*Plant Archives* Vol. 25, Supplement 1, 2025 pp.1069-1075 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org
DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2025.v25.supplement-1.145

# EFFECT OF BUNCH LOAD AND FOLIAR APPLICATION OF MICRONUTRIENTS ON GROWTH AND YIELD OF GRAPES CV. THOMPSON SEEDLESS

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(Date of Receiving : 09-08-2024; Date of Acceptance : 20-10-2024)

**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 growth and yield 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 the highest leaf chlorophyll (33.03 and 34.93 SPAD values), leaf area (85.94 and 137.09 cm²), specific leaf area (148.17 and 187.79 cm²/g) and the lowest specific leaf weight (6.75 and 5.43 mg/cm²) at 45 and 90 days after forward pruning (DAFP). This treatment also had the maximum berry length (22.16 mm), berry diameter (16.82 mm), number of berries per bunch (162.32), 100 berries weight (247.70 g), bunch weight (368.80 g), bunch length (22.11 cm), bunch width (10.25 cm), bunch volume (305.10 cm³), pedicel thickness (2.67 mm), benefit-to-cost ratio (2.84:1) and minimum berry shattering (3.82 %). The highest yield (14.41 kg/vine and 30.98 t/ha) was observed in treatment $B_2M_3$.
***Keywords*:** Grapes, bunch load, micronutrients, growth, yield

## 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.

India has a substantial grape cultivation area of 152,000 hectares, yielding 32.13 lakh metric tons annually, with an average productivity of 21.13 tons per hectare (Anon., 2021). Major grape-growing states include Maharashtra, Karnataka, Andhra Pradesh, Tamil Nadu, and regions in the North-West. Maharashtra leads, producing about 80 % of India's grapes, with Nasik and Vijayapura districts being top producers. Around 72 % of the production is used for table purposes, 22 % for raisins, and small portions for wine and juice. The northern dry zone of Karnataka also contributes significantly to India's grape cultivation.

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 yield, profitability and overall plant health with foliar application being an effective way to boost nutrition. Minerals like boron, calcium and silicon play key roles 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. This study focuses on the effects of bunch load and micronutrient application on the growth and yield of Thompson Seedless grapes.

## Material and Methods

The present investigation on the "Effect of bunch load and foliar application of micronutrients on the growth and yield 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 Dog Ridge 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 10$^{th}$, 2023 and fore pruning on October 13$^{th}$, 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) |
|---|---|---|
| $T_1$ | : | $B_1M_1$ |
| $T_2$ | : | $B_1M_2$ |
| $T_3$ | : | $B_1M_3$ |
| $T_4$ | : | $B_1M_4$ |
| $T_5$ | : | $B_2M_1$ |
| $T_6$ | : | $B_2M_2$ |
| $T_7$ | : | $B_2M_3$ |
| $T_8$ | : | $B_2M_4$ |

**Leaf chlorophyll (SPAD value)**

A SPAD-502 meter was used to quantify the chlorophyll content (SPAD values) of completely opened and physiologically matured leaves borne opposite to the inflorescence in each vine. This procedure was replicated across all treatments at 45 and 90 days after forward pruning.

**Leaf area (cm$^2$)**

Leaf area was calculated using the linear method (LBK method), where five leaves per vine were selected and the mean was calculated and expressed in square centimeters. The following is the mathematical formula for calculating it.

$$\text{Leaf area (LA)} = L \times B \times K\ (0.81)$$

Where

L = maximum length, B = maximum breadth and
K = Correction factor

**Specific leaf area (SLA) (cm$^2$/g)**

Five physiologically matured leaves per vine were collected after 45 and 90 days of fore pruning. Leaf area was measured by using LBK method and expressed in cm². Subsequently, the same leaves were oven-dried at 60°C and their dry masses were calculated and expressed in grams. Specific Leaf Area (SLA) values were obtained by dividing the leaf area by the dry weight of the same leaf. The resulting values are expressed in cm²/g.

