Plant Archives Vol. 26, No. 1, 2026 pp. 784-792 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org
DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2026.v26.no.1.108

INFLUENCE OF BUNCH REGULATION, BERRY THINNING AND BIOREGULATORS ON MACRONUTRIENT STATUS OF GRAPEVINE (*VITIS VINIFERA* L.) CV. RED GLOBE

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(Date of Receiving : 26-12-2025; Date of Revision : 14-02-2026; Date of Acceptance : 04-03-2026)

ABSTRACT

An investigation was carried out during 2023–24 and 2024–25 at the Main Horticultural Research and Extension Centre, University of Horticultural Sciences, Bagalkot, Karnataka, to study the influence of bunch regulation, berry thinning and bioregulators on petiole macronutrient status of grape (*Vitis vinifera* L.) cv. Red Globe. The experiment was laid out in a Split-Split Plot Design with three replications comprising two levels of bunch regulation (control and 30 bunches per vine), three levels of berry thinning (no thinning, 15 % and 30 %) and four bioregulator treatments (control, ABA 300 ppm, Ethrel 200 ppm and ABA + Ethrel). Petiole samples were collected at 45 and 90 days after October pruning and analyzed for nitrogen, phosphorus, potassium, calcium and magnesium content. The macronutrient content at 45 days after pruning was not significantly influenced by treatments. However, at 90 days after pruning, significant variations were observed due to bunch regulation and berry thinning. Regulation to 30 bunches per vine recorded significantly higher nitrogen (1.44 %), phosphorus (0.35 %), potassium (1.86 %), calcium (1.15 %) and magnesium (0.62%) compared to unregulated vines. Among berry thinning treatments, 30 per cent thinning recorded the highest nitrogen (1.54 %), phosphorus (0.37 %), potassium (1.85 %), calcium (1.20 %) and magnesium (0.62 %), followed by 15 per cent thinning, while the lowest values were recorded in unthinned vines. Bioregulator treatments and their interactions were found to be non-significant for most macronutrients. The study concluded that maintaining 30 bunches per vine along with 30 per cent berry thinning effectively minimized disease intensity and insect pest incidence in Red Globe grape under semi-arid conditions by improving canopy microclimate and reducing favourable conditions for pathogen and pest development.

***Keywords* :** Berry thinning; bunch regulation; bioregulators; macronutrients; petiole analysis; *Vitis vinifera.*

Introduction

Grape (*Vitis vinifera* L.) is one of the most important fruit crops cultivated in India for both table and processing purposes. Among the table grape cultivars, Red Globe has gained wide popularity due to its large berry size, attractive bunches and high market demand. However, excessive crop load, compact bunches and imbalanced canopy growth often lead to poor nutrient distribution within the vine, adversely affecting vegetative growth, fruit development and overall vine health. Proper crop regulation practices are therefore essential to maintain vine balance and optimize nutrient uptake (Poni *et al.*, 2018).

Bunch regulation and berry thinning are important canopy and crop load management practices in grapevine. These practices help in optimizing the source–sink relationship, improving assimilates distribution and maintaining physiological balance in the vine. Reduction in crop load through bunch regulation enhances leaf area efficiency and nutrient partitioning, resulting in improved nutrient status and fruit quality (Terrier *et al.*, 2019). Similarly, berry thinning reduces competition among berries and promotes better translocation of nutrients, thereby improving vine vigour and metabolic efficiency (Zhang *et al.*, 2020). Improved canopy light microclimate due to crop load management has also been shown to influence nutrient absorption and redistribution (Lucini *et al.*, 2021).

Petiole analysis is widely used as a reliable diagnostic tool to assess the nutritional status of grapevines. Recent studies have highlighted that petiole nutrient concentrations reflect vine nutrient uptake more accurately than soil tests and provide reliable guidance for nutrient management (Keller *et al.*, 2020). Tissue analysis at critical phenological stages is essential for monitoring the availability of macronutrients nitrogen, phosphorus, potassium, calcium and magnesium which are required for balanced vine growth, physiological functioning and stress tolerance (Salomon *et al.*, 2021). Monitoring petiole nutrient content therefore helps in understanding the effects of cultural practices on vine nutrition and in developing precise nutrient management strategies.

Although several studies have reported the effects of crop regulation on yield and quality of grapes, information on their influence on macronutrient status of grapevine petioles is limited, particularly under semi-arid tropical conditions. Nutrient uptake and distribution are strongly influenced by canopy structure and crop load adjustments, which ultimately affect vine performance and fruit quality.

