by weighing 100 berries and extracting their juice. The juice content was then calculated as the ratio of the juice volume to the weight of the berry pulp.

$$\text{Juice per cent (v/w)} = \frac{\text{Volume of juice (ml)}}{\text{Weight of berry pulp (g)}} \times 100$$

Physiological loss of weight (PLW)

The physiological loss of weight (PLW) was measured every two days by storing the bunches at room temperature. The PLW was calculated as a percentage using the following formula.

$$\text{Physiological loss in weight (\%)} = \frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}} \times 100$$

Results and Discussion

Table 1: TSS, titratable acidity and TSS: acid ratio of grapes cv. Thompson Seedless as influenced by bunch load management and foliar application of micronutrients

Treatments	TSS (°Brix)	Titratable acidity (%)	TSS: acid ratio
B_1M_1	20.32	0.45	45.16
B_1M_2	20.15	0.44	45.80
B_1M_3	22.50	0.40	56.25
B_1M_4	21.72	0.41	52.98
B_2M_1	18.52	0.57	32.49
B_2M_2	19.55	0.52	37.60
B_2M_3	19.68	0.47	41.87
B_2M_4	19.24	0.49	39.27
S.Em ±	**0.27**	**0.008**	**0.56**
CD at 5%	**0.83**	**0.025**	**1.71**

B_1- 35 Bunch M_1-Zn (0.03 %)
B_2- 50 Bunch M_2-B (0.05 %)
M_3-[Si (1 g/L) +Ca-EDTA (0.5 g/L) +B (0.05 %)]
M_4-[Zn (0.03 %) +Mn (0.05 %) +Fe (0.07 %)]

The maximum TSS (22.50 °Brix), TSS: acid ratio (56.25) and minimum titratable acidity (0.40 %) was recorded in treatment B_1M_3, followed by treatment B_1M_4 TSS (21.72 °Brix), TSS: acid ratio (52.98) and titratable acidity (0.41 %). In contrast, the lowest TSS (18.52 °Brix), TSS: acid ratio (32.49) and maximum titratable acidity (0.57 %) were observed in treatment B_2M_1 as shown in Table 1. The superior TSS and TSS: acid ratio along with reduced titratable acidity observed in treatment B_1M_3 are due to the synergistic effects of an optimal bunch load (35 bunches per vine) and targeted micronutrient application (Si 1 g/L + Ca-EDTA 0.5 g/L + B 0.05 %). A moderate bunch load minimizes competition among berries for nutrients, allowing for greater carbohydrate accumulation in each berry, which directly increases TSS levels. The specific micronutrients in this treatment further enhance these effects: silicon improves photosynthetic efficiency, water regulation and promoting sugar transport to the berries. Calcium strengthens cell wall integrity, indirectly aiding in sugar retention as the berries ripen and boron is essential for carbohydrate metabolism, enabling the efficient movement of sugars within the plant. Together, these factors elevate TSS while simultaneously reducing titratable acidity, as ripening involves a decline in organic acids. This combination results in a higher TSS: acid ratio, yielding a sweeter, more appealing flavor profile and demonstrating the advantages of aligning optimal bunch load with precise micronutrient support. These results align with the findings of Jayasena and Cameron (2008) in Crimson Seedless table grapes, Veena *et al.* (2015) in coloured and white grape, Fawzi *et al.* (2015) in Superior grape cultivar, Somkuwar *et al.* (2014) in table grape cv. Jumbo Seedless and Khilari *et al.* (2020) in table grapes.

Table 2: Juice, ascorbic acid and berry firmness of grapes cv. Thompson Seedless as influenced by bunch load and foliar application of micronutrients

Treatment	Juice (%)	Ascorbic acid (mg/100g fresh weight)	Berry firmness (N)
B_1M_1	71.33	3.88	4.10
B_1M_2	71.77	3.97	4.18
B_1M_3	76.22	4.26	4.58
B_1M_4	73.10	4.08	4.31
B_2M_1	64.70	3.04	3.23
B_2M_2	66.50	3.42	3.58
B_2M_3	67.06	3.74	3.89
B_2M_4	68.20	3.63	3.71
S.Em ±	**0.69**	**0.05**	**0.05**
CD at 5 %	**2.10**	**0.17**	**0.15**

B_1- 35 Bunch M_1-Zn (0.03 %)
B_2- 50 Bunch M_2-B (0.05 %)
M_3-[Si (1 g/L) +Ca-EDTA (0.5 g/L) +B (0.05 %)]
M_4-[Zn (0.03 %) +Mn (0.05 %) +Fe (0.07 %)]

Maximum juice content (76.22 %) was recorded in treatment B_1M_3 followed by treatment B_1M_4 (73.10 %), in contrast minimum juice content (64.70 %) was recorded in treatment B_2M_1. This is attributed to the optimal combination of fewer bunches per vine and the foliar application of a micronutrient mix that includes silicon, calcium and boron. Fewer bunches per vine as in B_1, reduce competition for resources leading to larger berry size, greater length and diameter which contributes to higher juice content. The M_3 treatment with its combination of silicon, calcium and boron further enhances this effect. Silicon strengthens cell walls and supports overall berry development, while calcium improves cell integrity and supports larger fruit formation. Boron facilitates better fruit set and growth, resulting in bigger berries with more internal juice capacity. The results are in close conformity with the finding of Chalak (2008) in grapes, Satisha *et al.* (2013) in wine grapes, Shubhangini (2016) in grapes cv. Red Globe, Porika *et al.* (2015) in grapes cv. Red Globe and Khilari *et al.* (2020) in table grapes .