$$SLA = \frac{\text{Leaf area (cm}^2)}{\text{Leaf dry weight (g)}}$$

**Specific leaf weight (SLW) (mg/cm$^2$)**

Five physiologically matured leaves per vine were collected after 45 and 90 days of fore pruning. Leaf area was measured using the LBK method and expressed in cm². The same leaves were then oven-dried at 60°C and their dry masses were determined and expressed in milligrams (mg). Specific Leaf Weight (SLW) values were obtained by dividing the dry weight of the leaf by the leaf area. The resulting values are expressed in mg/cm².

$$SLW = \frac{\text{Leaf dry weight (mg)}}{\text{Leaf area (cm}^2)}$$

**Berry length (mm)**

The length of berries was measured with a digital vernier calliper, selecting them randomly from each of the three separate bunches within a replication of each treatment. Measurements were recorded in millimeters (mm).

**Berry diameter (mm)**

The berry diameter was measured in the middle of the fruit at its maximum width using digital vernier calliper. The mean berry diameter is represented in mm.

**Bunch weight (g)**

An electronic weighing balance was utilized to weigh the grape bunches. The weight of three bunches were averaged during harvest to determine the mean bunch weight and expressed in grams (g).

**Bunch length (cm)**

The length of the bunch was measured from its base to its tip. To calculate the mean bunch length, the length of five bunches was averaged at harvest. The resultant mean bunch length was stated in centimeters (cm).

**Bunch width (cm)**

The width of the bunch was measured from the left end to the right-side end of the bunch. The mean width of the bunch was obtained by averaging the widths of five bunches at harvest. This mean bunch width was used to determine the overall mean bunch width and was expressed in centimeters (cm).

**100 berries weight**

The weight of 100 berries was observed by randomly picking 100 berries from each of three bunches in all treatments, considering replications. They were weighed using a digital weighing balance and their mean weight was expressed in grams (g).

**Bunch volume (cm$^3$)**

The volume of harvested bunches from each replication of each treatment was determined by dipping the bunches in a volumetric beaker filled with water. The volume of replacement (overflowed) water was measured using a volume tube, giving the bunch volume, which was expressed in cubic centimeters.

**Pedicel thickness (mm)**

Pedicel thickness was measured using a digital vernier calliper and recorded in millimeters (mm).

**Cost: Benefit ratio**

The benefit-cost ratio (BCR) is a measure that compares the total benefits of a project or investment to its total cost. It is calculated using the formula.

$$\text{Cost : Benefit ratio} = \frac{\text{Gross income (Rs/ha)}}{\text{Total cost of cultivation (Rs/ha)}}$$

**Berry shattering (%)**

The berry shattering percentage was determined by shaking the bunch after harvest and counting the dropped berries in comparison to the total number of berries in the bunch. It was expressed as a percentage (%).

**Yield (kg/vine)**

The yield per vine was calculated by multiplying the average bunch weight by the average number of bunches per vine. It was represented in terms of kilograms (kg).

**Yield (t/ha)**

The yield per hectare was calculated by multiplying the yield per vine by the total number of vines per hectare. It was represented in terms of tons (t).

## Results and Discussion

The highest leaf chlorophyll (33.03 and 34.93 SPAD values), leaf area (85.94 and 137.09 cm²) and specific leaf area (148.17 and 187.79 cm²/g) was recorded in treatment $B_1M_3$, followed by treatment $B_1M_4$ with leaf chlorophyll (31.05 and 33.05 SPAD values), leaf area (84.95 and 133.99 cm²) and specific leaf area (139.27 and 176.30 cm²/g). In contrast, the lowest leaf chlorophyll (27.19 and 29.19 SPAD values), leaf area (76.18 and 119.66 cm²) and specific leaf area (113.71 and 158.49 cm²/g) were observed in treatment $B_2M_1$. Additionally, the lowest specific leaf weight (6.75 and 5.43 mg/cm²) was recorded in $B_1M_3$ at 45 and 90 days after forward pruning (DAFP) as shown in Table 1. The superior performance in $B_1M_3$ can be attributed to the synergistic effects of an optimal bunch load (35 bunches per vine) and micronutrient application (Si 1 g/L + Ca-EDTA 0.5 g/L + B 0.05 %). A moderate bunch load ensures balanced nutrient allocation, avoiding overstretching resources which supports efficient leaf development and photosynthesis. Silicon enhances stress tolerance and chlorophyll retention; calcium strengthens cell structure and nutrient transport and boron promotes cell division and leaf expansion. The lower specific leaf weight in $B_1M_3$ reflects thinner, more efficient leaves, enhancing photosynthetic activity. These findings are in consistent with those of Omar and abdel (2000) in Thompson Seedless, El Baz *et al*. (2002) in Crimson Seedless, Ashwini *et al.* (2016) in wine grapes, Khilari *et al.* (2020) in table grapes and Suhasini (2020) in Fantasy Seedless.

