Nepalese Horticulture 19 : 24-30, 2025
ISSN : 2092-1122 | Print : 2542-2936 (Online)
DOI: 10.3126/nh.v19i1.86685

Research Article

OPEN ACCESS

Response of Gibberellic Acid Application on Berry Quality of Seeded and Seedless Grapevine Cultivars

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Received on: 14 June, 2025 **Revised on:** 15 Oct, 2025 **Accepted on:** 27 Oct, 2025

Abstract

In Nepal, cultivation of grapes in commercial scale has been started since 2016 AD. By the use of chemical flowering inducer, it has become possible to prepone grape production to escape rainy season. However, berry yield and quality are still poor that limit to scale up commercial production in Nepal. Gibberellic Acid (GA_3) is commonly used to increase berry yield and quality of grapevines throughout the world. Studies were carried out during 2022-2024 in the Kewalpur Agro-Farm, Dhading, Nepal to optimize the concentration and time of GA_3 application to improve the berry quality of different cultivars of grapevine. The experiment included table grape cv. Poloskei Muskotaly (few-seeded) received 0, 5, 10 and 20 ppm; while seedless table grape cv. Talizman (seedless) received 0, 10, 20 and 40 ppm GA_3 at post-flowering, 4–5 mm berry size, and both at post-flowering and 4–5 mm berry size stages. The effect of GA_3 varied on berry quality attributes with respect to the cultivars. Application of GA_3 significantly increased the quality of berries of seedless (Talizman) and few-seeded (Poloskei Muskotaly) table grapes. GA_3 applied at 10 ppm had the highest total soluble solid (TSS) in Talizman, whereas the application of 20 ppm GA_3 in Poloskei Muskotaly had the highest TSS, TSS/TTA ratio. Thus, the response of GA_3 application on quality attributes varies with respect to the cultivars of grapevine in mid-hill condition of Nepal.

Keywords: Doses of GA_3, Juice pH, Total Soluble Solid (TSS), Total Titratable Acidity (TTA)

Introduction:

Cultivation of grapes in commercial scale has been started since 2016 AD in Nepal. Grape is cultivated in subtropical types of climate in the hilly areas of Nepal which is situated at the altitude of 650 meter above sea level (masl). In Nepal, occurrence of heavy rainfall in the fruit harvest period is a major constraint for the commercial production of table grapes and poor yield as monsoon (June-July) is associated with diseases incidence identified as the major limitations (Dahal et al., 2017; Acharya et al., 2023). By the use of chemical flowering inducer, it has become possible to prepone grape production to escape rainy season (Ghimire et al., 2024). Now it has become possible to produce berries earlier than the main season. The yield and qualities of berries, however, are not to the international standards. GA_3 is commonly used to increase the berry yield and quality of grapevines (Dokoozlian an Peacock, 2001; Dahal et al., 2017).

Commercial vineyard by private sector introduced different wine and table type of grapevines in recent years. Three potential grape cultivars introduced in Nepal are Cabernet Sauvignon (seeded wine type) in 2016, Talizman (table type seedless) and Poloskei Muskotaly (table type few-seeded) in 2020 (Kumar Karki, 2025, Personal communication). Response of GA application is largely varied with respect to grapevine cultivars, which is unclear or might be due to bioactive

GA available (Acheampong et al., 2015). This varied response of different cultivars to GA might be the cause of different GA signaling components. Rusjan (2010) also studied on grape quality and their storage potential of cultivars 'Cardinal' and 'Michele Palieri,' and observed that table grape cultivar responded differently to GA_3 applications on fruit quality. Conde et al. (2007) also reported that the lower level of GA in Black Finger (BF seedless) grapevines may have high response to GA application associated to the absence of seed traces. In stenospermocarpic cultivars, th main sources of bioactive GAs are seed traces.

The juice and pulp industries seek for fruits having better parameters such as fruit length-width-weight, pulp, seed and peel percentages per fruit, peel diameter, soluble solids (°Brix), titratable acidity (%), vitamin C content (mg/100g of fresh fruit), pulp pH and TSS/TTA ratio (Yadav et al., 2022). It is mainly due to a higher demand for high quality products. Identification of right dose and time for exogenous GA_3 application is important to improve the berry yield and quality of Nepalese grape industry. This research aimed to find out the appropriate dose and time of GA_3 application to improve the berry quality of different grapevine cultivars.