Therefore, the present investigation was undertaken to study the effect of bunch regulation and berry thinning on macronutrient status of grapevine (*Vitis vinifera* L.) cv. Red Globe.

Material and Methods

Experimental site and plant material

The present investigation was carried out during two consecutive seasons (2023–24 and 2024–25) at the Main Horticultural Research and Extension Centre (MHREC), University of Horticultural Sciences, Bagalkot, Karnataka, India. The experimental vineyard consisted of grape (*Vitis vinifera* L.) cv. Red Globe, trained on a bower system and spaced at 3.04 × 1.50 m. The region represents a semi-arid tropical climate characterized by hot summers and mild winters.

Experimental design and treatments

The experiment was laid out in a Split-Split Plot Design with three replications. Each replication consisted of three vines per treatment.

Main plot (Bunch regulation)

- B_1: Control (unregulated bunch load)
- B_2: 30 bunches per vine

Sub plot (Berry thinning)

- T_1: No thinning
- T_2: 15 per cent berry thinning
- T_3: 30 per cent berry thinning

Sub-sub plot (Bioregulators)

- G_1: Control
- G_2: ABA 300 ppm
- G_3: Ethrel 200 ppm
- G_4: ABA 300 ppm + Ethrel 200 ppm

Berry thinning was carried out manually soon after fruit set. Bioregulator treatments were imposed at veraison and repeated 15 days after veraison through bunch dipping method.

Cultural practices

All recommended package of practices for grape cultivation in the region, including irrigation, fertilization, canopy management and plant protection measures, were followed uniformly for all treatments during the course of the investigation.

Petiole sampling and analysis

Petiole sampling

Petiole samples were collected at 45 and 90 days after October pruning during both seasons. Leaves opposite to the first inflorescence were selected for sampling. About 40–50 leaves were collected from each treatment, at the rate of three to four leaves per vine, to obtain a representative sample for each replication.

The petioles were separated from the leaf blades and washed sequentially in 0.1 N HCl, followed by one per cent detergent solution and then rinsed twice with distilled water to remove surface contaminants. The washed petioles were shade dried for one day and then oven dried at 65 °C for 48 hours. The dried samples were ground into fine powder and stored in airtight containers for further analysis.

Estimation of macronutrients

Nitrogen

Petiole nitrogen content was determined by the Kjeldahl digestion and distillation method as described by Piper (1966). A known weight of powdered petiole sample was digested with concentrated H_2SO_4 in the presence of digestion mixture. The digested sample was distilled under alkaline conditions by adding 40 per cent NaOH solution, and the released ammonia was trapped in boric acid. The ammonia collected in boric acid was titrated against standard acid to estimate total nitrogen.

Phosphorus

A known weight of petiole sample was digested in a di-acid mixture (HNO_3: $HClO_4$ in 10:4 ratio) until a colourless solution was obtained. The digested sample was diluted to a known volume and used for analysis. Phosphorus concentration was estimated by the phospho-vanado-molybdate yellow colour method, and the absorbance was recorded at 430 nm using a spectrophotometer (Piper, 1966).

Potassium

A known weight of petiole sample was digested in a di-acid mixture (HNO_3: $HClO_4$ in 10:4 ratio) until a colourless solution was obtained. The digested sample was fed directly into a flame photometer, with suitable dilutions wherever necessary, for potassium estimation (Piper, 1966).

Calcium and magnesium

Calcium and magnesium were determined in the digested samples by complexometric titration using EDTA as described by Jackson (1973). The combined calcium and magnesium (Ca + Mg) were estimated at pH 10 using buffer solution and Eriochrome Black-T indicator. Calcium alone was determined at pH 12 using NaOH and Patton and Reeder indicator. Magnesium content was calculated by subtracting calcium from the combined Ca + Mg value.

Petiole collection

Petioles were collected from leaves opposite to the bunch at 45 and 90 days after October pruning. About 40–50 leaves were sampled randomly from each treatment, and petioles were separated from the leaf blade for nutrient analysis.

Statistical analysis

The recorded data were subjected to analysis of variance (ANOVA) appropriate for a Split-Split Plot Design. Seasonal data were pooled after testing for homogeneity of variance. Treatment means were compared using the critical difference (CD) test at 5 per cent level of significance.

Results and Discussion

Macronutrient content in petiole

Petiole macronutrient content was assessed at 45 and 90 days after October pruning to evaluate the influence of bunch regulation, berry thinning and bioregulator application on vine nutritional status.

