Journal of Natural Science Review

Vol. 4, No. 1, 2026
https://kujnsr.com
e-ISSN: 3006-7804

Effect of Gibberellic Acid on Quantity and Quality of Seedless (Keshmishi) Grapes

Najihullah Saiq✉[1], Ghulam Rasoul Samadi[2]

[1] Student at the Department of Horticulture, Agriculture Faculty, Kabul University, Kabul, Afghanistan
[2] Department of Horticulture, Agriculture Faculty, Kabul University, Kabul, Afghanistan
✉E-mail: najihullah.saiq@gmail.com

ABSTRACT

Table grapes are among the most commercially significant non-climacteric fruits worldwide. In Afghanistan, grapes and raisins represent the most valuable perennial fruit crop, with annual production exceeding 1.1 million tons. However, seedless varieties like Keshmishi often produce small berries, limiting their market value. Gibberellic acid (GA_3), a widely available plant growth regulator, is commonly used to enhance berry size, but improper application can negatively affect grape quality and yield. This study investigated the optimal concentration and timing of GA_3 application to improve the quality and yield of Keshmishi grapes in a commercial vineyard in Esfandeh village, Ghazni province. Six treatments were tested, including different concentrations (20–60 ppm) applied at various phenological stages. Results showed that a 30 ppm GA_3 application after flowering significantly increased yield to 36.75 MT/ha—an improvement of 11.5 MT, or 45.5%, over the untreated/control. This treatment also produced larger, well-compacted bunches with minimal adverse effects. Applications at other stages or at higher concentrations did not significantly affect the yield. The study recommends post-flowering application of 30 ppm GA_3 for optimal results. Further research across different cultivars and economic analysis of treatment costs is advised to support broader application in commercial viticulture.

ARTICLE INFO

Article history:

Received: October 15, 2025
Revised: February 26, 2026
Accepted: March 16, 2026
Published: March 31, 2026

Keywords:

Gibberellin; Seedless (Keshmishi) grape; Yield; Quality; Compactness

To cite this article: Saiq, N.,& Samadi, G. R. (2026). Effect of Gibberellic Acid on Quantity and Quality of Seedless (Keshmishi) Grapes. *Journal of Natural Science Review*, 4 (1.), 221-232.
https://doi.org/10.62810/jnsr.v4i1.319

To link to this article: https://kujnsr.com/JNSR/article/view/319

INTRODUCTION

Grapes (*Vitis vinifera* L.), among the oldest domesticated fruit crops, are cultivated globally for their versatility in fresh consumption and processing into raisins, juices, wines, and other value-added products (Shirzad & Samadi, 2018). As a crop of significant economic value, grapes are grown across diverse agroclimatic zones, including temperate, tropical, and subtropical regions (Shirzad & Samadi, 2018). In Afghanistan, grape cultivation plays a pivotal role in the rural economy, with production reaching over 1.1 million tons in 2020 (MAIL, 2020).

The country's viticultural industry is primarily oriented around two sectors: fresh table grape production and raisin processing (Shirzad & Samadi, 2018).

Despite favorable agro-ecological conditions such as warm summers, full sunshine, and long growing seasons, Afghan grape production remains largely traditional and under-optimized. One major limitation is the inconsistent and often incorrect use of plant growth regulators (PGRs), particularly gibberellic acid (GA_3), which negatively affects fruit quality, particularly in seedless varieties like Keshmishi grapes (MAIL, 2020). Keshmishi grapes are widely cultivated for raisin production, but their marketability is hindered by small berry size and compact clusters resulting from inadequate GA_3 application (Shirzad & Samadi, 2018).