Materials and methods:

The study was conducted during December 2022 to June 2024 in the Kewalpur Agro-Farm (27.75°N, 85.11°E) of the Patleban Vineyard and Winery at the altitude of 650 masl at Dhading, Nepal. The randomized complete block design (RCBD) was employed during the experiment. Two factor experiments were carried out in few-seeded table grape (Poloskei Muskotaly) and seedless table grape (Talizman) cultivars to evaluate the effect of different GA_3 concentrations and time of application in three replications. Poloskei Muskotaly cultivar received 0, 5, 10 and 20 ppm; while cultivar Talizman received 0, 10, 20 and 40 ppm GA_3 at post-flowering, 4–5 mm berry size, and both at post-flowering and 4–5 mm berry size stages. GA_3 in a soluble granule form, produced by HIMEDIA Laboratories Pvt. Ltd, was used in the experiment. To analyze the different quality attributes, 10 berries were randomly sampled from each cluster of a treated grapevine. Qualitative attributes such as TSS, TTA, TSS/TTA ratio and juice pH were measured. The pH of berry juice was analyzed using digital pH meter (Lutron WA-2015) and TSS content of the berry juice was recorded in °Brix using digital refractometer (Atago Co., Ltd., PAL1). TTA was analyzed by titration method, in which extracted juice from 10 berries of each cluster was titrated against 0.1 N sodium hydroxide (NaOH) using phenolphthalein as indicator (AOAC, 1995). TTA was calculated by using the following formula;

$$\text{TTA \%} = \frac{Nb \times Vb \times Ea \times d.f. \times 100}{Vs}$$

Where, Nb = normality of the base, Vb = volume of the base, Ea= milli equivalent weight of tartaric acid, Vs= volume of sample, d. f. = dilution factor.

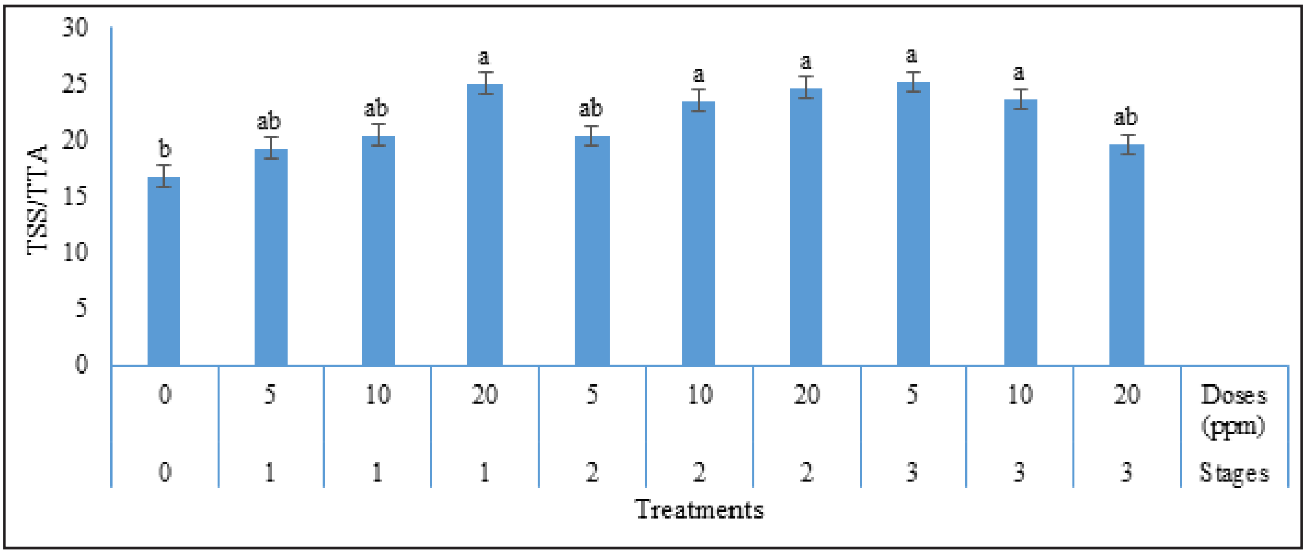
The collected data were processed by using MS Excel. Statistical analysis tool i.e. GenStat 18 (VSN International Limited, UK) was used, as per the given instruction for RCBD, for ANOVA preparation. Mean separation was performed using Duncan's Multiple Range Test (DMRT) at a 5% level of significance.