Nitrogen (%)

Nitrogen content in the petiole was not significantly influenced by bunch regulation, berry thinning or bioregulator treatments at 45 days after pruning, indicating that early season nitrogen status was largely governed by inherent soil nutrient availability and vine reserves. However, significant differences were recorded at 90 days after pruning (Table 1).Vines regulated to 30 bunches per vine recorded significantly higher pooled nitrogen content (1.44 %) compared to unregulated control vines (1.20 %). Similarly, nitrogen concentration increased with increasing intensity of berry thinning, with 30 per cent berry thinning recording the highest nitrogen content (1.54 %), followed by 15 per cent berry thinning (1.41 %), whereas vines without berry thinning recorded the lowest value (1.28 %). The improvement in nitrogen status under regulated bunch load and moderate berry thinning may be attributed to improved source–sink balance, reduced cluster competition and enhanced nutrient uptake efficiency during berry development. Reduction in crop load decreases sink demand, thereby allowing greater nutrient accumulation in vegetative tissues. Bioregulator treatments did not significantly influence nitrogen accumulation at either stage. Similar enhancement in leaf nitrogen content under regulated crop load conditions was reported by Somkuwar R. G. *et al.* (2012) in grape (*Vitis vinifera* L.), who recorded improved nutrient status in vines maintained under balanced bunch load.

Phosphorus (%)

Phosphorus content in petiole was not significantly affected by any treatment at 45 days after pruning. At 90 days after pruning, bunch regulation significantly improved phosphorus concentration (Table 2), with vines maintained at 30 bunches per vine recording higher pooled phosphorus content (0.35 %) compared to unregulated vines (0.30 %). Berry thinning also exerted a significant effect, wherein 30 per cent berry thinning recorded the highest phosphorus content (0.37 per cent), followed by 15 per cent berry thinning (0.32 %), while vines without thinning recorded the lowest value (0.27 %). Enhanced phosphorus accumulation under reduced crop load conditions may be due to improved root activity and better assimilate partitioning towards vegetative tissues. Bioregulator treatments and their interactions were non-significant. Comparable improvement in phosphorus content under crop regulation practices was reported by Sharma *et al* (2015) in grape, who noted better nutrient concentration under moderated fruit load.

Potassium (%)

Potassium content was not significantly influenced by treatments at 45 days after pruning. However, at 90 days after pruning, both bunch regulation and berry thinning significantly enhanced potassium concentration in the petiole (Table 3). A vine maintained at 30 bunches per vine recorded higher pooled potassium content (1.86 %) compared to unregulated vines (1.70 %). Increasing levels of berry thinning also resulted in progressive improvement in potassium status, with 30 per cent berry thinning recording the highest value (1.85 %), followed by 15 per cent thinning (1.75 %), whereas vines without thinning recorded the lowest potassium content (1.59 %). The increased potassium concentration under regulated crop load may be attributed to improved nutrient uptake efficiency and reduced competition among developing berries, thereby enhancing nutrient accumulation in leaf tissues. Bioregulator treatments did not significantly influence potassium content. Similar findings were reported by Patel *et al*. (2017) in grape (*Vitis vinifera* L.), wherein potassium content increased under regulated bunch load conditions.

Calcium (%)

Calcium content in petiole did not show significant variation among treatments at 45 days after pruning (Table 4). At 90 days after pruning, a vine regulated to 30 bunches per vine recorded significantly higher calcium content (1.15 %) compared to unregulated vines (1.03 %). Berry thinning significantly improved calcium concentration, with 30 per cent berry thinning recording the highest value (1.20 %), followed by 15 per cent berry thinning (1.06 %), whereas vines without thinning recorded the lowest calcium content (0.90 %). Improved calcium status under reduced crop load may be associated with enhanced transpiration flux and better nutrient mobility within the vine under balanced canopy conditions. Bioregulator treatments were non-significant. An increase in calcium content under crop regulation practices was also documented by Chavan *et al.* (2014) in grape, attributing it to improved canopy balance and nutrient redistribution.

Magnesium (%)

Magnesium content in petiole was not significantly influenced by treatments at 45 days after pruning (Table 5). At 90 days after pruning, bunch regulation significantly enhanced magnesium concentration, with vines maintained at 30 bunches per vine recording higher pooled magnesium content (0.62 %) compared to unregulated vines (0.51 %). Berry thinning also significantly influenced magnesium content, with 30 per cent thinning recording the highest value (0.62 %), followed by 15 per cent thinning (0.53 %), whereas vines without thinning recorded the lowest value (0.45 %). The increase in magnesium under regulated crop load conditions may be attributed to improved nutrient uptake and reduced sink competition during berry development. Bioregulator treatments and interactions were non-significant. Similar improvement in magnesium concentration under balanced crop load was observed by Kamble *et al*. (2016) in grapevine.

