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Significance of Foliar Spraying with Gibberellic Acid (40% WSG) and CPPU (1% SP) on Yield, Quality, Leaf Photosynthesis and Biochemical Changes in Grapes

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ABSTRACT: *The present investigation was conducted to study the effect of foliar application of Gibberellic acid (40% WSG) and CPPU (1% SP) with regards to the concentration, stage and time of application on yield, quality, leaf photosynthesis and biochemical changes in berries of grapes. The experiment was conducted at National Research Centre for Grapes, Pune during fruiting season of 2013-2014 on Thompson Seedless grapes. Foliar application of different concentrations of Gibberellic acid (GA_3) 40% WSG and 90% active ingredient while CPPU 1% SP was given at pre-bloom, flowering, 3-4 mm berry size and 6-7mm berry size stage as a spray. Application of 40 ppm GA_3 (40 % WSG) alone or in combination with 2 ppm CPPU (1% SP) was found to increase leaf photosynthesis, transpiration rate and also biochemical parameters viz. Protein content, starch and total carbohydrate in Thompson Seedless grapes. Positive correlation was recorded with berry quality, leaf photosynthesis and biochemical parameters in relation to yield. The data from this study indicated that spraying of 40 ppm GA_3 (40 % WSG) alone or in combination with 2 ppm CPPU (1% SP) found to be effective for improving leaf photosynthesis, biochemical changes, quality and yield parameters in Thompson Seedless grapes.*

Key words: *Foliar spray, Grape, PGR's, Photosynthesis, Quality, Yield*

INTRODUCTION

Grape (*Vitis vinifera* L.) is one of the most important fruit crop and occupy more land all over the world than any other single fruit. Seedless grapes are attracting enormous concern for its good eating in class, but it's usually smaller in size. So, grape growers have been focusing on the seedless cultivar with better berry size. Thompson Seedless is a commercially accepted table grape variety in India both for the domestic market and also for export. Plant growth regulators applied during the growth period promotes the growth through boosting cell division and increasing cell volume. Recently growth regulators are widely used in the field of grape production. Improvement of quality and yield are the most important aspects of grape production. Berry size is the core quality aspects in international markets, growers often overuse the growth regulators like Gibberellic acid (GA_3) and forchlorfenuron (CPPU) to enlarge berry size, Zoffoli *et al.* [27]. The quality is mainly determined by berry size, color and pulp content while yield is governed by the number of bunches per vine and bunch weight. In recent years an increasing range of use of growth promoting hormone has been noticed with their positive response on the crop productivity. Cultural practices used for table grape production include the use of GA_3 sprays at anthesis which reduces the number of flowers that set and then an additional GA_3 spray shortly thereafter which will increase berry size, Roper & Williams [19]. Gibberellic acid (GA_3) and CPPU is a plant hormone that stimulates and regulates plant growth. The size of seedless berries increased by GA_3 and CPPU treatments, Ikeda *et al.* [10]; Ishikawa *et al.* [11]. Foliar application of GA_3 counteracted some of the adverse effects of NaCl salinity with the accumulation of proline, which maintained membrane permeability and increased macro and micronutrient levels, Tuna *et al.* [25]. Berry size also increased with the applications of several Gibberellic acids (GA_3), at the time of prior to anthesis, at berry set (approximately two weeks) and after

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anthesis, Harrell and Williams [9]. Combined applications of GA_3 and CPPU, Ben-Arie *et al.* [2]; Avenant & Avenant [1], and/or CPPU alone, Ben-Arie *et al.* [2] improve grape berry firmness. Forchlorfenuron (CPPU) has been tried effectively, either alone or in combination with other growth regulator to improve grape quality, Mervet *et al*. [15]. Application of CPPU showed potential results, such as increasing berry set and berry size in Thompson Seedless grapes. Therefore, the current study aims to better understand the mechanism, the purpose of present investigation is to throw some focus on the significance of foliar spraying in different growth stages of berry development with Gibberellic acid (GA_3) 40% WSG, 90% active ingredient and (CPPU) Cap-Plus 1% SP on yield, quality, leaf photosynthesis and biochemical changes in berries of Thompson seedless grapes.

MATERIAL AND METHODS

A field experiment was carried out at experimental vineyards of National Research Centre for Grapes, Pune during fruiting season of 2013-2014 on Thompson Seedless grapes under Good Agricultural Practices (GAP). Grapevines were planted at 10' x 6' m spacing and pruned by retaining by a maximum of 7-9 nodes/vine. The different concentrations of Gibberellic acid (GA_3) Progibb 40% WSG (Water Soluble Granule), 90% active ingredient and (CPPU) Cap-Plus 1% SP (Soluble Powder) were sprayed with three replications. Each replication consisted of 10 plants. T1= 20 ppm GA_3 (Progibb 40% WSG), T2= 40 ppm GA_3 (Progibb 40% WSG), T3= 20 ppm GA_3 (Progibb 40% WSG)+ 2 ppm CPPU (Cap-Plus 1% SP), T4= 40 ppm GA_3 (Progibb 40% WSG)+ 2 ppm CPPU (Cap-Plus 1% SP), T5= 20 ppm GA_3 (90% active ingredient), T6= 40 ppm GA_3 (90% active ingredient), T7= 20 ppm GA_3 (90% active ingredient) + 2 ppm CPPU (Cap-Plus 1% SP), T8= 40 ppm GA_3 (90% active ingredient) + 2 ppm CPPU (Cap-Plus 1% SP) and T9= Control (Water). All these treatments were applied at Pre-bloom stage, flowering stage, 3-4 mm berry size and 6-7mm berry size. The GA_3 and CPPU were applied with a knapsack sprayer.