Since the 19th century, cultural practices such as girdling, pruning, and berry thinning, along with PGR applications, have been adopted to improve grape quality and yield (May, P,. 2004). Among these, the use of GA_3 has gained prominence for enhancing parameters such as berry size, bunch weight, sugar content, and acidity (Dokoozlian & Peacock, 2001; Srivastava & Handa, 2005). Research across several grape cultivars, including 'Thompson Seedless', 'Flame Seedless', and 'Italia', has shown that GA_3 significantly improves both vegetative and fruiting characteristics when applied at optimal concentrations and developmental stages (Poudel et al., 2022).

In Afghanistan, however, there is a lack of standardized knowledge and implementation practices regarding GA_3 use. Farmers, particularly in provinces like Ghazni, often apply gibberellin at inappropriate times or in excessive doses, leading to undesirable outcomes such as tight clusters, increased fungal susceptibility, delayed ripening, and reduced bud fertility (Samadi, 2018). As a result, the quality and yield of Keshmishi grapes are adversely affected, reducing their value in both fresh and raisin markets.

Gibberellins are naturally occurring plant hormones that regulate multiple physiological processes, including seed germination, shoot elongation, flowering, and fruit development, and GA_3, in particular, promotes berry expansion by stimulating cell division and elongation in the pericarp tissue. When applied at the correct phenological stage, GA_3 can improve fruit set, increase berry and cluster size, and enhance overall fruit quality (Churg, 1966). However, the effectiveness of GA_3 depends on various factors, including grape variety, dosage, application method, plant age, and environmental conditions (Churg, 1966).

Recognizing these challenges, this study focused on optimizing the application of GA_3 in Keshmishi grapes grown in Ghazni province. The primary aim is to identify the optimal timing and concentration of GA_3 that maximizes yield and fruit quality without inducing negative side effects. Given that grape cultivation is a high-income, labor-intensive agricultural sector in Afghanistan, improving the scientific basis for GA_3 use will benefit not only farmers but also traders, horticultural students, and the broader agricultural economy (Shirzad & Samadi, 2018).

The application of gibberellic acid (GA_3) has been widely adopted internationally to improve grape yield and fruit quality; however, in Afghanistan, particularly in Ghazni province, its use in Seedless (Keshmishi) grape production remains largely unstandardized. Growers often apply GA_3 at inappropriate concentrations or incorrect growth stages, resulting in inefficient or even negative outcomes. These practices frequently lead to small berry size, excessively compact clusters, poor-quality raisins, increased susceptibility to diseases, and ultimately reduced yields. Despite the economic importance of the Keshmishi (seedless) grape variety for raisin production, there is currently no locally conducted scientific research determining the optimal concentration and timing of GA_3 application under regional conditions. Consequently, inadequate berry enlargement, tight clusters, and lower productivity remain common challenges in vineyards.

In response to these issues, the present study aims to evaluate the effects of different GA_3 concentrations on the quality characteristics of Keshmishi grapes and to determine the optimal timing and dosage that positively influence yield and marketable fruit quality. By establishing scientifically validated recommendations, this research seeks to provide practical guidance for farmers and growers to improve berry size, cluster looseness, and overall productivity, thereby increasing farm income. Furthermore, enhancing grape quality will strengthen Afghanistan's competitiveness in the international raisin market by improving export standards and value. Finally, the findings will contribute locally generated scientific evidence that can serve as a foundation for future viticulture research and academic work in the region.

Given the significance of the topic and the necessity for a precise understanding of the Gibberellic Acid effects on Quantity and Quality of Seedless (Keshmishi) Grapes, this study has been initiated with the following objectives:

- Evaluate the effects of different concentrations of GA_3 on the quality characteristics of Keshmishi grapes.
- Determine the optimal timing and dosage of GA_3 application that positively influences yield and marketable fruit traits.

METHODS AND MATERIALS

The experiment was conducted from May to September 2024 in a commercial vineyard located in Isfanda village, Ghazni Province, in the central region of Afghanistan (33°28′13″ N, 68°24′20″ E, 2136.94 m above sea level). The site lies within the central dry zone of Ghazni, characterized by arid climatic conditions suitable for grape cultivation. The study focused on the local Keshmishi grapevine variety to evaluate the effects of gibberellic acid (GA_3) applications on growth, yield, quality, and the benefit–cost ratio.

