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EFFECT OF GIBBERELLIC ACID (GA_3) SPRAYING AND DIPPING ON QUALITY OF GRAPE (*VITIS VINIFERA* L.) IN TELANGANA INDIA

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ABSTRACT

Grapes (*Vitis vinifera* L.), a high-value subtropical fruit crop, are widely cultivated in India, with Thompson Seedless being the dominant variety due to its export potential. However, the quality and shelf life of grapes are often compromised due to their perishable nature. This study, conducted at the Grape Research Station, Rajendranagar (Telangana), aimed to evaluate the effect of Gibberellic Acid (GA_3) application through spraying and dipping methods on the quality of three grape cultivars -Thompson Seedless, K.R. White and Flame Seedless. The experiment followed a Factorial Randomized Block Design with three application schedules and standard agronomic practices. Parameters like Total Soluble Solids (TSS), acidity, sugars, phenolic content and shelf life were assessed.

The study showed that grape quality significantly improved with GA_3 application, especially using the combined spraying and dipping method (Schedule-2). *Thompson Seedless* had the highest total soluble solids (20.03 °Brix) and lowest acidity (0.35%), resulting in the best Brix to acid ratio (58.65%). Schedule-2 also enhanced total sugars, reducing sugars and phenolic content across all cultivars. *Flame Seedless* showed the highest phenols but the shortest shelf life, while *Thompson Seedless* exhibited the longest shelf life (9.11 days). Overall, Schedule-2 was most effective in improving sugar accumulation, acidity reduction, phenolic content and extending shelf life, confirming its benefit for better grape quality.

***Key words*:** Gibberellic Acid (GA3), Spraying, Dipping, Fruit quality, Total Soluble Solids, Brix: acid ratio, Phenolics, Shelf life.

Introduction

Grapes (*Vitis vinifera* L.), among the earliest cultivated fruits, are an important subtropical crop of the Vitiaceae family. They are native to the Mediterranean and Southern Caucasus regions, yet considered endemic to Western Asia and Europe (Venkitasamy *et al.*, 2019). In India, grape cultivation began in 1300 A.D. with the arrival of Persian conquerors. Grapes are non-climacteric fruits grown on woody, perennial, deciduous vines and are consumed mainly as fresh fruit, dried (raisins) or used in wine production. Nutritionally, they are rich in vitamins (A, B-complex, C), minerals (iron, calcium, potassium), organic acids and polyphenolic compounds such as resveratrol, quercetin and catechin, which exhibit strong antioxidant properties (Bose, 2021; Singh *et al.*, 2023). These bioactive compounds are linked to reduced risks of chronic diseases, including cardiovascular diseases and cancer (Arts & Hollman, 2005; Erdman *et al.*, 2007; Leifert & Abeywardena, 2008).

In India, *Thompson Seedless* is the most extensively

Table 1: Effect of Gibberellic acid (GA_3) spraying and dipping on total soluble solids (° Brix), titrable acidity (%), brix to acid ratio in grape cv. Thompson seedless, K.R. White, Flame seedless.

	Total soluble solids (° Brix)				Titrable acidity (%)				Brix to acid ratio			
	C1	C2	C3	Mean	C1	C2	C3	Mean	C1	C2	C3	Mean
S1	19.21^{cd}	19.73^{bc}	18.86^{cd}	19.27^{b}	0.37	0.38	0.44	0.39^{a}	52.07	51.96	42.89	48.97^{b}
S2	21.54^{a}	20.23^{b}	19.46^{bcd}	20.41^{a}	0.29	0.28	0.33	0.30^{b}	74.29	71.95	58.49	68.25^{a}
S3	19.33^{bcd}	18.57^{d}	18.51^{d}	18.80^{b}	0.39	0.40	0.41	0.38^{a}	49.59	45.70	46.28	47.19^{b}
Mean	20.03^{a}	19.51^{a}	18.94^{b}		0.35^{b}	0.37^{b}	0.39^{a}		58.65^{a}	56.54^{a}	49.22^{b}	
	C	S	C × S		C	S	C × S		C	S	C × S	
S.Em	0.174	0.174	0.301		0.007	0.007	0.012		1.425	1.425	2.469	
CD (5%)	0.520	0.520	0.901		0.021	0.021	NS		4.273	4.273	NS	

