Gibberellic acid application practices influence yield attributes of grapevine cultivar 'Talizman' in subtropics

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ABSTRACT

Ever increasing demand and imports are the scope for viticulture expansion in Nepal. This study aimed to assess the effect of exogenous GA_3 doses and at various stages of berry growth on berry yield, cluster weight and return fruitfulness in seedless cv. Talizman. Experiments were carried out in two factorial randomized complete block design during 2022-2025 in a commercial vineyard at Dhading, Nepal. Four concentrations of GA_3 (0, 10, 20 and 40 ppm) were applied at post-flowering, 4-5 mm berry size and both at post-flowering and 4-5 mm berry size stages. GA_3 10 ppm applied at 4-5 mm berry size increased berry weight and cluster weight by 24.14% and 62.92% over control, respectively. The 76% and 56% variation in berry weight was explained by berry transversal and longitudinal diameter, respectively. Similarly, average berry weight and berry number in cluster contributed on 78% variation in cluster weight. Hence, increase on berry weight using GA_3 along with berry number significantly increase the vine yield.

Keywords: Berry yield, GA application, grape, Nepal

INTRODUCTION

Grapes (*Vitis vinifera* L.) are rich source of vitamins, minerals and unique natural products like resveratrol. Seedless varieties of grapevine are mostly preferred for table purpose (Tetali *et al*., 2020). Grape is one of the ever-demanding crops in Nepal, but its cultivation is limited due to rainy season concurrent with the harvesting period that shortens the production window. Ultimately, that leads to lower and poor quality yield, which is the major problem of grapevine cultivation in particular throughout the mid-hills of Nepal including Dhading. The application of hydrogen cyanamide (H_2CN_2) during late January preponed 3-4 weeks the natural bud burst timing with uniform budburst that leads to early harvesting before the monsoon. However, the yield was quite low. The GA_3 is used to increase berry size for better yield. However, the timing and stages of application are crucial (Acharya *et al.,* 2023). They also reported that 39 ha of grapevine-cultivated area in Nepal excluding home garden cultivation. During 2014-2024 AD, the import value (NPR) of dried and fresh grapes increased by more than four and two times *i.e.*,43.5 Vs. 226.8 million and 674.7 Vs. 2147 million in 2014 and 2024, respectively (Acharya *et al.*, 2025a). It shows the great scope for viticulture for import substitution, livelihood improvement and food and nutritional security.

Exogenous Gibberellic Acid (GA_3) application at different doses and berry growth stages are crucial for yield enhancement in fresh grape production. GA_3 applied at post-flowering or after berry set in seedless table grape cultivars increased both the size of berries and clusters (Casanova *et al.*, 2009; Dokoozlian and Peacock, 2001). The time of application and the concentration of GA_3 depend on the cultivar as the seed content in berries varies and growing

environment (Dookozlian and Peacock, 2001). Cultivar and location specific researches are important to optimize GA_3 doses and berry growth stages in the existing vineyard management practices to increase berry and cluster yield. This study assessed the effect of GA_3 application doses at various berry growth stages to increase berry size for better yield in seedless grapevine cv. Talizman.

MATERIALS AND METHODS

Seedless table grape cv. Talizman planted in 2016 in open field condition of Dhading, Nepal was selected for the study. The field experiments were conducted during December, 2022 – March, 2025 in a commercial vineyard at Kewalpur, Dhading (27.75°N, 85.11°E), Nepal at the altitude of 650 meter above sea level (masl). Considering the last 10 years weather data (2015-2024), the site experienced the monsoon since second fortnight of June and the maximum monthly rainfall was in July (373 mm). The daily maximum temperature was during April-June while the minimum was in January-February (Data source: https://power.larc.nasa.gov). The hobo data logger (MX2302A) was used to collect the daily temperatures and relative humidity in the study site. The average daily temperature was 22.2°C in both years and the relative humidity was 57.1% and 59.2% in 2023 and 2024, respectively during the experimentation period *i.e.*, 27 January to 11 June.