Experimental Design and Layout

The experiment followed a completely randomized block design (CRBD) with six treatments and five replications, comprising a total of 30 experimental units (one vine per unit). The vines were arranged in five rows, each containing six experimental units. Field observations were recorded from all the experimental units.

Plant Material

The study utilized 20–25-year-old vines of the Keshmishi cultivar, the predominant grape variety in Ghazni Province. The vines were spaced 3.0 m × 2.5 m apart, traditionally trained as runner shrubs on earthen mounds. Pruning was performed on 31 October 2023 before the experimental season. The Keshmishi variety is a widely cultivated Afghan landrace used for fresh consumption, raisin production, and vinegar making (Faiz, 2018).

Preparation of GA_3 Solutions

Commercially available TOCAA tablets containing 10% GA_3 were used. Solutions of 20, 30, 40, 50, and 60 ppm concentrations were prepared by dissolving the required quantity of GA_3 in distilled water. For example, 80 mg of GA_3 powder was dissolved in 4 L of water to prepare a 20 ppm solution. A total of 4 L of solution was required per application to treat six vines. Prepared solutions were applied as foliar sprays to bunches and berries until fully soaked.

Harvesting and Data Collection

Bunches were harvested at full ripening from each vine per treatment. Observations were recorded on growth, yield, quality, and sensory attributes as follows:

Growth Parameters

- Bunch length (cm): measured from peduncle to distal end using scale markings.
- Bunch weight (g): average weight of three bunches per treatment using an electronic balance.
- Bunch volume (cm^3): determined by water displacement in a volumetric beaker.
- Bunch compactness: ratio of bunch weight to bunch volume.
- Berry dimensions (mm): length and diameter measured with a digital vernier caliper.
- Berry weight (g): average weight of randomly selected berries using an electronic balance.

Quality Parameters

- Total soluble solids (°Brix): determined using a digital refractometer from juice of ripe berries.
- Titratable acidity (%): estimated by titration with NaOH using phenolphthalein as indicator.

Yield Parameters

- Yield per vine was recorded in kilograms and converted to metric tons per hectare (MT ha^{-1}).

Statistical Analysis

Data were analyzed using ANOVA in STAR statistical software (v. 2.0.1). Treatment means were compared using the Least Significant Difference (LSD) test at 1% and 5% levels of significance. Data organization and visualization were performed in Microsoft Excel 2021.

FINDINGS

The application of different concentrations of gibberellic acid (GA_3) significantly influenced the growth parameters of Keshmishi grapes, including bunch and berry characteristics, as shown in Table 1.

Among the treatments, maximum bunch length (26.68 cm) was recorded in vines treated with 30 ppm GA_3 applied after the flowering stage. This was significantly higher than the control (22.52 cm) and the 60-ppm treatment (21.46 cm), while the other treatments (20, 40, and 50 ppm) produced intermediate lengths (24.12–24.65 cm) that were not significantly different from the control.

Bunch weight also showed highly significant differences among treatments. The highest bunch weight was observed in the 30 ppm treatment (735.02 g), followed by the 40 ppm treatment (515.12 g). The lowest weight was recorded in the 20 ppm treatment (344.56 g), with control and other treatments showing intermediate values (453.92–460.22 g).

Bunch volume varied significantly among treatments, with the maximum volume recorded in the 30 ppm GA_3 treatment (670 cm^3), followed by the 40 ppm treatment (544 cm^3). The control recorded 421.6 cm^3, while the 20, 50, and 60 ppm treatments produced lower volumes (262–404 cm^3). Bunch appearance, evaluated as the ratio of weight to volume, differed significantly, with the most compact clusters observed in the control (1.46 g/mL) and 20 ppm treatment (1.32 g/mL). In comparison, the 30 and 40 ppm treatments produced the loosest compact clusters (1.00–1.03 g/mL).