**Table 1:** Leaf chlorophyll, leaf area, Specific leaf area and specific leaf weight of grapes cv. Thompson Seedless as influenced by bunch load and foliar application of micronutrients

| Treatment | Leaf chlorophyll (SPAD values) | | Leaf area ($cm^2$) | | Specific leaf area (SLA) ($cm^2/g$) | | Specific leaf weight (SLW) ($mg/cm^2$) | |
|---|---|---|---|---|---|---|---|---|
| | 45 DAFP | 90 DAFP | 45 DAFP | 90 DAFP | 45 DAFP | 90 DAFP | 45 DAFP | 90 DAFP |
| **$B_1M_1$** | 29.22 | 31.19 | 80.89 | 133.63 | 130.47 | 169.15 | 7.66 | 5.91 |
| **$B_1M_2$** | 29.91 | 31.91 | 81.87 | 132.35 | 134.21 | 171.89 | 7.45 | 5.82 |
| **$B_1M_3$** | 33.03 | 34.93 | 85.94 | 137.09 | 148.17 | 187.79 | 6.75 | 5.43 |
| **$B_1M_4$** | 31.05 | 33.05 | 84.95 | 133.99 | 139.27 | 176.30 | 7.18 | 5.67 |
| **$B_2M_1$** | 27.19 | 29.19 | 76.18 | 119.66 | 113.71 | 158.49 | 8.79 | 6.73 |
| **$B_2M_2$** | 27.46 | 29.62 | 77.08 | 128.13 | 115.04 | 160.56 | 8.48 | 6.41 |
| **$B_2M_3$** | 27.40 | 29.43 | 78.37 | 130.83 | 122.45 | 164.36 | 8.17 | 6.08 |
| **$B_2M_4$** | 27.43 | 29.40 | 78.63 | 131.64 | 120.97 | 162.51 | 8.27 | 6.18 |
| **S.Em ±** | **0.55** | **0.57** | **0.45** | **1.27** | **1.38** | **1.93** | **0.09** | **0.08** |
| **CD at 5 %** | **1.69** | **1.73** | **1.36** | **3.86** | **4.20** | **5.87** | **0.28** | **0.26** |

DAFP- Days after forward pruning

$B_1$- 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 berry length (22.16 mm), diameter (16.82 mm) and berries per bunch (162.32 berries/bunch) was recorded in treatment $B_1M_3$ followed by treatment $B_1M_4$ with a berry length (20.94 mm), berry diameter (16.02 mm) and berries per bunch (156.12 berries/bunch). Additionally, the highest 100 berries weight was recorded in treatment $B_1M_3$ (247.40 g) which was statistically on par with $B_1M_4$. In contrast, the minimum berry length (16.35 mm), berry diameter (14.28 mm), berries per bunch (128.19 berries/bunch) and 100-berry weight (191.19 g) were observed in $B_2M_1$ as shown in Table 2. These differences can be attributed to the synergistic effects of silicon, calcium and boron, where silicon strengthens cell walls and enhances stress tolerance, calcium promotes cell division and membrane stability and boron supports reproductive growth and sugar transport. These combined effects likely improved berry size, weight and overall fruit set. These results are in accordance with the findings of Anjum *et al.* (2020) in grapes cv. Sultanina, Khalil *et al.* (2020) in grapes, Al-Atrushy *et al.* (2019) in grapevine cv. Mirane and Khilari *et al.* (2020) in table grapes.