[Cultivars- C1- Thompson seedless; C2- K.R. White; C3- Flame seedless; **Schedules:** S1- Schedule 1; S2- Schedule 2; S3- Schedule 3**]**.

grown table grape variety, accounting for over 70% of the grape cultivation area due to its high export potential (Loay, 2007; Marzouk & Kassem, 2011). However, its high perishability and sensitivity to post-harvest deterioration necessitate improved cultural practices. One key strategy to enhance berry quality and yield is the application of plant growth regulators like Gibberellic Acid (GA_3), which promotes cell division, berry enlargement and reduces cluster compactness (Korkutal & Gokhan, 2007; Dimovska *et al.*, 2011). GA_3 is commonly applied during specific phenological stages-pre-bloom, full bloom or post fruit-set-either through foliar spraying or bunch dipping (Abu-Zahra, 2013). These practices improve berry size, firmness, sugar content and reduce disease susceptibility, making grapes more marketable and suitable for export.

Bunch dipping, which involves submerging grape clusters in GA_3 solution, ensures direct and effective hormone absorption and is particularly effective in small vineyards (Marzouk & Kassem, 2011). This technique significantly increases bunch weight, berry diameter and total soluble solids (TSS), while also reducing fungal infections such as *Botrytis cinerea* (Somkuwar *et al.*, 2006; Korkutal *et al.*, 2008). Although labor-intensive, dipping offers more consistent results compared to

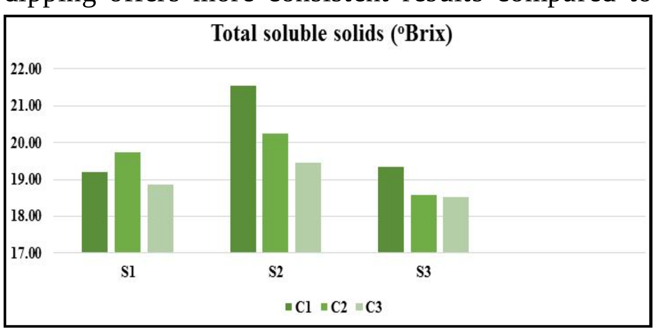

Fig. 1: Effect of Gibberellic acid (GA_3) spraying and dipping on Total soluble solids (°Brix). **[Cultivars-** C1- Thompson seedless; C2- K.R. White; C3- Flame seedless; **Schedules:** S1- Schedule 1; S2- Schedule 2; S3- Schedule 3**]**.

spraying. With changing consumer preferences and rising export demands for colored varieties like *Flame Seedless* (Satisha *et al.*, 2021), maintaining fruit quality through GA3 treatments is essential for profitability and sustaining India's grape export industry (APEDA, 2024; Nanjappanavar *et al.*, 2024).

Materials and Methods

The present study, titled *"Effect of Gibberellic Acid* (GA_3) *Spraying and Dipping on Quality of Grape* (*Vitis vinifera L.*) *in Telangana,"* was conducted during October 2024 to March 2025 at the Grape Research Station, Rajendranagar, under Sri Konda Laxman Telangana Horticultural University, Hyderabad. The experiment was laid out in a Factorial Randomized Block Design (FRBD) with nine treatment combinations involving three cultivars (*Thompson Seedless, K.R. White* and *Flame Seedless*) and three GA_3 application schedules, each replicated thrice with four vines per replication. Vines were eight years old, planted at a spacing of 2.74 m × 1.52 m and trained on the Y-system.

GA_3 was applied through spraying and bunch dipping at different phenological stages, including parrot green stage, flowering and berry development stages, using concentrations ranging from 10 to 40 ppm. Schedule 1 involved only spraying, Schedule 2 combined spraying and dipping, while Schedule 3 involved a higher proportion of dipping. Observations were recorded on key quality parameters after harvest at 18 °Brix maturity stage during February-March.