Results:

Doses and stages of GA_3 application on berry quality

Cultivar Poloskei Muskotaly:

In 2024, the highest TSS (17.25°Brix), TSS/TTA ratio (26.38) and pH (3.69) was found in the berries with the



Stages: 0= control, 1= >50% flowering, 2= 4-5 mm berry size, 3= both stages i.e. >50% flowering and 4-5 mm berry size.
Figure 1. Effect of GA_3 spray on TSS/TTA ratio of cv. Poloskei Muskotaly grape in 2023 (Mean ± SE).

application of 20 ppm GA_3, whereas, the control had the highest TTA (0.81) (Table 1).

The interaction effect of GA_3 doses and stages of application as in case of TSS/TTA ratio in 2023 was significantly different (Figure 1). The highest TSS/TTA ratio was with the application of 5 ppm at 3rd stage (25.14), which is at par with the 20 ppm at 1st stage (25.01), 20 ppm at 2nd stage (24.66), 10 ppm at 3rd stage (23.59) and 10 ppm at 2nd stage (23.49).

Cultivar Talizman:

The cluster treated with 10 ppm GA_3 had the highest TSS (14.82°Brix) in 2023 (Table 2) and the effect of GA_3 was not significant on other quality attributes such as TTA, TSS/TTA ratio and pH. There was negligible effect of stage of GA_3 application in the quality attributes of Talizman grape.

The interaction effect of GA_3 doses and stages was found significant as in case of TSS in 2024 (Figure 2) and in

Table 1. Effect of GA_3 (stages and doses) application on berry quality (Mean ± SE) of cv. Poloskei Muskotaly grape in mid-hill condition of Nepal during 2023-2024

Factors	Treatments	Year	TSS (°Brix)	TTA (%)	TSS/TTA ratio	pH
Combine control	S0: No GA_3 application	2023	16.49±0.32	1.01±0.13	16.81±2.23	3.09±0.11
		2024	15.65±0.33	0.81±0.05	19.36±1.54	3.60±0.01
		2023-24	16.07±0.23	0.92±0.06	18.09±1.09	3.34±0.10
Factor A: Stages (S)	S1: Post flowering	2023	16.70±0.54	0.79±0.04	21.56±1.46	3.25±0.05
		2024	16.50±0.29	0.75±0.04	22.33±1.38	3.64±0.01
		2023-24	16.60±0.43	0.77±0.04	21.95±1.39	3.45±0.08
	S2: 4-5 mm berry	2023	16.79±0.27	0.76±0.05	22.82±1.32	3.29±0.04
		2024	17.00±0.34	0.70±0.03	24.65±1.36	3.66±0.03
		2023-24	16.90±0.30	0.73±0.04	23.74±1.33	3.48±0.07
	S3: both S1 and S2	2023	16.75±0.59	0.75±0.04	22.77±1.48	3.26±0.04
		2024	16.72±0.39	0.68±0.04	25.08±1.64	3.66±0.03
		2023-24	16.74±0.48	0.72±0.04	23.93±1.57	3.46±0.08
Factor B: Doses (D)	D0: 0 ppm	2023	16.49±0.32	1.01±0.13	16.81±2.23	3.09^{c}±0.11
		2024	15.65^{b}±0.33	0.81^{a}±0.05	19.36^{c}±1.54	3.60^{b}±0.01
		2023-24	16.07±0.23	0.92±0.06	18.09^{c}±1.09	3.34^{c}±0.10
	D1: 5 ppm	2023	16.68±0.60	0.78±0.03	21.58±1.12	3.23^{b}±0.02
		2024	16.43^{b}±0.36	0.77^{a}±0.04	21.82^{bc}±1.51	3.62^{b}±0.03
		2023-24	16.56±0.48	0.78±0.04	21.70^{b}±1.29	3.43^{b}±0.07
	D2:10 ppm	2023	16.72±0.27	0.76±0.04	22.49±1.25	3.24^{b}±0.04
		2024	16.55^{b}±0.27	0.69^{b}±0.02	23.87^{ab}±0.95	3.65^{ab}±0.02
		2023-24	16.63±0.26	0.73±0.03	23.18^{ab}±1.10	3.45^{b}±0.08
	D2:20 ppm	2023	16.84±0.54	0.76±0.05	23.08±1.80	3.32^{a}±0.05
		2024	17.25^{a}±0.35	0.66^{b}±0.03	26.38^{a}±1.59	3.69^{a}±0.03
		2023-24	17.04±0.44	0.71±0.05	24.73^{a}±1.74	3.51^{a}±0.08
p-value	S		ns(2023)	ns(2023)	ns(2023)	ns(2023)
			ns (2024)	ns (2024)	ns(2024)	ns(2024)
			ns(2023-2024)	ns(2023-2024)	ns(2023-2024)	ns(2023-2024)
	D		ns(2023)	ns(2023)	ns(2023)	*(2023)
			*(2024)	**(2024)	**(2024)	*(2024)
			ns(2023-2024)	ns(2023-2024)	*(2023-2024)	*(2023-2024)
	D x S		ns(2023)	ns(2023)	*(2023)	ns(2023)
			ns(2024)	ns(2024)	ns(2024)	ns(2024)
			ns(2023-2024)	ns(2023-2024)	ns(2023-2024)	ns(2023-2024)