Four concentrations (0, 10, 20 and 40 ppm) of GA_3 were imposed in 2023 and 2024 at the stages of post-flowering, 4-5 mm berry size and both at post-flowering and 4-5 mm berry size in seedless table cv. Talizman. The stages of berry growth and concentrations of GA_3 were considered as first and second factors in factorial randomized complete block design with three replications, respectively. Laboratory grade GA_3 SG (HiMedia Laboratories Pvt. Ltd, India) used to prepare the stock solution in deionized water. The sticker Allvit (National Agro Industries Pvt. Ltd., Nepal) 5g added to the 10L of GA_3 solution. The solution sprayed in grape cluster using a knapsack sprayer with a fine nozzle during the evening hours to minimize evaporation and maximize effectiveness.

The annual growth stages including berry growth stages were noted based on modified E-L stages (Coombe and Dry, 2004). The first application of GA_3 was at its post-flowering stage (>50% caps fall *i.e.*, E-L stage 23) on 2nd April 2023 and 2024. The second application was at 4 to 5 mm berry size (E-L stage 29) on 8th April 2023 and 15th April 2024. After 5–6 weeks of budburst in 2025, inflorescences per vine were counted to assess the following season fruitfulness *i.e.*, return fruitfulness.

Ten berries were randomly picked (four berries from top, four berries from middle and two berries from tip portion) from each cluster to assess the berry and cluster attributes. Cluster was harvested when random sample berries in the vineyard had ~16^{o}Brix measured by digital refractometer (PAL1; Atago Co., Ltd.). A digital balance was used to weigh the cluster, berries and a digital caliper was used to measure the berry diameter in millimeters (mm). Cluster length and cluster weight measured were also recorded. Pooled data (average of 2023 and 2024) of quantitative attributes subjected to ANOVA. A GenStat 18 (VSN International Limited, UK) statistical analysis tool was used for ANOVA following the instruction for RCBD. Multiple regression considered the berry weight and berry number as factors to assess their contribution on cluster weight.

RESULTS AND DISCUSSION

Effect of GA_3 application on berry attributes

The application of 10ppm GA_3 produced the highest berry transversal diameter (21.0 mm), berry longitudinal diameter (24.33mm) and 10-berry weight (59.0g), however, there was non-significant interaction effect of GA_3 concentrations and stages of application on the number of berries per cluster (Table 1). There was significant effect of stages of application on berry transversal and

longitudinal diameter and 10-berry weight. GA_3 applied at 4-5mm berry size had the highest berry transversal diameter (21.0mm), berry longitudinal diameter (24.0mm) and 10-berry weight (60.1g).

Application of 10 ppm GA_3 at 4-5 mm berry size stage enhanced the berry weight by 24.14% over the control (no GA_3 application), followed by 19.11% and 11.49% with the application of 20 and 40ppm GA_3 application, respectively. GA_3 application is more common in seedless cultivars and mostly applied to seedless cultivars at post-flowering stage or after berry set to enlarge the size of berries (diameter and length), berry weight, cluster weight, cluster length to achieve standard quality of grapes (Dokoozlian and Peacock, 2001; Casanova *et al.*, 2009; Elgendy *et al.*, 2012). Anjum *et al.* (2020) reported the 10-berry weight increased in GA_3 treated grapes in cv. Sultanina. The increase in berry size by GA_3 application is mediated by a faster berry growth rate; earlier glucose, fructose, and sucrose uptake; an increase in absolute glucose and fructose content (mg/berry); and an increase in absolute berry water content (Casanova *et al.*, 2009). Enhanced cell division and cell expansion by GA_3 application is responsible for the increased berry weight in grapes (Dimovska *et al.*, 2014). Cai *et al*. (2024) reported that the GA_3 treatments increased the longitudinal diameter of the berry, but there was no effect in the transverse diameter in Shine Muscat-seedless. Regarding quality parameters of this experiment, Acharya *et al.* (2025b) reported that GA_3 applied at 10 ppm had the highest total soluble solid (TSS) but non-significant effect of GA_3 doses was on other quality attributes such as total titratable acidity (TTA), TSS/TTA ratio and pH in Talizman.