Significant differences were also observed in berry characteristics. Berry length was highest in the 30 ppm treatment (21.57 mm), followed by the 40 and 60 ppm treatments (17.18 and 17.51 mm), while the control and 20 ppm treatments produced shorter berries (14.22 and 15.50 mm). Similarly, berry diameter was greatest in the 30 ppm treatment (16.03 mm). The 40, 50, and 60 ppm treatments produced smaller berry diameters (14.99-15.20 mm), while the control and 20 ppm treatments yielded the smallest berries (12.75-13.50 mm).

The weight of 50 berries was significantly affected by GA_3 concentration and timing. The highest weight was recorded in the 30 ppm treatment applied after flowering (171.98 g), followed by the 40 and 60 ppm treatments (125.24 and 132.83 g). The lowest weight was observed in the 20 ppm treatment before the flowering stage (77.95 g) and control (92.91 g).

Overall, vines treated with 30 ppm GA_3 after flowering consistently showed superior growth parameters, producing the largest, heaviest, and most voluminous bunches and berries, as well as the proper compact clusters, compared to other treatments and the untreated control. Treatments with 40 and 50 ppm GA_3 applied during the berry growth stage yielded moderate improvements, while 20 and 60 ppm applications were less effective, producing smaller, denser clusters.

Table 1. *Growth parameters (Bunch length, Bunch weight, Bunch volume, Bunch Compact/ Loose, Berry length, Berry diameter, Weight of 50 Berries) in Seedless (Keshmishi) grapes as influenced by different concentrations of gibberellic acid treatment*

Treatment	Bunch length(cm)	Bunch weight (g)	Bunch volume (cm3)	Bunch Compact/ Loose	Berry length (mm)	Berry diameter (mm)	Weight of 50 Berries (gr)
T1 (20 ppm)	24.40 ab	344.56 b	262.00 d	1.32 ab	14.22 c	12.75 b	15.59 c
T2 (30 ppm)	26.68 a	735.02 a	670.00 a	1.03 b	21.57 a	16.03 a	34.40 a
T3 (40 ppm)	24.65 ab	515.12 ab	544.00 ab	1.00 b	17.51 b	15.20 a	26.57 b
T4 (50 ppm)	24.12 ab	460.22 b	404.00 bcd	1.16 ab	17.20 b	14.99 a	25.05 b
T5 (60 ppm)	21.46 b	401.26 b	351.00 cd	1.13 ab	17.18 b	14.99 a	26.08 b
T6 (control)	22.52 b	453.92 b	421.60 bc	1.46 a	15.50 bc	13.50 b	18.58 c
F-test	*	**	**	*	**	**	**
LSD 5% & 1%	3.019	170.89	141.46	0.27	1.91	1.17	5.46
CV %	9.54	19.57	17.78	17.21	6.19	4.48	12.45
SEm±	1.45	60.06	49.72	0.12	0.67	0.41	0.19

Means with the same letter are not different at 5% or at 1% level of significance.

Quality Parameters

As shown in Table 2, total soluble solids (TSS) of Keshmishi grape juice varied significantly among GA_3 treatments. The highest TSS was recorded with 30 ppm GA_3 applied after flowering (21.22 °B), followed by 20 ppm before flowering (19.73 °B) and the control (19.35 °B). Moderate values were observed with 40 and 60 ppm treatments (18.47 & 18.62 °B). At the same time, the lowest TSS occurred with 50 ppm applied at the 4 mm berry stage (17.56 °B), indicating that both GA_3 concentration and application timing affect sugar accumulation.