**Table 2:** Berry length, berry diameter, number of berries per bunch and 100 berries weight of grapes cv. Thompson Seedless as influenced by bunch load and foliar application of micronutrients

| Treatment | Berry length (mm) | Berry diameter (mm) | Number of berries per bunch | 100 berries weight (g) |
|---|---|---|---|---|
| **$B_1M_1$** | 18.96 | 15.52 | 142.22 | 227.58 |
| **$B_1M_2$** | 19.52 | 15.81 | 146.19 | 232.72 |
| **$B_1M_3$** | 22.16 | 16.82 | 162.32 | 247.40 |
| **$B_1M_4$** | 20.94 | 16.02 | 156.12 | 243.39 |
| **$B_2M_1$** | 16.35 | 14.28 | 128.19 | 191.19 |
| **$B_2M_2$** | 17.74 | 14.87 | 134.26 | 201.60 |
| **$B_2M_3$** | 18.15 | 15.25 | 137.19 | 222.05 |
| **$B_2M_4$** | 18.01 | 15.11 | 135.17 | 217.18 |
| **S.Em ±** | **0.24** | **0.22** | **2.00** | **1.68** |
| **CD at 5 %** | **0.74** | **0.69** | **6.07** | **5.10** |

$B_1$- 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 %)]

**Table 3:** Bunch weight, bunch length, bunch width, bunch volume, pedicel thickness and shattering per cent of grapes cv. Thompson Seedless as influenced by bunch load foliar application of micronutrients

| Treatment | Bunch weight (g) | Bunch length (cm) | Bunch width (cm) | Bunch volume ($cm^3$) | Pedicel thickness (mm) | Shattering (%) |
|---|---|---|---|---|---|---|
| **$B_1M_1$** | 333.91 | 18.94 | 8.35 | 253.11 | 2.04 | 4.52 |
| **$B_1M_2$** | 335.78 | 19.23 | 8.63 | 269.32 | 2.10 | 4.31 |
| **$B_1M_3$** | 368.80 | 22.11 | 10.25 | 305.10 | 2.67 | 3.82 |
| **$B_1M_4$** | 342.26 | 20.70 | 9.50 | 277.50 | 2.42 | 4.10 |
| **$B_2M_1$** | 274.82 | 16.56 | 7.19 | 215.11 | 1.34 | 7.56 |
| **$B_2M_2$** | 281.12 | 17.84 | 7.90 | 223.11 | 1.46 | 6.23 |
| **$B_2M_3$** | 286.23 | 18.27 | 8.19 | 240.94 | 1.83 | 5.30 |
| **$B_2M_4$** | 283.65 | 18.04 | 8.17 | 233.14 | 1.71 | 5.57 |
| **S.Em ±** | **4.86** | **0.26** | **0.11** | **4.28** | **0.03** | **0.08** |
| **CD at 5 %** | **14.74** | **0.80** | **0.33** | **12.49** | **0.09** | **0.24** |

$B_1$- 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 bunch weight (368.80 g), bunch length (22.11 cm), bunch width (10.25 cm), bunch volume (305.10 cm³), pedicel thickness (2.67 mm) and minimized berry shattering (3.82 %) were recorded in treatment $B_1M_3$, followed by treatment $B_1M_4$ with a bunch weight of (342.26 g), bunch length (20.70 cm), bunch width (9.50 cm), bunch volume (277.50 cm³) and pedicel thickness (2.42 mm). In contrast, treatment $B_2M_1$ recorded the minimum bunch weight (274.82 g), bunch length (16.56 cm), bunch width (7.19 cm), bunch volume (215.11 cm³) and pedicel thickness (1.34 mm) as shown in Table 3. These differences can be attributed to the synergistic effects of a moderate bunch load and micronutrient application. The combination of silicon (Si), calcium (Ca) and boron (B) in treatment $B_1M_3$ likely strengthened the bunch structure, enhanced nutrient transport and improved fruit set. Silicon aids in cell wall fortification, calcium promotes cell cohesion and firmness whereas, boron facilitates sugar transport and fruit development resulting in larger and more uniform bunches. Furthermore, thicker pedicels in $B_1M_3$ provided better attachment of berries, reducing the incidence of berry shattering, which can occur due to weak pedicel structures or poor nutrient distribution as seen in treatments with lower pedicel thickness. These results are in accordance with findings of Marini (2006) in peach, Anand (2021) in grapes, Al-*Atrushy et al.* (2019) in grapevine cv. Mirane and Khilari *et al.* (2020) in table grapes.