Relationship of berry diameter, number and weight

The relationship between berry transversal and longitudinal diameter with berry weight is presented in Figure 1. About 76% variation in berry weight was due to berry transversal diameter (1a), while 56% variation in berry weight was due to berry longitudinal diameter (1b). The regression analysis was significant ($P< 0.05$). It means that the berry transversal diameter and longitudinal diameter significantly contribute on berry weight (R^2= 0.76 and 0.56, respectively). Transversal diameter had more contribution on berry weight than longitudinal diameter. Besides, berry weight only explained the 26% variation in cluster weight and both berry number and berry weight significantly influenced on cluster weight explaining the 78% variation in cluster weight. In small size berry cv. Cabernet Sauvignon, Acharya *et al.* (2025c) reported that reported that 30.56% and 24.33% variation in berry weight explained by the berry transversal and berry longitudinal diameter, respectively. A significant positive correlation was also reported in berry diameter and berry weight in cv. Thompson seedless (Abu-Zahra, 2010).

Effect of GA_3 application on cluster attributes

Cluster attributes such as average cluster length and 10-cluster weight were found the highest (189.2 mm and 2533 g) in 10 ppm GA_3 treated plots (Table 1), however, the GA_3 application at different stages was non-significant in cluster attributes. The interaction effect of stages and doses was also non-significant. The 10 ppm GA_3 application at 4-5 mm berry size stage increased cluster weight by 62.92% over the control (no GA_3), followed by 49.48% and 32.70% with the application of 20 and 40 ppm GA_3, respectively. The cluster weight is more responsible to determine grapevine yield. Shah *et al.* (2015) found similar results in grape cv. Perlett in which maximum cluster length recorded at 25 ppm. Expansion of the cell wall most likely caused the cluster length to increase, encouraging the breakage of hydrogen bonds between polysaccharides and increasing the flexibility of the cell wall, which permits water to enter and encourages cell stretching (Da Silva *et*

al., 2018). According to Dimovska *et al.* (2014), the length and width of clusters treated with GA_3 were greater than the control ones. They also found that a 66% increase in cluster weight in 'Flame Seedless' after three times 20 ppm GA_3 application. Dimovska *et al.* (2011) on the 'Belgrade' cultivar demonstrated that the 20 ppm GA_3 applied in three spray caused cluster weight to increase by 31%, and by 19% in the case of cv. Thompson Seedless. Anjum *et al.* (2020) stated that the gibberellic acid treatments influenced the average cluster weight. According to Elgendy *et al.* (2012), the increase in cluster weight was due to the GA_3 treatment's increase in berry weight and size. Increased yield with the application of GA_3 is due to enhanced fruit growth and improved cluster architecture.

Effect of GA_3 application on return fruitfulness

The number of effective buds is an important factor in determining a grapevine's yield performance. Application of GA_3 doses (0, 10, 20 and 40 ppm) and berry growth stages (post-flowering, 4-5 mm berry size and both at post-flowering and 4-5 mm berry size) had no effect on return fruitfulness (following season of GA_3 application in 2025) in grapevine of cv. Talizman (Figure 2). Dahal *et al.* (2019) also found that GA_3 had an inconsistent influence on return fruitfulness when applied at mid or late flowering stages in cv. Menindee Seedless grapevine. The clusters are initiated during the previous year's growing season before bloom, and the final number of clusters is determined by approximately a month after bloom (Archer, 2011). Williams (2000) stated that the maximum number of clusters per vine is determined during the previous year and the formation of clusters for next year's crop begins concurrently with the formation of leaf primordia within the compound bud. In California's Central Valley, bud fruitfulness (clusters per shoot) vary by about 25% from year to year, and growers can get a first estimate of yield potential by dissecting buds and counting cluster primordia during the dormant season (Martinson *et al*., 2012).