In contrast, the acidity of berry juice was not significantly affected by GA_3 treatments (F-test, NS). Values ranged from 0.66% to 0.76% across all treatments, with no statistically meaningful differences between the control and the treated vines. Similarly, juice pH was not significantly influenced by the GA_3 applications (F-test, NS), although the highest pH (3.00) was observed in the 30 ppm treatment after flowering. Other treatments, including 20, 40, 50, and 60 ppm applications, as well as the control, showed minor variations in pH (2.58–2.84) that were not statistically significant.

These results suggest that while GA_3 application can enhance sugar content in Keshmishi grapes, it does not significantly affect juice acidity or pH under the conditions of this study.

Table 2. *Quality parameters (Total soluble solid, Acidity, pH) in Seedless (Keshmishi) grapes as influenced by different concentrations of gibberellic acid treatment*

Treatment	Total soluble solids (TSS)	Acidity of berry juice (%)	pH of Berry Juice
T1 (20 ppm)	19.73 ab	0.70	2.80
T2 (30 ppm)	21.22 a	0.66	3.00
T3 (40 ppm)	18.47 bc	0.72	2.58
T4 (50 ppm)	17.56 c	0.76	2.76
T5 (60 ppm)	18.62 bc	0.68	2.84
T6 (control)	19.35 bc	0.66	2.76
F-test	*	NS	NS
LSD 5% & 1%	1.86	-	-
CV %	7.37	18.92	7.58
SEm±	0.89	0.08	0.13

Yield and Organoleptic Evaluation

Gibberellic acid (GA_3) treatments significantly influenced the total yield of Keshmishi grapes. The highest yield was recorded in vines treated with 30 ppm GA_3 after flowering (36.75 MT per ha), representing a 45.5% increase over the untreated control (25.25 MT per ha). The 40 ppm treatment during the 4 mm berry stage produced the next highest yield (33.25 MT per ha), followed by 20 ppm before flowering (29.15 MT per ha), 50 ppm during the 4 mm stage (28.8 MT per ha), and 60 ppm during the 4 mm stage (25.35 MT per ha). These results indicate that both the concentration and timing of GA_3 application strongly affect overall productivity.

Organoleptic evaluation of grapes by a five-member panel showed significant differences among treatments. The 30 ppm GA_3 treatment applied after flowering recorded the highest scores for appearance (4.0), texture (3.8), colour (3.6), flavour (4.0), and overall acceptability (3.6). Other treatments generally received lower scores, with appearance and texture around 2.4–2.6. Colour ratings ranged from 2.6 to 3.6, flavour from 2.4 to 4.0, and overall acceptability from 2.4 to 3.6, indicating the superiority of the 30 ppm GA_3 treatment.

These results suggest that applying 30 ppm GA_3 after flowering increases yield and improves the sensory quality of Keshmishi grapes, indicating that proper concentration and timing are important for both yield and quality.

Table 3. *Total yield and organoleptic parameters (Berry Appearance, Colour, Texture, Flavour, and Overall Acceptability) in Seedless (Keshmishi) grapes as influenced by different concentrations of gibberellic acid treatment*

Treatment	Total Yield (MT/Hectare)	Berry Appearance	Colour	Texture	Flavour	Overall Acceptability
T1 (20 ppm)	29.15 ab	2.60 b	2.60 b	2.80 b	2.60 bc	2.80 b
T2 (30 ppm)	36.75 a	4.00 a	3.60 a	3.80 a	4.00 a	3.60 a
T3 (40 ppm)	33.25 ab	2.60 b	2.60 b	2.80 b	3.20 b	2.60 b
T4 (50 ppm)	28.8 ab	2.40 b	2.60 b	2.80 b	3.00 bc	3.00 ab
T5 (60 ppm)	25.35 b	2.60 b	2.60 b	2.20 b	2.40 c	2.60 b

T6 (control)	25.25	b	2.40	b	2.80	b	2.80	b	2.80	bc	2.60	b
F-test	*		**		*		**		**		*	
LSD 5% & 1%	6.0582		0.62		0.63		0.63		0.63		0.64	
CV %	20.57		17.08		17.25		16.85		16.10		17.09	
SEm±	2.90		0.29		0.30		0.30		0.30		0.30	

Means with the same letter are not different at 5% or at 1% level of significance.