The quality parameters of grape berries were evaluated using standard procedures. Total soluble solids (°Brix) were measured using a hand refractometer. Titratable acidity was estimated by titrating the juice sample with 0.1 N NaOH using phenolphthalein as an indicator and expressed as percent citric acid (Lunkes and Hashizume, 2014). The Brix: acid ratio was calculated by dividing the TSS by the acidity value. Total and reducing sugars were determined using the Lane and

Table 2: Effect of Gibberellic acid (GA_3) spraying and dipping on total sugars (%), reducing sugars (%), non-reducing sugars (%) in grape cv. Thomson seedless, K.R. White, Flame seedless.

	Total sugars (%)				Reducing sugars (%)				Non-Reducing sugars (%)			
	C1	**C2**	**C3**	**Mean**	**C1**	**C2**	**C3**	**Mean**	**C1**	**C2**	**C3**	**Mean**
S1	17.17	16.93	14.48	16.19[c]	15.64	15.49	12.19	14.44[b]	1.52	1.44	2.29	1.75
S2	18.27	18.36	16.38	17.67[a]	16.44	16.70	13.74	15.62[a]	1.83	1.67	2.64	2.05
S3	17.28	17.53	15.19	16.63[b]	15.69	16.00	12.66	14.78[b]	1.59	1.41	2.53	1.84
Mean	17.57[a]	17.89[a]	15.35[b]		15.92[a]	16.06[a]	12.86[b]		1.65[b]	1.50[b]	2.49[a]	
	C	**S**	**C × S**		**C**	**S**	**C × S**		**C**	**S**	**C × S**	
S.Em	0.100	0.100	0.173		0.122	0.122	0.212		0.091	0.091	0.157	
CD (5%)	0.300	0.300	NS		0.366	0.366	NS		0.277	NS	NS	

[Cultivars- C1- Thompson seedless; C2- K.R. White; C3- Flame seedless; **Schedules:** S1- Schedule 1; S2- Schedule 2; S3- Schedule 3**]**.

Eynon method as described by Ranganna (1986), while non-reducing sugars were obtained by subtracting reducing sugars from total sugars. Total phenolic content was estimated using the Folin-Ciocalteu reagent method and expressed as mg of Gallic acid equivalent per 100 g sample (Singleton and Rossi, 1965). Shelf life was assessed based on visual appearance, with the endpoint marked by the onset of over-ripeness and spoilage (Turner, 1997).

Statistical Analysis

The data recorded on berry yield, physical traits, quality parameters and shelf life were statistically analyzed using the Analysis of Variance (ANOVA) technique for a Factorial Randomized Block Design (FRBD), following the procedure outlined by Panse and Sukhatme (1985). The statistical analysis was carried out using OPSTAT software. Significance of treatment effects was tested at the 5% probability level using the F-test. Where significant differences were observed, the critical difference (CD) at 5% was calculated to compare the means.

Results and Discussion

Quality in grapes is a crucial determinant of their commercial value and it can be enhanced through the application of plant bio-regulators like gibberellic acid (GA_3). GA_3 influences a range of physiological processes including sugar accumulation, acid metabolism, phenolic biosynthesis and postharvest longevity. The following parameters were significantly affected by GA_3 application schedules, grape cultivars and their interactions.

Total Soluble Solids (°Brix)

Total Soluble Solids (TSS) were significantly influenced by cultivar, GA_3 scheduling and their interaction. 'Thompson Seedless' recorded the highest TSS (20.03 °Brix), closely followed by 'K.R. White' (19.51 °Brix), while 'Flame Seedless' showed the lowest (18.94 °Brix). Among the GA_3 application schedules, Schedule-2 resulted in the highest TSS (20.41 °Brix), suggesting its efficacy in enhancing sugar accumulation. The interaction T_2 (Thompson Seedless + Schedule-2) recorded the highest TSS of 21.54 °Brix.

The increase in TSS can be attributed to enhanced photosynthate mobilization and conversion of starch and organic acids into sugars under GA_3 influence. GA_3 is known to promote sink strength by increasing auxin levels, which in turn accelerate sugar accumulation in berries. Similar findings were reported by Cheema *et al*., (1997) and Satisha *et al*., (2021).