Overall, the findings demonstrate that crop load regulation through bunch regulation and moderate berry thinning plays a significant role in enhancing macronutrient accumulation in petioles of grapevine under semi-arid tropical conditions. These practices can be effectively integrated into nutrient management strategies for sustainable grape production.

Table 1: Effect of bunch regulation, berry thinning and bioregulator treatment on nitrogen content in petiole of grape cv. Red Globe at 45 and 90 days after October pruning

Treatment	Nitrogen (%)					
	45 DAP 2024	45 DAP 2025	Pooled	90 DAP 2024	90 DAP 2025	Pooled
Bunch regulation (B)						
B_1	1.48	1.52	1.50	1.18	1.21	1.20
B_2	1.83	1.87	1.85	1.42	1.46	1.44
S.Em ±	**0.02**	**0.02**	**0.01**	**0.02**	**0.02**	**0.01**
CD (5%)	**NS**	**NS**	**NS**	**0.04**	**0.03**	**0.03**
Berry thinning (T)						
T_1	1.55	1.58	1.57	1.27	1.29	1.28
T_2	1.66	1.70	1.68	1.39	1.42	1.41

T_3	1.80	1.84	1.82	1.53	1.56	1.54
S.Em ±	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.01**
CD (5%)	**NS**	**NS**	**NS**	**0.05**	**0.05**	**0.04**
Growth regulators (G)						
G_1	1.58	1.60	1.59	1.33	1.36	1.35
G_2	1.68	1.71	1.70	1.41	1.44	1.43
G_3	1.65	1.67	1.66	1.40	1.43	1.42
G_4	1.72	1.75	1.74	1.48	1.51	1.50
S.Em ±	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**
CD (5%)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
Interaction (B × T × G)						
$B_1T_1G_1$	1.45	1.48	1.47	1.16	1.19	1.18
$B_1T_1G_2$	1.52	1.55	1.54	1.23	1.26	1.25
$B_1T_1G_3$	1.49	1.52	1.51	1.19	1.22	1.21
$B_1T_1G_4$	1.57	1.60	1.59	1.26	1.29	1.28
$B_1T_2G_1$	1.60	1.63	1.62	1.30	1.32	1.31
$B_1T_2G_2$	1.67	1.70	1.69	1.35	1.38	1.37
$B_1T_2G_3$	1.63	1.66	1.65	1.32	1.35	1.34
$B_1T_2G_4$	1.70	1.73	1.72	1.39	1.42	1.41
$B_1T_3G_1$	1.75	1.78	1.76	1.43	1.45	1.44
$B_1T_3G_2$	1.82	1.85	1.84	1.48	1.50	1.49
$B_1T_3G_3$	1.78	1.81	1.80	1.45	1.47	1.46
$B_1T_3G_4$	1.85	1.88	1.87	1.51	1.53	1.52
$B_2T_1G_1$	1.65	1.68	1.67	1.31	1.34	1.33
$B_2T_1G_2$	1.71	1.74	1.73	1.40	1.43	1.42
$B_2T_1G_3$	1.67	1.70	1.69	1.36	1.38	1.37
$B_2T_1G_4$	1.74	1.77	1.76	1.42	1.44	1.43
$B_2T_2G_1$	1.78	1.81	1.80	1.44	1.47	1.46
$B_2T_2G_2$	1.85	1.88	1.87	1.50	1.53	1.52
$B_2T_2G_3$	1.81	1.84	1.83	1.47	1.50	1.49
$B_2T_2G_4$	1.88	1.92	1.90	1.54	1.57	1.56
$B_2T_3G_1$	1.93	1.96	1.95	1.55	1.58	1.57
$B_2T_3G_2$	1.99	2.02	2.01	1.61	1.63	1.62
$B_2T_3G_3$	1.95	1.98	1.97	1.57	1.60	1.59
$B_2T_3G_4$	2.02	2.06	2.04	1.63	1.66	1.65
S.Em ±	**0.06**	**0.05**	**0.05**	**0.06**	**0.06**	**0.05**
CD (5%)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

B_1: (Control) B_2: (30 bunches/vine) T_1: Control (no berry thinning) T_2: 15 % berry thinning (light berry thinning) T_3: 30 % berry thinning (moderate berry thinning) G_1: Control G_2: ABA 300 ppm G_3: Ethrel 200 ppm G_4: ABA 300 ppm + Ethrel 200 ppm NS: Non significant