DISCUSSION

The application of growth regulators, particularly Gibberellic Acid (GA3), has consistently been shown to enhance grape yield and quality across diverse grape-growing regions worldwide. Earlier studies by Poudel et al., 2022 demonstrated the effectiveness of GA3 and GA-like substances in improving both fruit size and quality. Similarly, Kumar &Sharma (2016) reported that plant growth-promoting substances significantly influence fruit set, berry size, bunch size, yield, and other quality parameters of grapes. Among these substances, GA3 has been particularly effective in improving berry and bunch characteristics, as confirmed by VanderWeide et al. (2024). Based on this evidence, the present study investigated the effect of different GA3 doses on the quantity and quality of Keshmishi grapes in Ghazni province, Afghanistan.

The results of this study revealed that grapes treated with 30 ppm GA_3 after flowering (Trt-2) showed the best growth and yield, with significantly higher bunch length, weight, and volume, likely due to enhanced rachis cell elongation and better nutrient allocation. These findings align with those of Ahmad et al. (2005) in Perlette grapes, Farooq and Hulamani (2001) in Arkavati grapes, and Dimovska et al. (2014) in Flame Seedless grapes, confirming that post-flowering GA3 application optimizes bunch elongation across different varieties.

The study also observed that GA3 application reduced cluster compactness in seedless grapes, with Trt-2 showing the most loosely compact clusters. This reduction in compactness is attributed to GA3's effect on lowering fruit set and promoting berry thinning, a phenomenon previously reported in Thompson Seedless and Crimson Seedless grapes (Sunita, 2017). By reducing the number of berries per bunch, GA3 allows the remaining berries to receive more nutrients, thereby increasing berry length, diameter, and weight. The highest individual berry size and 50-berry weight were recorded in Trt-2, reflecting the combined effect of enhanced cell division and subsequent cell expansion in the mesocarp and pericarp tissues. Similar observations were made in Thompson Seedless grapes (Rafaat et al., 2012) and Crimson Seedless grapes (Sunita, 2017).

Quality parameters were also positively influenced by GA3 application. Total soluble solids (TSS) were highest in Trt-2 grapes, indicating enhanced sugar accumulation, while acidity and pH were not significantly affected. These results are consistent with previous studies in Red Globe grapes (Avenant, 2017) and indicate that GA3 primarily accelerates sugar accumulation rather than affecting acidity or juice pH (Marzouk and Kassem, 2011). The findings suggest that GA3 improves grape taste and ripening without compromising the balance of acidity.

Yield per vine and per hectare was also maximized in Trt-2, reflecting the combined effects of improved bunch length, berry size, and cluster thinning. GA3 treatment, when applied post-flowering, effectively promotes berry enlargement and optimizes yield, as reported in Thompson Seedless (Kumar & Sharma, 2016), and Einset Seedless grapes (Kaplan et al., 2017). These results emphasize the importance of timing and dosage: higher GA3 concentrations or earlier applications did not yield comparable benefits.

Organoleptic evaluation further confirmed the superior quality of Trt-2 grapes. Panelists consistently rated Trt-2 highest in berry appearance, color, texture, flavor, and overall acceptability. This improvement is likely due to GA3's thinning effect, which reduces fruit set and enhances berry development, contributing to better shape, color uniformity, taste, and texture. Similar effects have been reported by Habibi (2009) and Khalil et al. (2022).

Overall, this study demonstrates that applying 30 ppm GA_3 after flowering is the most effective treatment for improving the yield and quality of Keshmishi grapes. Higher doses or earlier applications were less effective, indicating that proper timing and concentration are essential. The results confirm that GA_3 enhances berry size, cell elongation, and cluster thinning, thereby improving quantitative and qualitative traits. These findings provide practical guidance for grape growers in Afghanistan and similar regions to improve grape productivity and market value.