Titratable Acidity (%)

Titratable acidity showed a significant response to cultivar and GA_3 schedule, but not to their interaction. 'Thompson Seedless' had the lowest acidity (0.35%), followed by 'K.R. White' (0.37%), whereas 'Flame Seedless' showed the highest (0.39%). Schedule-2 was most effective in reducing acidity (0.30%).

The reduction in acidity is linked to increased metabolic activity induced by GA_3, especially the conversion of organic acids into sugars and other metabolites during berry ripening. GA_3 enhances respiratory enzyme activity that consumes malic acid, leading to reduced acidity. These findings are in agreement with Ghorbani *et al*., (2017), although Rusjan

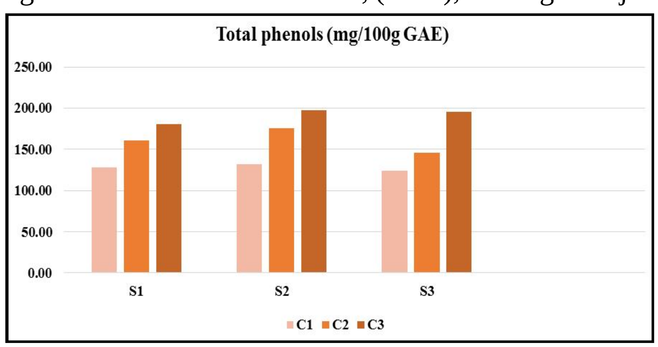

Fig. 2: Effect of Gibberellic acid (GA_3) spraying and dipping on Total phenols (mg/100g GAE). **[Cultivars**- C1- Thompson seedless; C2- K.R. White; C3- Flame seedless; **Schedules:** S1- Schedule 1; S2- Schedule 2; S3- Schedule 3**]**.

Table 3: Effect of Gibberellic acid (GA_3) spraying and dipping on total phenols (mg/100 g GAE), shelf life (days) in grape cv. Thomson seedless, K.R. White, Flame seedless.

Treatment	Total phenols (mg/100 g GAE)				Shelf life (days)			
	C1	C2	C3	Mean	C1	C2	C3	Mean
S1	128.03[e]	160.95[c]	181.13[b]	156.70[b]	8.67	7.33	6.00	7.33[c]
S2	132.08[e]	175.57[b]	197.74[a]	168.46[a]	9.67	9.33	7.00	8.67[a]
S3	124.15[e]	146.00[d]	195.32[a]	155.16[b]	9.00	8.00	6.33	7.78[b]
Mean	128.08[c]	160.84[b]	191.40[a]		9.11[a]	8.22[b]	6.44[c]	
	C	S	C × S		C	S	C × S	
S.Em	1.498	1.498	2.422		0.140	0.140	0.242	
CD (5%)	4.193	4.193	7.262		0.419	0.419	NS	

[Cultivars- C1- Thompson seedless; C2- K.R. White; C3- Flame seedless; **Schedules:** S1- Schedule 1; S2- Schedule 2; S3- Schedule 3**].**

(2010) observed limited effect of GA_3 when applied alone.

Brix to Acid Ratio

The Brix to acid ratio, a key maturity index, was significantly affected by cultivar and GA_3 schedule. 'Thompson Seedless' recorded the highest ratio (58.65%), followed by 'K.R. White' (56.54%), while 'Flame Seedless' showed the lowest (49.22%). Schedule-2 produced the highest ratio (68.25%), indicating better sugar-acid balance.

This improvement in ratio is due to the simultaneous increase in TSS and decrease in acidity. GA_3 enhances sugar translocation and reduces organic acid accumulation, improving palatability. Singh and Singh (1980) and Ahmed *et al.*, (2005) have reported similar effects in other grape cultivars.

Total Sugars (%)

Total sugar content varied significantly among cultivars and GA_3 schedules. 'K.R. White' (17.89%) and 'Thompson Seedless' (17.57%) had higher sugar levels compared to 'Flame Seedless' (15.35%). Schedule-2 again proved superior, recording (17.67%), followed by Schedule-3 and Schedule-1.

