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Bio-efficacy and Phytotoxicity of Gibberellic Acid (GA_3) Technical 90% for Improving Yield and Quality in Grapes (*Vitis vinifera* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The experiment was conducted on Thompson Seedless grapevines grafted on dog ridge rootstock to study its response towards the application of gibberellic acid (GA_3) Tech. 90% at different time intervals. The experiment was designed in a randomized block design (RBD) having five treatments with four replications were carried out at Maharashtra Rajya Draksha Bagaitdar Sangh, Pune during 2020-2021 & 2021 - 2022. Significant differences were observed with the applications of GA_3 at different developmental stages (pre-bloom and fruit set) resulted in to increased bunch weight, berry weight, berry length, berry size, pedicel thickness, rachis length, and quality parameters *viz.* total soluble solids along with the highest yield per vine exogenous application of different concentrations of GA_3 at different time interval schedules was beneficial for the quality and yield of Thompson Seedless grapevines.

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1. INTRODUCTION

The India is in the midst of a horticulture revolution. Grape is emerging as an fruit crop of India; it has the third highest productivity and is the highest among fruit crops to earn foreign exchange. At present, out of total estimated area of 5.34 million ha under fruit crop in India, grape occupies about 84,400 ha with an annual production of 1.81 million metric tons. Out of total cultivated area under grapes, Thompson Seedless and its clone Tas -A- Ganesh are grown in about 90% of the total area. Unfortunately the productivity is declining for the past 10-15 years in major grape growing region of the country due to problems associated with disease infestations, physiological disorders and drought and also soil salinity. Within the grapes growing regions, the growers are adopting different degree of inputs based on their own experiences, which leads to uncertainty in yield over the years. Economic analysis has indicated a continuous increase in production and development of grape processed product in the international market. However, India's share in the international grapes trade remains meager with the exports of table grapes accounting 2-3% of the total production. This is mainly because of non-maintenance of various standard parameters with respect to fresh fruit and processed products.

Grape is a commercially important fruit crop of India. The grapes are exported to Europe, UK and Middle East countries. The export suffers because of poor berry quality and noncompliance to quality standards imposed by the importing countries, particularly with respect to the size and sugar content of the berries. It is possible to achieve these standards through excellent management practices coupled with the use of gibberellins (GA_3) at the different stages of berry development. This bio-regulator has the capacity to modify or to regulate the crop growth though they are in minute quantities. It has been often reported that the Gibberellic acid (GA_3) is beneficial to increase size of fruits in different crops through cell elongation and also increases chlorophyll content and photosynthesis rate**.** On the other hand, exogenously applied GA_3 was observed to be transported through the phloem pathway to sink (berries). Exogenously applied hormone can also be readily taken up in to the vascular bundles and may get translocated over considerable distance from the point of application. These observations indicate a potential co-ordination system between root and shoot regulated by synthesis and transport of exogenous hormones initially through the vascular system followed by vascular transport. Chiou and Bush [1] provided evidence that "this pivotal activity was regulated by a response pathway sensitive to sucrose levels in leaf. These characteristics are consistent with a sucrose-dependent signaling pathway that dynamically regulates phloem loading by responding to the sucrose levels in the phloem". These results suggest that gibberellins are transported with carbohydrates reported. Application of GA_3 to the flavedo of 'Shamouti' oranges before and after harvest showed delayed development of the pale color due to the absorption of GA_3 by both attached and detached fruits, although this effect was not more marked and persistent in the former.

The study aims to evaluate grapes vines to gibberellins and the possible improvement of Gibberellin metabolism for increasing the size of berries through better source-sink relationship, which is pre-requisite for the export. This would give an idea of concentration and time of application of gibberellins so that product cost can be minimized and the dose of response curve for each vines can be worked out. Studies on the bio-efficacy and phytotoxicity of gibberellic acid will indicate the pattern of translocation and metabolisms of photosynthesis this will helping better understanding of the source sink relationship. The physiological and biochemical estimation envisaged the investigation that would give an insight into various anabolic and catabolic process involved in berry development. The findings of the study have fundamental values to grape growers. Considering this at optimum dose and right time of application would not only reduce the cost of cultivation apart from enhancing the productivity particularly the size of berries which is basic requirement for the export of grapes for table purpose. This will promote the judicious use of gibberellic acid for achieving quality in compliance to international standards with maximum productivity.