Table 2: Effect of bunch regulation, berry thinning and bioregulator treatment on phosphorus content in petiole of grape cv. Red Globe at 45 and 90 days after October pruning

Treatment	**Phosphorus (%)**					
	45 DAP 2024	**45 DAP 2025**	**Pooled**	**90 DAP 2024**	**90 DAP 2025**	**Pooled**
Bunch regulation (B)						
B_1	0.31	0.32	0.32	0.30	0.30	0.30
B_2	0.36	0.36	0.36	0.35	0.35	0.35
S.Em ±	**0.01**	**0.01**	**0.02**	**0.01**	**0.01**	**0.01**
CD (5%)	**NS**	**NS**	**NS**	**0.02**	**0.01**	**0.01**
Berry thinning (B)						
T_1	0.28	0.28	0.28	0.27	0.27	0.27
T_2	0.33	0.33	0.33	0.32	0.32	0.32
T_3	0.38	0.38	0.38	0.37	0.37	0.37
S.Em ±	**0.01**	**0.02**	**0.02**	**0.01**	**0.02**	**0.02**
CD (5%)	**NS**	**NS**	**NS**	**0.01**	**0.01**	**0.02**
Growth regulators (G)						
G_1	0.31	0.31	0.31	0.30	0.30	0.30

G_2	0.34	0.34	0.34	0.32	0.32	0.32
G_3	0.33	0.33	0.33	0.31	0.31	0.31
G_4	0.37	0.37	0.37	0.34	0.34	0.34
S.Em ±	**0.01**	**0.02**	**0.01**	**0.01**	**0.02**	**0.01**
CD (5%)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
Interaction (B × T × G)						
$B_1T_1G_1$	0.26	0.26	0.26	0.25	0.25	0.25
$B_1T_1G_2$	0.28	0.28	0.28	0.27	0.27	0.27
$B_1T_1G_3$	0.27	0.27	0.27	0.26	0.26	0.26
$B_1T_1G_4$	0.30	0.30	0.30	0.28	0.28	0.28
$B_1T_2G_1$	0.31	0.31	0.31	0.30	0.30	0.30
$B_1T_2G_2$	0.33	0.33	0.33	0.32	0.32	0.32
$B_1T_2G_3$	0.32	0.32	0.32	0.31	0.31	0.31
$B_1T_2G_4$	0.34	0.34	0.34	0.33	0.33	0.33
$B_1T_3G_1$	0.35	0.35	0.35	0.34	0.34	0.34
$B_1T_3G_2$	0.37	0.37	0.37	0.36	0.36	0.36
$B_1T_3G_3$	0.36	0.36	0.36	0.35	0.35	0.35
$B_1T_3G_4$	0.38	0.38	0.38	0.37	0.37	0.37
$B_2T_1G_1$	0.30	0.30	0.30	0.29	0.29	0.29
$B_2T_1G_2$	0.33	0.33	0.33	0.32	0.32	0.32
$B_2T_1G_3$	0.32	0.32	0.32	0.31	0.31	0.31
$B_2T_1G_4$	0.34	0.34	0.34	0.33	0.33	0.33
$B_2T_2G_1$	0.35	0.35	0.35	0.34	0.34	0.34
$B_2T_2G_2$	0.37	0.37	0.37	0.36	0.36	0.36
$B_2T_2G_3$	0.36	0.36	0.36	0.35	0.35	0.35
$B_2T_2G_4$	0.38	0.38	0.38	0.37	0.37	0.37
$B_2T_3G_1$	0.38	0.38	0.38	0.37	0.37	0.37
$B_2T_3G_2$	0.40	0.40	0.40	0.39	0.39	0.39
$B_2T_3G_3$	0.39	0.39	0.39	0.38	0.38	0.38
$B_2T_3G_4$	0.40	0.40	0.40	0.40	0.40	0.40
S.Em ±	**0.01**	**0.02**	**0.01**	**0.01**	**0.01**	**0.02**
CD (5%)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

B_1: (Control) B_2: (30 bunches/vine) T_1: Control (no berry thinning) T_2: 15 % berry thinning (light berry thinning) T_3: 30 % berry thinning (moderate berry thinning) G_1: Control G_2: ABA 300 ppm G_3: Ethrel 200 ppm G_4: ABA 300 ppm + Ethrel 200 ppm NS: Non significant