The maximum berry firmness (4.58 N) recorded in treatment B_1M_3, followed by B_1M_4 (4.31 N). However, treatment B_2M_1 recorded the minimum berry firmness (3.23 N). The higher firmness in B_1M_3 is attributed to fewer bunches per vine, which reduces competition for resources such as nutrients and water leading to better berry development. With fewer bunches each berry receives a more concentrated supply of these essential resources, enhancing its structural integrity and firmness. In addition, the foliar application of silicon, calcium and boron further supports berry firmness by strengthening cell walls, improving cell turgor and promoting overall berry health. However, B_2M_1 with a higher bunch load and only zinc application results in increased competition among berries for nutrients and water reducing individual berry firmness. This interaction highlights how optimal bunch load combined with effective micronutrient treatments can significantly enhance berry firmness. These results align with the findings of Jayasena and Cameron (2008) in Crimson Seedless table grapes, Khalil *et al.* (2020) in grapes cv. Sahebi, Somkuwar *et al.* (2014) in grape cv. Jumbo Seedless and Khilari *et al.* (2020) in table grapes.

The interaction between bunch load and foliar micronutrient treatments significantly affected ascorbic acid content in B_1M_3 (35 bunches per vine with silicon, calcium and boron) yielding the highest (4.26 mg/100g) and B_2M_1 (50 bunches per vine with zinc) recorded lowest (3.04 mg/100g) ascorbic acid content. The lower bunch load in B_1M_3 allows better resource allocation, minimizing competition and enhancing ascorbic acid synthesis. Silicon strengthens cell walls, calcium stabilizes cell membranes and boron improves nutrient transport, all contributing to increased antioxidant production. Conversely, higher bunch load in B_2M_1 may limit nutrient uptake and metabolic efficiency, leading to lower ascorbic acid levels, these results align with the findings of Khilari *et al.* (2020) in table grapes.

Table 3: Physiological loss in weight of grapes cv. Thompson Seedless as influenced by bunch load and foliar application of micronutrients

Treatments	Physiological loss in weight (%)			
	2^{nd} day	4^{th} day	6^{th} day	Mean
B_1M_1	7.50	13.32	19.32	13.38
B_1M_2	7.11	13.11	19.11	12.04
B_1M_3	6.13	11.25	17.78	11.72
B_1M_4	6.20	12.71	18.67	12.52
B_2M_1	8.98	15.45	23.67	16.03
B_2M_2	8.61	14.82	20.82	14.75
B_2M_3	8.25	14.11	20.11	14.15
B_2M_4	8.40	14.30	20.33	14.34
S.Em ±	**0.13**	**0.19**	**0.30**	
CD at 5 %	**0.41**	**0.58**	**0.90**	

B_1- 35 Bunch M_1-Zn (0.03 %)
B_2- 50 Bunch M_2-B (0.05 %)
M_3-[Si (1 g/L) +Ca-EDTA (0.5 g/L) +B (0.05 %)]
M_4-[Zn (0.03 %) +Mn (0.05 %) +Fe (0.07 %)]

The influence of bunch load, foliar micronutrient treatments and their interactions on physiological loss of weight (PLW) was recorded on the 2^{nd}, 4^{th} and 6^{th} day after storage. Among all interactions, the B_1M_3 treatment recorded the lowest PLW (6.13 %) on the 2^{nd} day, (11.25 %) on the 4^{th} day and (17.78 %) on the 6^{th} day. However, the B_2M_1 treatment exhibited the highest PLW (8.98 %) on the 2^{nd} day, (15.45 %) on the 4^{th} day and (23.67 %) on the 6^{th} day. The reduced PLW in B_1M_3 can be attributed to fewer bunches per vine, which enhances berry firmness, skin thickness and texture, coupled with the beneficial effects of silicon, calcium and boron in improving overall berry quality and reducing moisture loss. Conversely, the higher bunch load in B_2M_1 and the sole application of zinc result in increased moisture loss due to reduced berry firmness and less effective micronutrient support. The results are in close conformity with the finding of Srivastava and Soni (1989) in Perlette grapes and Kumar and Rajan (2008) in grape cv. Flame Seedless and Pusa Navrang.

Conclusion

The study concluded that, different bunch load and foliar micronutrient applications significantly influenced quality of Thompson Seedless grapes. 35 bunches per vine treated with a combination of Si 1 g/L + Ca-EDTA 0.5 g/L + B 0.05 % followed by vines with 35 bunches and application of Zn 0.03 % + Mn 0.05 % + Fe 0.07 % showed improved quality traits. These findings emphasize that the combination of silicon, calcium and boron contributes significantly to overall grape production, positively affecting quality.

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