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; stages: S0= control, S1= >50% flowering, S2= 4-5 mm berry size, S3= both stages i.e. >50% flowering and 4-5 mm berry size.

Table 2. Effect of GA_3 (stages and doses) application on berry quality (Mean ± SE) of cv. Talizman grape in mid-hill condition of Nepal during 2023-2024

Factors	Treatments	Year	TSS (°Brix)	TTA (%)	TSS/TTA ratio	pH
Combine control	S0: No GA_3 application	2023	11.87±0.40	0.84±0.10	14.70±2.27	3.30±0.03
		2024	13.01±0.57	0.82±0.02	15.81±0.39	3.49±0.01
		2023-24	12.44±0.33	0.83±0.04	15.25±0.86	3.40±0.04
Factor A: Stages (S)	S1: Post flowering	2023	13.61±0.31	0.77±0.03	18.02±0.87	3.29±0.04
		2024	13.67±0.33	0.80±0.05	17.52±1.01	3.55±0.03
		2023-24	13.64±0.31	0.78±0.04	17.77±0.92	3.42±0.05
	S2: 4-5 mm berry	2023	14.42±0.40	0.71±0.03	20.83±1.29	3.30±0.03
		2024	14.10±0.24	0.85±0.04	16.74±0.55	3.55±0.02
		2023-24	14.26±0.33	0.78±0.04	18.78±1.19	3.43±0.05
	S3: both S1 and S2	2023	14.34±0.35	0.77±0.03	18.91±0.83	3.33±0.03
		2024	13.47±0.29	0.76±0.04	18.14±1.13	3.52±0.02
		2023-24	13.90±0.35	0.76±0.03	18.52±0.98	3.43±0.04
Factor B: Doses (D)	D0: 0 ppm	2023	11.87^{c}±0.40	0.84±0.10	14.70±2.27	3.30±0.03
		2024	13.01±0.57	0.82±0.02	15.81±0.39	3.50^{b}±0.01
		2023-24	12.44±0.33	0.83±0.04	15.25±0.86	3.40±0.04
	D1: 10 ppm	2023	14.82^{a}±0.36	0.75±0.03	20.20±1.26	3.30±0.03
		2024	14.17±0.21	0.79±0.04	18.33±1.04	3.59^{a}±0.01
		2023-24	14.50±0.31	0.77±0.04	19.26±1.16	3.45±0.05
	D2: 20 ppm	2023	13.87^{b}±0.32	0.75±0.03	19.00±1.08	3.31±0.04
		2024	13.69±0.34	0.82±0.05	17.11±0.91	3.53^{b}±0.02
		2023-24	13.78±0.32	0.78±0.04	18.06±1.02	3.42±0.05
	D2: 40 ppm	2023	13.67^{b}±0.33	0.75±0.03	18.56±0.85	3.31±0.03
		2024	13.37±0.28	0.80±0.03	16.95±0.82	3.52^{b}±0.02
		2023-24	13.52±0.30	0.77±0.03	17.75±0.86	3.42±0.04
p-value	S		ns$^{(2023)}$	ns$^{(2023)}$	ns$^{(2023)}$	ns$^{(2023)}$
			ns$^{(2024)}$	ns$^{(2024)}$	ns$^{(2024)}$	ns$^{(2024)}$
			*$^{(2023-2024)}$	ns$^{(2023-2024)}$	ns$^{(2023-2024)}$	ns$^{(2023-2024)}$
	D		*$^{(2023)}$	ns$^{(2023)}$	ns$^{(2023)}$	ns$^{(2023)}$
			*$^{(2024)}$	ns$^{(2024)}$	ns$^{(2024)}$	*$^{(2024)}$
			*$^{(2023-2024)}$	ns$^{(2023-2024)}$	ns$^{(2023-2024)}$	ns$^{(2023-2024)}$
	D x S		ns$^{(2023)}$	ns$^{(2023)}$	ns$^{(2023)}$	ns$^{(2023)}$
			**$^{(2024)}$	ns$^{(2024)}$	ns$^{(2024)}$	ns$^{(2024)}$
			**$^{(2023-2024)}$	ns$^{(2023-2024)}$	ns$^{(2023-2024)}$	ns$^{(2023-2024)}$