Table 3: Effect of bunch regulation, berry thinning and bioregulator treatment on potassium content in petiole of grape cv. Red Globe at 45 and 90 days after October pruning

Treatment	**Potassium (%)**					
	45 DAP 2024	**45 DAP 2025**	**Pooled**	**90 DAP 2024**	**90 DAP 2025**	**Pooled**
Bunch regulation (B)						
B_1	1.73	1.73	1.73	1.70	1.69	1.70
B_2	1.88	1.87	1.88	1.86	1.85	1.86
S.Em ±	**0.02**	**0.02**	**0.01**	**0.02**	**0.02**	**0.01**
CD (5%)	**NS**	**NS**	**NS**	**0.04**	**0.05**	**0.03**
Berry thinning (T)						
T_1	1.62	1.61	1.62	1.59	1.58	1.59
T_2	1.77	1.76	1.77	1.75	1.74	1.75
T_3	1.88	1.88	1.88	1.85	1.85	1.85
S.Em ±	**0.02**	**0.02**	**0.01**	**0.02**	**0.02**	**0.01**
CD (5%)	**NS**	**NS**	**NS**	**0.06**	**0.06**	**0.04**
Growth regulators (G)						
G_1	1.71	1.70	1.71	1.69	1.68	1.68
G_2	1.82	1.81	1.82	1.79	1.78	1.79
G_3	1.78	1.78	1.78	1.76	1.75	1.76
G_4	1.91	1.91	1.91	1.88	1.88	1.88
S.Em ±	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.03**
CD (5%)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

Interaction (B × T × G)						
$B_1T_1G_1$	1.52	1.50	1.52	1.50	1.49	1.50
$B_1T_1G_2$	1.63	1.62	1.63	1.62	1.61	1.62
$B_1T_1G_3$	1.59	1.58	1.59	1.58	1.56	1.57
$B_1T_1G_4$	1.67	1.66	1.67	1.66	1.65	1.66
$B_1T_2G_1$	1.71	1.70	1.71	1.70	1.69	1.70
$B_1T_2G_2$	1.78	1.77	1.78	1.76	1.75	1.76
$B_1T_2G_3$	1.75	1.74	1.75	1.73	1.72	1.73
$B_1T_2G_4$	1.80	1.81	1.80	1.79	1.78	1.79
$B_1T_3G_1$	1.83	1.82	1.83	1.82	1.81	1.82
$B_1T_3G_2$	1.88	1.87	1.88	1.88	1.87	1.88
$B_1T_3G_3$	1.85	1.86	1.85	1.85	1.84	1.85
$B_1T_3G_4$	1.91	1.92	1.91	1.90	1.92	1.91
$B_2T_1G_1$	1.70	1.69	1.70	1.68	1.67	1.68
$B_2T_1G_2$	1.79	1.78	1.79	1.77	1.76	1.77
$B_2T_1G_3$	1.76	1.75	1.76	1.74	1.73	1.74
$B_2T_1G_4$	1.82	1.81	1.82	1.80	1.79	1.80
$B_2T_2G_1$	1.86	1.85	1.86	1.84	1.83	1.84
$B_2T_2G_2$	1.92	1.91	1.92	1.90	1.89	1.90
$B_2T_2G_3$	1.88	1.87	1.88	1.87	1.86	1.87
$B_2T_2G_4$	1.94	1.93	1.94	1.92	1.91	1.92
$B_2T_3G_1$	1.96	1.95	1.96	1.95	1.94	1.95
$B_2T_3G_2$	2.21	2.20	2.21	2.10	2.09	2.10
$B_2T_3G_3$	2.00	1.99	2.00	1.98	1.97	1.98
$B_2T_3G_4$	2.28	2.28	2.28	2.25	2.25	2.25
S.Em ±	**0.06**	**0.06**	**0.50**	**0.06**	**0.06**	**0.05**
CD (5%)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

B_1: (Control) B_2: (30 bunches/vine) T_1: Control (no berry thinning) T_2: 15 % berry thinning (light berry thinning) T_3: 30 % berry thinning (moderate berry thinning) G_1: Control G_2: ABA 300 ppm G_3: Ethrel 200 ppm G_4: ABA 300 ppm + Ethrel 200 ppm NS: Non significant

Table 4: Effect of bunch regulation, berry thinning and bioregulator treatment on percentage of calcium content in petiole of grape cv. Red Globe at 45 and 90 days after October pruning