CONCLUSION

A field experiment conducted from May to September 2024 in Isfanda village, Ghazni province, examined the effects of different GA_3 concentrations and application timings on Keshmishi (seedless) grapes. Six treatments significantly affected bunch growth, berry size, yield, and quality. Among them, applying 30 ppm GA_3 after flowering produced the best results, improving cluster development, berry growth, and overall grape quality. Notably, yield increased to 36.75 MT/ha, representing an 11.5 MT (45.5%) increase compared to the control (25.25 MT/ha), demonstrating the critical importance of proper GA_3 timing and concentration.

Further research is needed to standardize the use of growth regulators across different seedless grape varieties to improve productivity and fruit quality under varying agroclimatic conditions. Future studies should investigate the relationship between gibberellic acid concentrations and biochemical parameters, such as starch and sugar content, to enhance grape quality. These points inform the study's final recommendations:

Gibberellin spray application at 30 ppm after flowering to bunches of grapes until they were soaked, as it yielded 36.75 MT/ha, the highest. The yield was increased by 11.5 MT, or 45.5%, per ha compared to the control, with the largest berries, properly compact bunches, large clusters, and the highest percentage of normal berries. Additionally, it requires an optimal concentration of GA3 and has the potential for very low negative side effects.

AUTHORS CONTRIBUTIONS

- Ghulam Rasoul Samadi conceptualized and supervised the study.
- Najihullah Saiq investigated, analyzed data, and wrote the manuscript with input from all authors.
- All authors reviewed and approved the final version.

ACKNOWLEDGEMENTS

We are deeply grateful to Allah the Almighty for His guidance and strength throughout this research journey. We also sincerely thank my family for their unwavering support during the completion of my M.Sc. degree.

FUNDING INFORMATION

This research received no external funding. The authors conducted the study using the facilities and equipment of the Agricultural Faculty, Kabul University.

CONFLICT OF INTEREST STATEMENT

The authors declare that they have no conflicts of interest. This research was conducted independently, and all work utilized the facilities and equipment of the Agricultural Faculty, Kabul University.

DATA AVAILABILITY STATEMENT

Data is available upon request from the corresponding author, subject to ethical approval.

REFERENCES

Ahmad, M., Kaul, R. K., & Kaul, B. L. (2005). Effect of girdling, thinning and GA_3 on fruit growth, yield, quality and shelf life of grapes (*Vitis vinifera* L.) cv. Perlette. *Acta Horticulturae*, *696*, 309–313. https://doi.org/10.17660/ActaHortic.2005.696.54

Avenant. (2017). Effect of gibberellic acid, CPPU, and harvest time on browning of *Vitis vinifera* L. 'Regal Seedless'. In *IX International Symposium on Grapevine Physiology and Biotechnology* (*Acta Horticulturae*, *1157*), 357–366. https://doi.org/10.17660/ActaHortic.2017.1157.52

Chaitakhob, N. B., Janchean, N., Pilap, & Methaneekornchai, S. (2014). Influence of gibberellic acid and N6-benzyladenine on the development of seed and berry quality in Perlette seedless grape. *Acta Horticulturae*, *1024*, 197–203. https://doi.org/10.17660/ActaHortic.2014.1024.24

Churg, J. B. (1966). *Poona Agricultural College Magazine*, *56*(3 & 4), 91. Print journal; available in archives.