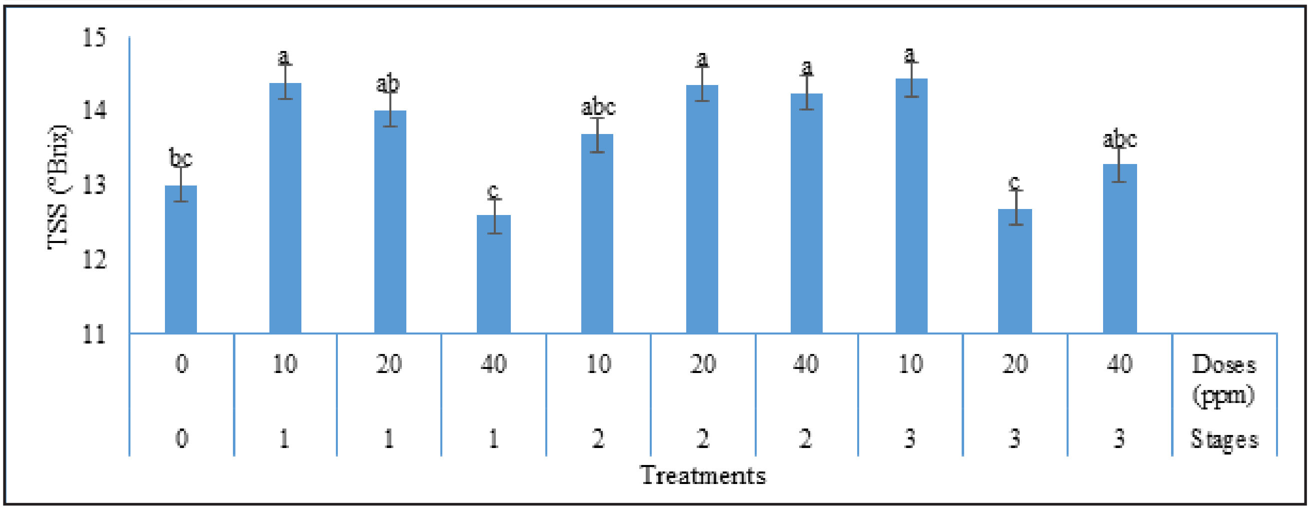
Symbol 'ns' indicates non-significant ($p > 0.05$) between doses and stages, symbol '*' indicates significant ($p < 0.05$) between doses and stages and symbol '**' indicates significant ($p < 0.01$) between doses and stages; stages: S0= control, S1= >50% flowering, S2= 4-5 mm berry size, S3= both stages i.e. >50% flowering and 4-5 mm berry size.

the pooled years of 2023-2024 (Figure 3). Application of 10 ppm GA_3 applied at 3rd stage had the highest TSS (13.43°Brix) in 2024, which is at par with the 20 ppm GA_3 at 2nd stage and 40 ppm GA_3 at 2nd stage. Likewise, in Figure 3, 10 ppm GA_3 applied at 3rd stage was found the highest TSS (14.99°Brix) in the pooled years of 2023-2024.