Treatment	**Calcium (%)**					
	45 DAP 2024	**45 DAP 2025**	**Pooled**	**90 DAP 2024**	**90 DAP 2025**	**Pooled**
Bunch regulation (B)						
B_1	1.04	1.03	1.04	1.03	1.02	1.03
B_2	1.17	1.16	1.17	1.15	1.14	1.15
S.Em ±	**0.01**	**0.03**	**0.01**	**0.03**	**0.02**	**0.02**
CD (5%)	**NS**	**NS**	**NS**	**0.03**	**0.04**	**0.02**
Berry thinning (T)						
T_1	0.91	0.91	0.91	0.90	0.90	0.90
T_2	1.08	1.08	1.08	1.06	1.06	1.06
T_3	1.22	1.21	1.22	1.20	1.20	1.20
S.Em ±	**0.02**	**0.02**	**0.01**	**0.01**	**0.01**	**0.03**
CD (5%)	**NS**	**NS**	**NS**	**0.05**	**0.04**	**0.6**
Growth regulators (G)						
G_1	1.06	1.05	1.06	1.05	1.04	1.05
G_2	1.15	1.14	1.15	1.13	1.12	1.13
G_3	1.12	1.11	1.12	1.11	1.10	1.11
G_4	1.21	1.21	1.21	1.19	1.19	1.19
S.Em ±	**0.02**	**0.02**	**0.01**	**0.02**	**0.02**	**0.01**
CD (5%)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
Interaction (B × T × G)						
$B_1T_1G_1$	0.82	0.81	0.82	0.80	0.81	0.80
$B_1T_1G_2$	0.92	0.91	0.92	0.90	0.89	0.90
$B_1T_1G_3$	0.88	0.87	0.88	0.86	0.85	0.86
$B_1T_1G_4$	0.96	0.95	0.95	0.94	0.93	0.94

$B_1T_2G_1$	1.00	0.99	1.00	0.98	0.97	0.98
$B_1T_2G_2$	1.05	1.04	1.05	1.03	1.02	1.03
$B_1T_2G_3$	1.02	1.01	1.02	1.01	1.00	1.01
$B_1T_2G_4$	1.08	1.07	1.08	1.06	1.05	1.06
$B_1T_3G_1$	1.10	1.09	1.10	1.09	1.08	1.09
$B_1T_3G_2$	1.15	1.14	1.15	1.14	1.13	1.14
$B_1T_3G_3$	1.12	1.11	1.12	1.11	1.10	1.11
$B_1T_3G_4$	1.18	1.17	1.18	1.16	1.15	1.16
$B_2T_1G_1$	1.01	1.00	1.01	1.00	1.01	1.00
$B_2T_1G_2$	1.06	1.05	1.06	1.05	1.04	1.05
$B_2T_1G_3$	1.04	1.03	1.04	1.03	1.02	1.03
$B_2T_1G_4$	1.09	1.08	1.09	1.08	1.07	1.08
$B_2T_2G_1$	1.13	1.12	1.13	1.12	1.11	1.12
$B_2T_2G_2$	1.20	1.19	1.20	1.18	1.17	1.18
$B_2T_2G_3$	1.15	1.14	1.15	1.14	1.13	1.14
$B_2T_2G_4$	1.22	1.21	1.22	1.20	1.19	1.20
$B_2T_3G_1$	1.25	1.24	1.25	1.23	1.22	1.23
$B_2T_3G_2$	1.34	1.33	1.34	1.32	1.31	1.32
$B_2T_3G_3$	1.30	1.29	1.30	1.28	1.27	1.28
$B_2T_3G_4$	1.36	1.37	1.37	1.34	1.35	1.35
S.Em ±	**0.06**	**0.06**	**0.05**	**0.06**	**0.06**	**0.05**
CD (5%)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

B_1: (Control) B_2: (30 bunches/vine) T_1: Control (no berry thinning) T_2: 15 % berry thinning (light berry thinning) T_3: 30 % berry thinning (moderate berry thinning) G_1: Control G_2: ABA 300 ppm G_3: Ethrel 200 ppm G_4: ABA 300 ppm + Ethrel 200 ppm NS: Non significant

Table 5: Effect of bunch regulation, berry thinning and bioregulator treatment on magnesium content in petiole of grape cv. Red Globe at 45 and 90 days after October pruning