**Table 04 :** Yield and B:C ratio of grapes cv. Thompson Seedless as influenced by bunch load and foliar application of micronutrients

| Treatment | Yield (kg/vine) | Yield (t/ha) | B: C ratio |
|---|---|---|---|
| **$B_1M_1$** | 11.45 | 24.62 | 2.36: 1 |
| **$B_1M_2$** | 11.52 | 24.77 | 2.37: 1 |
| **$B_1M_3$** | 12.91 | 27.76 | 2.84: 1 |
| **$B_1M_4$** | 11.87 | 25.52 | 2.61: 1 |
| **$B_2M_1$** | 13.74 | 29.54 | 2.43: 1 |
| **$B_2M_2$** | 13.82 | 29.71 | 2.42: 1 |
| **$B_2M_3$** | 14.41 | 30.98 | 2.49: 1 |
| **$B_2M_4$** | 14.28 | 30.70 | 2.46: 1 |
| **S.Em ±** | **0.13** | **0.28** | -- |
| **CD at 5 %** | **0.39** | **0.85** | -- |

$B_1$- 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 %)]

Highest yield (14.41 kg/vine and 30.98 t/ha) was recorded in treatment $B_2M_3$, which was on par with $B_2M_4$ (14.28 kg/vine and 30.70 t/ha) of treatment whereas, $B_1M_1$ had the lowest yield (11.45 kg/vine and 24.62 t/ha) as shown in Table 4. It is mainly because of maximum bunches per vine in treatment $B_2M_3$ which naturally increases yield per vine and the synergistic effects of the micronutrients. Silicon strengthens the plant and improves stress resistance, calcium aids in nutrient translocation and boron enhances reproductive growth which contributes to better fruit set and bunch development. In contrast, the lowest yield in $B_1M_1$ (35 bunches per vine and only zinc application) As zinc alone lacks the comprehensive support provided by silicon, calcium and boron leading to reduced overall vine performance. These results align with the findings of Somkuwar and Ramteke (2006) Tas-A-Ganesh table grapes, Al-Atrushy *et al*. (2019) in grapevine cv. Mirane, Khilari *et al*. (2020) in table grapes and Somkuwar *et al*. (2020) in Thompson Seedless grapes.

The highest B: C ratio (2.84: 1) was achieved in the $B_1M_3$ treatment, while the lowest (2.36: 1) was observed in $B_2M_1$ as shown in Table 4. $B_1M_3$ which involved fewer bunches per vine and the application of silicon, calcium and boron benefitted from enhanced sunlight exposure, better sugar accumulation, increased pulp content and improved color development leading to higher quality bunches and a better market price. In contrast $B_2M_1$ with only zinc application did not achieve the same improvement in these quality attributes. The combination of micronutrients in $M_3$ supported superior pulp development and color, enhancing the overall quality and value of the produce compared to $M_1$. The results are in close conformity with the finding of Bhalerao and Patel (2012) in papaya cv. Taiwan Red lady, Suman *et al*. (2016) in guava and Sathiyamurthy *et al* .(2017) in tomato.

## Conclusion

The study concluded that, different bunch load and foliar micronutrient applications significantly influenced vine growth and yield 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 physiological traits and higher (B: C ratio). However, 50 bunches per vine recorded the highest production. These findings emphasize that the combination of silicon, calcium and boron contributes significantly to overall grape production, positively affecting growth and yield.

**Acknowledgement**

The authors are grateful to HREC Tidagundi (Vijayapura) for providing the research material to carry out the experiment.

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