The increase in total sugars can be attributed to the enzymatic conversion of stored carbohydrates and enhanced phloem loading capacity induced by GA_3. Enhanced source-sink dynamics under GA_3 influence led to increased sugar deposition in berries. Khalil (2022) reported similar findings in GA_3-treated grape clusters.

Reducing Sugars (%)

Reducing sugar content was significantly affected by both cultivar and schedule. 'K.R. White' had the highest reducing sugars (16.06%), followed by 'Thompson Seedless' (15.92%), while the lowest was recorded in 'Flame Seedless' (12.86%). Among the schedules, Schedule-2 led with (15.62%), indicating its efficiency.

Reducing sugars are primarily formed due to hydrolysis of non-reducing sugars and starch, processes accelerated by GA_3. Enhanced enzymatic activity and phloem unloading lead to higher reducing sugar levels in the berries. These results align with the findings of Nanjappanavar *et al.*, (2024).

Non-Reducing Sugars (%)

Non-reducing sugars showed significant variation among cultivars, but not across schedules or interactions. 'Flame Seedless' recorded the highest non-reducing sugars (2.49%), while 'K.R. White' showed the lowest (1.50%).

Although GA_3 scheduling did not show a statistically significant effect on non-reducing sugars, the higher values in 'Flame Seedless' may be due to lower hydrolysis rates or higher initial sucrose content. Singh and Khanduja (1977) reported that GA_3 enhances both reducing and non-reducing sugar levels through improved carbohydrate metabolism.

Total Phenols (mg/100g GAE)

Phenolic content was influenced by cultivar, schedule and their interaction. 'Flame Seedless' recorded the highest phenols (191.40 mg/100g GAE), followed by 'K.R. White' (160.84 mg/100g GAE), while 'Thompson Seedless' had the lowest (128.08 mg/100g GAE). Schedule-2 showed the highest phenol accumulation (168.46 mg/100g GAE). T8 (Flame Seedless + Schedule-2) recorded the maximum (197.74 mg/100g GAE).

The rise in phenolic content is attributed to GA_3's stimulation of the phenylpropanoid pathway, which enhances the biosynthesis of flavonoids and other polyphenols. Tyagi (2022) supported this by showing upregulation of phenol biosynthesis genes after GA_3 application. However, Fraser (2007) noted that excessive GA_3 might increase bitterness due to elevated phenol levels, affecting market quality.

Shelf Life (Days)

Shelf life was significantly affected by cultivar and GA_3 scheduling. 'Thompson Seedless' had the longest shelf life (9.11 days), followed by 'K.R. White' (8.22 days), while 'Flame Seedless' had the shortest (6.44 days). Schedule-2 resulted in the highest shelf life (8.67 days).

Improved shelf life is attributed to GA_3's effect on berry firmness, which results from enhanced cell expansion and strengthened cell walls in the berry pericarp. GA_3 also delays senescence, leading to slower deterioration. These results are in line with findings from Ahmed *et al*., (2005) and Khalil (2020), who reported similar improvements in postharvest longevity with GA_3 application.

Conclusion

The present study demonstrated that the application of GA_3, particularly under Schedule-2 (a combination of spraying and dipping), significantly improved the qualitative parameters of grapes across all cultivars. Thompson Seedless and K.R. White cultivars showed superior performance in terms of total soluble solids, sugar content, brix-to-acid ratio and shelf life, whereas Flame Seedless recorded the highest phenolic content. The improvement in quality traits is largely attributed to GA_3's role in enhancing carbohydrate translocation, stimulating metabolic activities, reducing organic acids and increasing sink strength of berries. The increased sugar accumulation and extended shelf life could be linked to GA_3-induced changes in phloem loading, cell expansion

and delayed senescence. Although interaction effects were significant for some traits like TSS and phenolics, Schedule-2 consistently resulted in better outcomes, suggesting it as the most effective method for improving grape quality and nutritional status under Telangana conditions.

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