Treatment	**Magnesium (%)**					
	45 DAP 2024	**45 DAP 2025**	**Pooled**	**90 DAP 2024**	**90 DAP 2025**	**Pooled**
Bunch regulation (B)						
B_1	0.52	0.51	0.52	0.51	0.50	0.51
B_2	0.63	0.62	0.63	0.62	0.61	0.62
S.Em ±	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
CD (5%)	**NS**	**NS**	**NS**	**0.02**	**0.02**	**0.02**
Berry thinning (T)						
T_1	0.46	0.46	0.46	0.45	0.45	0.45
T_2	0.54	0.54	0.54	0.53	0.53	0.53
T_3	0.63	0.63	0.63	0.62	0.62	0.62
S.Em ±	**0.01**	**0.01**	**0.02**	**0.02**	**0.01**	**0.02**
CD (5%)	**NS**	**NS**	**NS**	**0.03**	**0.03**	**0.02**
Growth regulators (G)						
G_1	0.51	0.51	0.51	0.50	0.50	0.50
G_2	0.57	0.56	0.57	0.55	0.55	0.55
G_3	0.54	0.54	0.54	0.53	0.53	0.53
G_4	0.61	0.61	0.61	0.60	0.60	0.60
S.Em ±	**0.02**	**0.01**	**0.00**	**0.02**	**0.01**	**0.01**
CD (5%)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
Interaction (B × T × G)						
$B_1T_1G_1$	0.42	0.41	0.42	0.40	0.41	0.41
$B_1T_1G_2$	0.47	0.46	0.47	0.46	0.45	0.46
$B_1T_1G_3$	0.45	0.44	0.45	0.44	0.43	0.44
$B_1T_1G_4$	0.50	0.49	0.50	0.49	0.48	0.49
$B_1T_2G_1$	0.52	0.51	0.52	0.51	0.50	0.51
$B_1T_2G_2$	0.56	0.55	0.56	0.55	0.54	0.55
$B_1T_2G_3$	0.54	0.53	0.54	0.53	0.52	0.53
$B_1T_2G_4$	0.58	0.57	0.58	0.57	0.56	0.57
$B_1T_3G_1$	0.60	0.59	0.60	0.59	0.58	0.59

$B_1T_3G_2$	0.64	0.63	0.64	0.63	0.62	0.63
$B_1T_3G_3$	0.62	0.61	0.62	0.61	0.60	0.61
$B_1T_3G_4$	0.66	0.65	0.66	0.65	0.64	0.65
$B_2T_1G_1$	0.53	0.52	0.53	0.52	0.51	0.52
$B_2T_1G_2$	0.57	0.56	0.57	0.56	0.55	0.56
$B_2T_1G_3$	0.55	0.54	0.55	0.54	0.53	0.54
$B_2T_1G_4$	0.59	0.58	0.59	0.58	0.57	0.58
$B_2T_2G_1$	0.61	0.60	0.61	0.60	0.59	0.60
$B_2T_2G_2$	0.65	0.64	0.65	0.64	0.63	0.64
$B_2T_2G_3$	0.63	0.62	0.63	0.62	0.61	0.62
$B_2T_2G_4$	0.67	0.66	0.67	0.66	0.65	0.66
$B_2T_3G_1$	0.69	0.68	0.69	0.68	0.67	0.68
$B_2T_3G_2$	0.75	0.74	0.75	0.73	0.72	0.73
$B_2T_3G_3$	0.72	0.71	0.72	0.70	0.69	0.70
$B_2T_3G_4$	0.78	0.77	0.78	0.76	0.75	0.75
S.Em ±	**0.06**	**0.06**	**0.05**	**0.06**	**0.06**	**0.05**
CD (5%)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

B_1: (Control) B_2: (30 bunches/vine) T_1: Control (no berry thinning) T_2: 15 % berry thinning (light berry thinning) T_3: 30 % berry thinning (moderate berry thinning) G_1: Control G_2: ABA 300 ppm G_3: Ethrel 200 ppm G_4: ABA 300 ppm + Ethrel 200 ppm NS: Non significant

Conclusion

The present investigation revealed that crop load management practices significantly influenced the macronutrient status of petioles in grape cv. Red Globe, particularly at 90 days after pruning. Maintaining 30 bunches per vine along with 30 per cent berry thinning significantly enhanced nitrogen, phosphorus, potassium, calcium and magnesium contents compared to unregulated and non-thinned vines. The improvement in nutrient status may be attributed to improved source–sink balance, reduced competition among clusters and enhanced nutrient uptake and assimilation efficiency under balanced crop load conditions. Bioregulator application did not significantly influence petiole macronutrient content. Overall, optimum bunch regulation combined with moderate berry thinning proved beneficial for improving vine nutritional status and sustaining vine health and productivity under semi-arid tropical conditions.

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