Dimovska, V., Petropulos, V. I., Salamovska, A., & Ilieva, F. (2014). Effect of different concentrations of gibberellic acid (GA_3) on Flame Seedless grape variety (*Vitis vinifera* L.). *Bulgarian Journal of Agricultural Science*, *20*(1), 137–142. Link

Dokoozlian, N. K., & Peacock, W. L. (2001). Gibberellic acid applied at bloom reduces fruit set and improves size of 'Crimson Seedless' table grapes. *HortScience*, *36*(4), 706–709. https://doi.org/10.21273/HORTSCI.36.4.706

El-Razek, E. A., Aml, R. M., Yousef, S., & Abdel-Hamed, N. (2015). Effect of chelated Fe, Zn, and Mn soil application with spraying GA_3 and ascorbic acid on growth, yield, and fruit quality of Flame Seedless grapevines under calcareous soil conditions. *International Journal of Chemical Technology Research*, *8*, 441–451. Link

Farooq, M., & Hulamani, N. C. (2001). Effects of growth regulators and boric acid and their stage of treatment on bunch characters of Arkavathi grapes. *Karnataka Journal of Agricultural Sciences*, *13*(4), 1049–1053. Link

VanderWeide, J., Nasrollahiazar, E., Schultze, S., Sabbatini, P., & Castellarin, S. D. (2024). Impact of cluster thinning on wine grape yield and fruit composition: A review and meta analysis. *Horticulturae*, Article 2504396. https://doi.org/10.1155/2024/2504396

Habibi, H. K. (2009). *Effect of gibberellic acid and brassinosteroid on bunch and berry characters, yield and quality of Bangalore blue grapes* (Unpublished master's thesis). GKVK, Bangalore, India.

Kaplan, M., Najda, A., Baryla, P., & Klimek, K. (2017). Effect of gibberellic acid concentration and number of treatments on yield components of Einset Seedless grapevine cultivar. *Horticultural Science*, *44*(4), 195–200. https://doi.org/10.17221/51/2015-HORTSCI

Khalil, A., Sharma, M. K., Kumar, A., Nazir, N., & Javeed, K. (2022). Effect of growth regulators on yield and quality of Sahebi grape (*Vitis vinifera*) under temperate conditions. *The Indian Journal of Agricultural Sciences*, *92*(10), 1181–1185. https://doi.org/10.56093/ijas.v92i10.109022

Kumar, K. T., & Sharma, M. K. (2016). Effect of GA_3 in combination with urea phosphate and BA on yield and physical quality parameters of grape cv. Thompson Seedless. *The Bioscan*, 49–52. Link

May, P. (2004). *Flowering and fruit set in grapevines*. Phylloxera and Grape Industry Board of South Australia in association with Lythrum Press, Adelaide, South Australia, 113. Link

Marzouk, H. A., & Kassem, H. A. (2011). Improving yield, quality, and shelf life of Thompson Seedless grapevine by preharvest foliar applications. *Scientia Horticulturae*, *130*(2), 425–430. https://doi.org/10.1016/j.scienta.2011.07.013

Poudel, P., Atreya, P. N., & Dahal, K. C. (2022). Effect of gibberellic acid on yield and fruit quality of table grape var. Himrod. *Journal of Agriculture and Environment*, *23*(1), 131–142. https://doi.org/10.3126/aej.v23i1.46922

Rafaat, S. S. E., Ghada, S., Shaker, & Ahmed, O. A. (2012). Effect of foliar spraying with gibberellic acid and/or sitofex on bud behavior, vegetative growth, yield and cluster quality of Thompson Seedless grapevines. *Journal of American Science*, 21–34.Link

Shirzad, B. M., & Samadi, G. R. (1397). *Deciduous fruits of Afghanistan*. Kabul University, Agriculture Faculty, Kabul, Afghanistan: Sayed Haseeb Publisher.

Srivastava, A., & Handa, A. K. (2005). Hormonal regulation of tomato fruit development: A molecular perspective. *Journal of Plant Growth Regulation, 24*(2), 67–82. http://doi.org/10.1007/s00344-005-0015-0

Sunita, T. (2017). *Influence of gibberellic acid (GA_3) on growth, yield, and quality parameters of Red Globe grapes (Vitis vinifera L.)* (Doctoral dissertation).