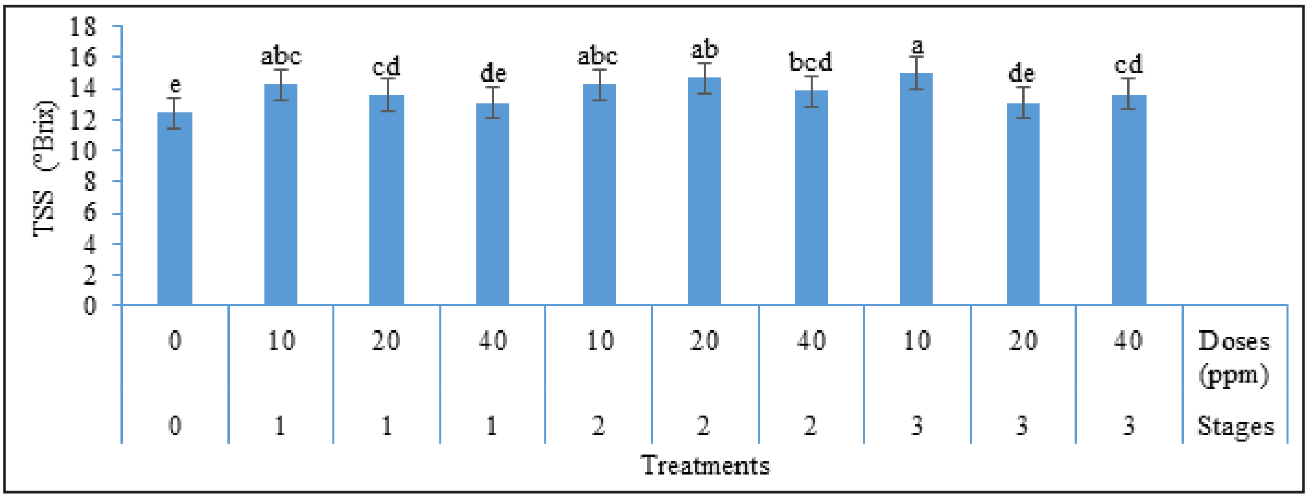
Discussion:

This study determined that as in case of cv. Poloskei Muskotaly (few-seeded berry), where GA_3 doses (0, 5, 10 and 20 ppm) applied at post-flowering, 4-5 mm berry size and both at post-flowering and 4-5 mm berry size, the highest TSS, TSS/TTA ratio and pH was found with the application of 20 ppm GA_3, while the control (no GA) had the highest TTA. In the interaction of GA_3 doses and stages, the highest TSS/TTA ratio was with the application of 5 ppm GA_3 at 3rd stage, which is at par with the 20 ppm GA_3 at 1st stage, 20 ppm GA_3 at 2nd stage, 10 ppm GA_3 at 3rd stage and 10 ppm GA_3 at 2nd stage.

Similarly, in Talizman (seedless berry), with the application of GA_3 doses (0, 10, 20 and 40 ppm) at post-flowering, 4-5 mm berry size and both at post-flowering and 4-5 mm berry size, 10 ppm GA_3 had the highest TSS



Stages: 0= control, 1= >50% flowering, 2= 4-5 mm berry size, 3= both stages i.e. >50% flowering and 4-5 mm berry size.
Figure 2. Effect of GA_3 spray on TSS of cv. Talizman grape in 2024 (Mean ± SE).



Stages: 0= control, 1= >50% flowering, 2= 4-5 mm berry size, 3= both stages i.e. >50% flowering and 4-5 mm berry size.
Figure 3. Effect of GA_3 spray on TSS of cv. Talizman grape in 2023-2024 (Mean ± SE).

and non-significant effect of GA_3 doses was on other quality attributes such as TTA, TSS/TTA ratio and pH. There was no effect of stage of GA_3 application in the berry quality attributes of cv. Talizman. However, the interaction effect of GA_3 doses and stages was found significant as in case of TSS, in which the similar effect was found in the application of 10 ppm GA_3 applied at 3rd stage, 20 ppm GA_3 applied at 2nd stage and 40 ppm GA_3 applied at 2nd stage.