2. MATERIALS AND METHODS

The trial was conducted in a research and developmental grape vineyard of the Maharashtra Draksha Bagaitdar Sangh at Pune, India (18.32 °N and 73.51°E). The soil type of

this region was deep black clay loam (vertisol), with a pH of about 7.8 and electrical conductivity (EC) of 1.6 m mhos/cm, with an average temperature of 20 to 28 °C. The vines Thompson Seedless (*Vitis vinifera*) grafted on dog ridge rootstocks were selected for the study.

The vines were planted in N-S direction with a spacing of 2.66 meter between the rows and 1.33 meter between the vines. The vines were trained to mini-Y- trellises with a single cordon placed in horizontal orientation followed by drip irrigated as per the irrigation schedule developed for the region, based on pan evaporimeter readings. The experimental vines were fertilized with organic manure and commercial inorganic fertilizers through fertigation. Vines were pruned twice in a year – once during summer (popularly known as back pruning), to develop canes with differentiated fruit buds, and another pruning on the matured canes about five to six months after back pruning (popularly known as forward pruning), to encourage bunch development. The fruit pruning was done during 29.09.2021 for 1st season and 01.10.2022 for 2nd season. The experiment was laid out in Randomized Block Design (RBD) with five treatments and four replications. The treatment details were mentioned & applications scheduled were presented in Table 1. All the good agricultural practices were followed to keep the vines healthy. The objective of the study was to evaluate the Gibberellic acid (GA_3) Technical 90% on berry size and quality parameters of Thompson Seedless grapevines.

2.1 Observations Recorded

Yield per vine (Kg) at harvest, average berry pedicel (mm), diameter, berry length (mm), and berry diameter (mm) were measured by using the digital Vernier caliper (RSK™, China). Average berry weight bunch weight and yield per vine were recorded. Hundred berry samples were randomly selected from each replicate, processed in a blender and strained through two layers of muslin cloth. Soluble solids concentration was determined from the juice using a digital refractometer (ERMA, Japan). The titratable acidity was calculated by using the titration method. 5 ml of fruit juice from each replication was titrated with sodium hydroxide solution of known normality (NaOH N =0.1N) using phenolphthalein as an indicator as suggested by (A.O.A.C, 1985). The results of these titrations were converted to percent of titratable acidity using the following equation;

$$\text{Percent of titratable acidity} = \frac{(\text{N.NaOH} \times \text{ml.NaOH} \times 0.075^* \times 100)}{(\text{Juice in ml})}$$

*0.075 = Equivalent weight of tartaric acid.

3. RESULTS AND DISCUSSION

The data recorded on yield and quality parameters of Gibberellic acid (GA_3) Tech. 90% treated vines were presented in Table 2. The least berry quality parameters such as Bunch weight (228.17 g), 50 berry weight (121.51 g), berry diameter (15.81 mm), berry length (15.72 mm), pedicel diameter 0.70 mm, skin thickness (17.77 mm) and number of berries per bunch (69.34) were recorded with the untreated control. The highest bunch weight, 50 berry weight, berry diameter, berry length, pedicel diameter, skin thickness and number of berries per bunch was recorded the vines treated with Gibberellic acid (GA_3) Tech. 90% @ 62.50 ppm at the different scheduled time intervals, and which was found at

Table 1. Treatment details evolution of gibberellic acid (GA_3) Tech. 90% in grapevines