CONCLUSION

Gibberellic acid doses application at different berry growth stages of grapevine cv. Talizman influenced the vine yield attributes *i.e.*, berry and cluster attributes. GA_3 10 ppm at 4-5 mm berry size application increased the berry weight by 24.14% and cluster weight by 62.92% with no adverse effect on berry yield of current season and next season fruitfulness. Thus, the application of right dose at appropriate berry growth stage application is an innovative technology to address the problem of low vine yield due to short production window constraint by the monsoon. This technology could have a great potential to enhance commercial grape production in Nepal.

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CONFLICT OF INTEREST STATEMENT

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Table 1: Effect of GA_3 application (berry growth stages and doses) on berry and cluster attributes (Mean ± SE) of grapevine cv. Talizman (Average of 2023 and 2024)

Factors	Treatments	Berry transversal diameter (mm)	Berry longitudinal diameter (mm)	Berry number/ cluster	10-Berry weight (g)	Cluster length (mm)	10-Cluster weight (g)
Combine control	S0: No GA_3 application	18.2^{c}±0.4	19.8^{b}±1.0	25.5±3.0	47.5^{c}±2.6	149.5±6.1	1555.0±196.3
Factor A: Stages (S)	S1: Post flowering	20.1^{b}±0.4	23.5^{a}±0.6	47.2±4.1	54.0^{b}±3.4	179.7±11.6	2339.0±178.1
	S2: 4-5 mm berry	21.0^{a}±0.5	24.0^{a}±0.5	41.6±5.1	60.1^{a}±3.9	173.8±7.1	2255.0±228.8
	S3: both S1 and S2	20.1^{b}±0.3	23.6^{a}±0.5	48.0±4.1	54.3^{b}±2.7	179.4±6.2	2326.0±153.3
Factor B: GA_3 Doses (D)	D0: 0 ppm	18.2^{c}±0.4	19.8^{c}±1.0	25.5±3.0	47.5^{c}±2.6	149.5^{c}±6.1	1555.0^{c}±196.3
	D1: 10 ppm	21.0^{a}±0.3	24.3^{a}±0.5	47.6±4.9	59.0^{a}±3.2	189.2^{a}±10.0	2533.0^{a}±223.6
	D2:20 ppm	20.5^{a}±0.4	23.6^{ab}±0.5	46.5±4.2	56.6^{ab}±3.4	174.0^{b}±6.9	2324.0^{ab}±144.5
	D3:40 ppm	19.7^{b}±0.4	23.1^{b}±0.5	42.7±4.4	53.0^{bc}±3.6	169.7^{b}±7.4	2063.0^{b}±155.4
P-value	S	**	**	ns	**	ns	ns
	D	*	*	ns	*	**	*
	D x S	ns	ns	ns	ns	ns	ns

Symbol 'ns' indicates non-significant (P>0.05) between doses and stages. Symbol '' indicates significant (P<0.05) between doses and stages and symbol '**' indicates significant (P<0.01) between doses and stages.*