In a separate study with the application of GA_3 doses (0, 5 and 10 ppm) at post-flowering, 4-5 mm berry size and both at post-flowering and 4-5 mm berry size had non-significant effect on quality attributes in cv. Cabernet Sauvignon. The main reason might be that the Cabernet Sauvignon is a true seeded cultivar with small sized berry and it is likely that the endogenous GA_3 might be sufficient to regulate the berry quality (Acharya et al., 2025). Singh et al. (2002) reported that developing seeds are a known source of GAs in many plant species. It is also reported that with the application of GA_3, non-significant effect was found on the quality of berries in Cabernet Sauvignon (Gao et al., 2020).

Moreover, Anjum et al. (2020) reported that application of 200 ppm GA_3 significantly increased the TSS but decreased the titratable acidity (TA) while comparing with the control. GA_3 also did not affect the pH of fruit juice (Anjum et al., 2020; Avenant and Avenant, 2005). Improved TSS by GA_3 was also reported by Jegadeeswari et al. (2010) in Muscat (seeded) cultivar with 25 ppm GA_3 application. GA_3 stimulates for enhancing the leaf area, photosynthates and transport of assimilates towards the reproductive part, causing the increase in total soluble solids (Elgendy et al., 2012). Rachna and Singh (2013) reported that GA_3 application directly affected the fruits' ability to assimilate metabolic chemicals, which enhanced TSS regulation. While, Alshallash et al. (2023) explained that advancement in berry maturation is the cause behind enhanced TSS and decreased TTA in spite of the change in sugar accumulation rate.

In cultivar Crimson Seedless, Satisha et al. (2021) found no significant difference in TSS, however, the highest TA was found in the control (0.52%) and the least acidity

(0.41%) was found as in case of clusters treated with 5 ppm GA. Anjum et al. (2020); Abu-Zahra and Salameh (2012); Domingos et al. (2016) also reported similar result that GA_3 cluster-sprayed fruit had reduced TTA. Abu-Zahra (2010) documented that GA_3 was responsible to enhance the maturity of grape berries by decreasing the TA content of the berries. The application of gibberellic acid on grapes improved quality of berries by increasing the sugar content and reducing the acidity of the berries (Abu-Zahra and Salameh, 2012; Kaplan et al., 2017) by increasing conversion of acids into sugars (Wali et al., 1990). The average TSS/TTA ratio was significantly different among the GA_3 doses with minimum value for the control as reported by Poudel et al. (2022) in var. Himrod. Similarly, increase in GA_3 concentration also enhanced TSS/TTA ratio in cvs. Thompson Seedless and Flame Seedless (Elgendy et al., 2012; Tambe, 2002). Exogenous factors such as temperature, light, and water availability and endogenous factors such as nutritional and hormonal factors determine the berry quality (Ollat et al., 2002).

Conclusion:

Effect of GA_3 varied on berry quality attributes on seeded, few-seeded (table grape) and seedless (table grape) cultivars Cabernet Sauvignon, Poloskei Muskotaly and Talizman, respectively. The effect of GA_3 application was more effective pronounced in the few-seeded and seedless cvs. Poloskei Muskotaly and Talizman. In seedless grape "Talizman" 10 ppm GA_3 application resulted the highest TSS, while in few-seeded Poloskei Muskotaly, the highest TSS, TSS/TTA ratio and pH was with the application of 20 ppm GA_3 and the control had the highest TTA. However, there was no effect of GA_3 application in seeded cultivar (Cabernet Sauvignon). It reveals that the response of GA_3 application on quality attributes varies with respect to the cultivars of grapevine in mid-hill condition of Nepal.

Acknowledgement:

The authors gratefully acknowledge to the Tribhuvan University (TU), Collaborative Research Grant-Research Coordination and Development Council (RCDC) for funding this research. The Kewalpur Agro-Farm is highly appreciated for providing the necessary arrangements of this research.

Declaration of the conflict of interest and ethical approval:

The authors declare that there is no conflict of interest with this research work and the publication of this paper.

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