Tr. No.	Treatment details	Dose (ppm)	Application scheduled		
			Pre-bloom (20 - 25 Days after pruning),	**Fruit setting** (50 - 55 days after pruning)	**3-4 mm berry size** (60 - 65 days after pruning),
1.	Gibberellic acid (GA_3) Tech. 90%	40.00			
2.	Gibberellic acid (GA_3) Tech. 90%	50.00			
3.	Gibberellic acid (GA_3) Tech. 90%	62.50			
4.	Gibberellic acid (GA_3) Tech. 90% (Market standard)	50.00			
5.	Control	--			

par with Gibberellic acid (GA_3) Tech. 90 % @ 50 ppm at the different scheduled time intervals. The results obtained in this study might be due to the application of Gibberellic acid (GA_3) Tech. 90% which might induce the hormonal activity resulted into the increase in cell number and cell size. Similarly, Rafat, et al., (2012) reported the application of GA_3 along with sitofix (CPPU) increase in bunch weight the cell number and cell size. The results obtained on pedicel diameter was significantly higher over control treatment. Which indicate pedicel diameters increased through metabolic changes by the application of growth regulators especially GA_3. Several studies have been reported that reduction in peroxidase activity in increase in enzyme activity which contributed the thickness by Ramteke et al. [2], Abdul et al. [3] on 'Fujiminari' grapes. Retamales et al. [4]. Mohsen et al. [5] revealed that "spraying GA_3 at 0.5 mg/l at full bloom was the optimum treatment for Crimson Seedless berry thinning, this treatment showed improved bunch and berry physical and chemical characteristics, in addition to the packable yield of tested table grape cv. Without a better reduction in a number of berries/bunch, as well as yield and bunch weights as compared with the alternative tested GA_3 concentrations and control". Samra et al. [6] also reported that application of GA_3 significantly increased berry length Flame seedless vines.

The quality parameters of grape berries such as total soluble solids and total acidity were found irreversible preposition in this study. The total soluble solids was influenced the application of GA_3 Tech. 90% which indicates the application GA_3plays an important role in acid metabolism in grapevines. The present findings confirms the findings of Khan et al. [7] who found that a positive response of GA_3 in Flame seedless grapevines. Similarly, Patil et al. [8] found that with 50 mg GA_3 treatment induced significantly highest percentage of reducing sugars in grapes cv. *Vitis viniferafera* L. Several studies, Rusjan [9] studied "on impacts of the gibberellin (GA_3) application on grapevine (*Vitis vinifera* L.) varieties 'Cardinal' and 'Michele Palieri,' on grape quality and their storage potential, the treatment with GA_3 @ 50ppm showed highest total sugar concentration & CIRG indices and the quality of table grape responded differently to GA_3 applications, especially the different impacts were observed according to varieties".

The data recorded on yield per vines of Gibberellic acid (GA_3) Tech. 90% treated vines were presented in Table 3. The least yield per vines (9.694 kg) was recorded with the untreated control. Whereas the highest yield per vines (12.55 kg) was recorded the vines treated with GA_3@ 62.50 ppm at the different scheduled time intervals, and which was found at par with GA_3@ 50 ppm yield per vines (12.55 kg) at the different scheduled time intervals. The results obtained in this investigation might be due the application of GA_3@ 62.50 ppm at the different scheduled time intervals through increased in berry diameters, bunch weight and berry weight. This study confirms the findings of Warusavitharana et al. [10] evaluated that "effect of Cytokinins and Brassinosteroid with Gibberellic acid on Yield and Quality of Thompson Seedless Grapes, and the results showed application of GA_3 at 10 ppm at before blooming stage, 15 ppm at after flowering initiation, 25 ppm mixed with brassinosteroid @ 1 ppm, and benzyl adenine @ 10 ppm at 3 to 4 mm berry diameter stage in twice at 4 leaves and berry setting stage and found maximum berry diameter, berry length, berry weight, number of berries per bunch, number of bunches per vine, bunch weight and yield with the attractive grayish-yellow color of berries". Similarly, Wassel et al. [11] also recorded that "combined application of micronutrients (Zn, Fe, and Mn) at 0.2%, gibberellic acid at 25 ppm, and ascorbic acid at 500 ppm on white Banaty seedless grapevines, the results showed the maximum weight of clusters and number of clusters per vine that indicated remarkable promotion on yield". Several studies reported that the application of GA_3 alone or with combination increased in berry size, cluster weight, berry weight by Chen et al. [12] in Red Globe, Usha et al. [13] Perlette grapes.