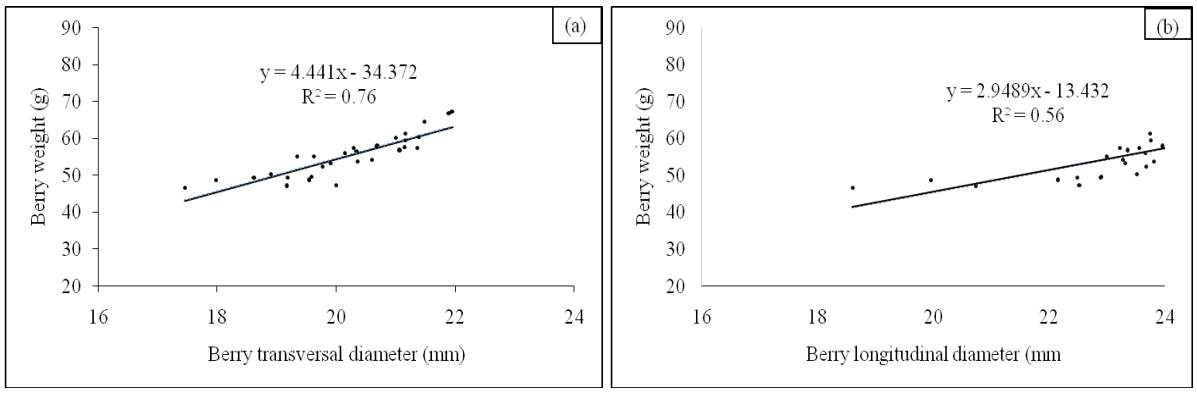

Figure 1: Linear regression showing the berry weight in relation to berry transversal diameter (a) and berry longitudinal diameter (b) of grapevine cv. Talizman (Average of 2023 and 2024).

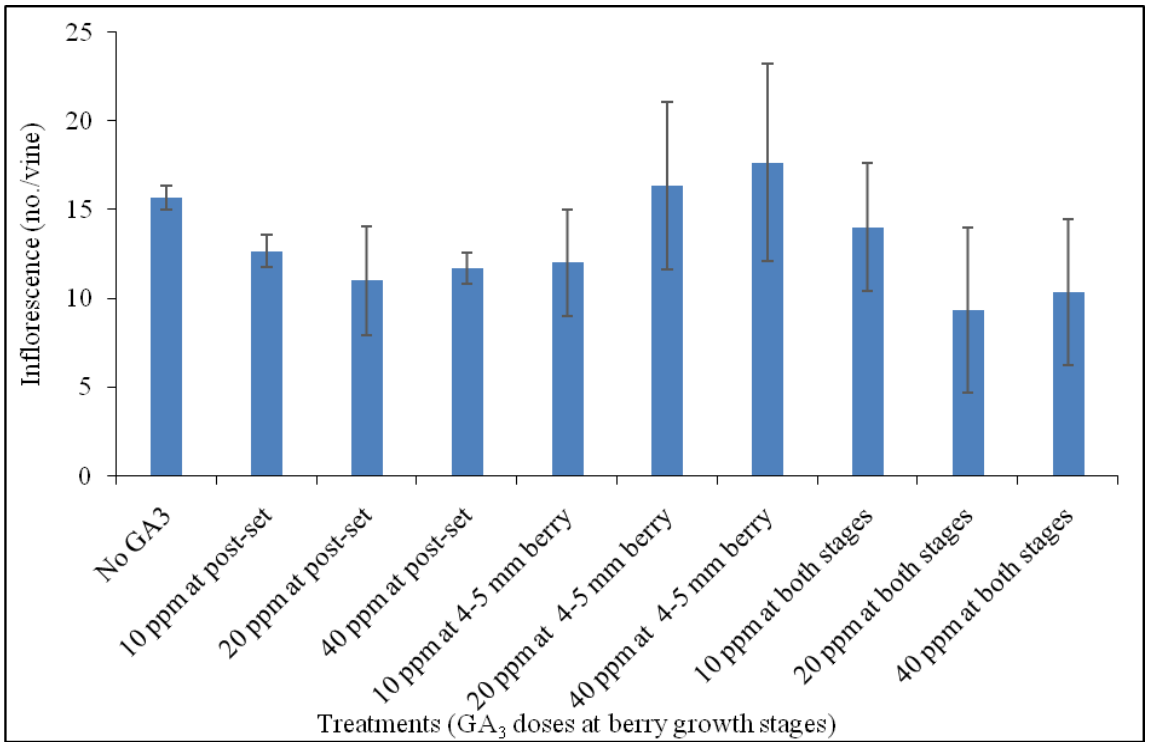

Figure 2: GA_3 applications (berry growth stages and doses) effect on inflorescence number (Mean ± SE per vine) in the following season (2025) of grapevine cv. Talizman.