Avenant and Avenant [14] also confirmed "the effects of application of gibberellic acid and CPPU on colour and berry size of'redglobe' grapes. The combined applications of 20 mg L-1 GA3 plus 5 mg L-1 CPPU plus 1.5% seaweed at 12 mm berry size, 16 mm berry size and véraison stage, showed highest yield with a desirable colour". According to Gowda et al. (2005) there is an positive influence of the GA_3 on the increase and development of bunches and berries of Thompson Seedless grapes.

Table 2. Evaluation of Gibberellic acid (GA_3) Tech. 90% in yield and quality parameters in grapevines during 2020-21 and 2021-22

Treatment details	Dose (ppm)	Bunch Weight (g)	50 Berry Weight (g)	Berry diameter (mm)	Berry length (mm)	Pedicel diameter (mm)	Skin Thickness (mm)	TSS (°Brix)	Acidity (%)	Yield/ vine kg /Vine	No. of berry/Bunch
T1: Gibberellic acid (GA_3) Tech. 90%	40.00	252.41	134.54	16.80	18.343	0.88	19.96	19.30	0.489	11.23	78.67
T2: Gibberellic acid (GA_3) Tech. 90%	50.00	255.03	137.30	18.93	19.197	1.09	25.75	19.00	0.731	12.35	93.34
T3: Gibberellic acid (GA_3) Tech. 90%	62.50	279.58	154.21	19.54	20.763	1.15	26.937	18.67	0.743	12.55	97.07
T4: Gibberellic acid (GA_3) Tech. 90% (Market standard)	50.00	280.73	158.30	20.20	20.658	9.07	23.48	17.93	0.556	11.433	85.97
T5:Control	--	228.17	121.51	15.81	15.728	0.70	17.787	20.61	0.423	9.694	69.34
SEm (±)		**8.18**	**5.60**	**0.20**	**0.52**	**0.02**	**0.40**	**0.12**	**0.04**	**0.06**	**1.24**
C.D @ 0.5 %		**24.40**	**16.67**	**0.61**	**1.57**	**0.06**	**1.20**	**0.34**	**0.012**	**0.20**	**3.73**

Table 3. Evaluation of Gibberellic acid (GA_3) Tech. 90% in yield parameters in grapevines during 2020-21 and 2021-22

Treatment details	Dose (ppm)	Yield/ vine kg /Vine	Yield (ton) /acre (ton)	Spad	Rachis length (cm)
T1: Gibberellic acid (GA_3) Tech. 90%	40.00	11.23	8.48	31.063	14.41
T2: Gibberellic acid (GA_3) Tech. 90%	50.00	**12.35**	**9.33**	**33.48**	**18.79**
T3: Gibberellic acid (GA_3) Tech. 90%	62.50	**12.55**	**9.48**	**35.22**	**19.49**
T4: Gibberellic acid (GA_3) Tech. 90% (Market standard)	50.00	11.433	8.64	38.39	**15.15**
T5:Control	--	9.694	7.32	30.363	12.64
SEm (±)		**0.40**	**0.05**	**0.58**	**0.23**
C.D @ 0.5 %		**0.12**	**0.15**	**1.74**	**0.70**

4. CONCLUSION

This study was undertaken to evaluate the effects of GA_3 Tech. 90% on the quality and yield of grapes. Significance application of GA_3 at different developmental stages (pre-bloom and fruits) was increased yield and maintained the quality of grapes as compared to control. This study showed the exogenous application of different concentrations of GA_3at different time interval schedule was beneficial for the quality and yield of Thompson Seedless grapevines.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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