At the time of harvest, bunches fulfilled the requirement of export standard of international market were only selected and harvested as per the standard practices. To study the effect of these treatments on growth, yield and quality, bunches under each treatment were harvested at the same time and date. The bunch weight was derived by averaging the weight of ten bunches randomly from each treatment and was expressed in grams per bunch. Bunch weight was recorded using weighing balance (Adair Dutt, Mumbai, India). At harvest Berry length and berry diameter were derived by averaging the 50 berries randomly from each treatment and measured using vernier caliper (RSK, China) while expressed in millimeter (mm). Berry skin thickness was measured using micro screw gauze (No. 103-101-10, Mitutoyo, Japan) and expressed in micrometer (μm). Fifty berry samples were randomly selected from each replicate and processed in a blender and strained through two layers of muslin cloth. Soluble solids concentration was determined from the juice using a digital refractometer (model ERMA INC, Tokyo, Japan) and acid-base titration method respectively. Total soluble solids (TSS) were expressed in degree Brix (°β) and acidity was expressed in percentage (%).

Gas Exchange Parameters

Gas exchange parameters such as photosynthetic rate and transpiration rate were measured using an infrared gas analyzer (Model, LI-COR LI-6400) in the leaves before they were sampled for the estimation of the various biochemical constituents. The readings were measured in full sunlight between 09:00 and 11:00. The area of the chamber for holding the leaves was 6.25 cm2. The photosynthetic rate was expressed as μmol CO2/m2/Sec, while the transpiration rate was expressed as mmol H_2O/m2/Sec. Water-use efficiency at the level of a single leaf was derived using the formula WUE =photosynthetic rate / transpiration rate.

Biochemical Studies

The reducing sugar was estimated by the dinitrosalicylic acid (DNSA) method. Total carbohydrate and Starch was estimated by Anthrone method suggested by Sadashivam and Manickam [20] using D-glucose as standard. Protein was estimated by using the method described by Lowery *et al.* [13]. For Protein estimation standard used was Bovine Serum Albumin (mg/g). The blue color developed was read at 660 NM on UV-visible spectrophotometer (Shimadzu- 1700). Total Phenolic content was estimated using 4- methyl catechol as a standard. The concentration of total phenolics was expressed as the catechol equivalent (mg/g) method suggested by Singleton and Rossi, [22]. All the data were statistically performed using the GLM procedure of SAS System software, version 9.3 SAS [21].

RESULTS AND DISCUSSION

Effect of GA_3 and CPPU foliar spraying on yield and quality parameters

Concerning the effect of foliar spraying of Gibberellic acid (GA_3) Progibb 40% WSG, 90% active ingredient and (CPPU) Cap-Plus 1% SP on yield and quality parameters is depicted in Table 1. The various GA_3 and CPPU concentrations alone or in combination had significant effects on bunch and berry characteristics. Data revealed that, spraying of GA_3 concentration alone and in combination with CPPU increased bunch weight, berry diameter and berry length (Table 1). Maximum bunch weight (234.20g) was recorded with treatment 40 ppm GA_3 (40 % WSG) + 2 ppm CPPU (1% SP) whereas, for control it was recorded 111.70g (Table 1). GA_3 has been usually used in seedless grape production to enlarge berry and bunch weight, Lu *et al*. [14]. Gibberellic acid (GA_3) increases berry size of Emperatriz Seedless grape, 80 mg L–1 GA_3 increased berry weight by 50%-90%, Casanova *et al*. [4]. On the other hand, highest berry length and berry diameter had noticed with the treatment of 40 ppm GA_3 (40 % WSG) + 2 ppm CPPU (1% SP) that was 20.70 mm and 18.70 mm respectively and for control it was 16.70 mm and 13.90 mm respectively. The present results concerning with effect of CPPU on berry characteristics are in line with those obtained by Rafaat *et al*. [18] with spraying of sitofex at 3 to 5 ppm and/or GA_3 at 10 to 40 ppm increased weight, size, length, diameter of Thompson Seedless grapes.

Table 1
Effect of GA_3 and CPPU foliar spraying on yield and quality parameters in Thompson Seedless grapes

Treatment Details	*Average Bunch weight (g)*	*Berry diameter (mm)*	*Berry Length (mm)*	*Berry Skin Thickness (µm)*	*TSS (°β)*	*Acidity (%)*	*Yield/vine (kg)*
T1	132.90^{g}	15.80^{de}	17.60^{e}	26.50^{cd}	23.90^{a}	0.54^{bc}	5.20^{f}
T2	219.70^{b}	18.00^{ba}	20.00^{b}	26.10^{ed}	23.70^{a}	0.52^{ed}	7.90^{b}
T3	178.40^{d}	17.10^{c}	18.7^{c}	27.20^{cb}	22.40^{b}	0.51^{ef}	7.00^{c}
T4	234.20^{a}	18.40^{a}	20.70^{a}	28.40^{a}	22.70^{b}	0.53^{cd}	8.70^{a}
T5	128.70^{g}	15.50^{e}	17.70^{e}	26.00^{ed}	21.60^{c}	0.55^{ab}	5.00^{f}
T6	146.10^{f}	16.00^{ed}	18.00^{de}	25.70^{e}	21.60^{c}	0.54^{bc}	5.60^{e}
T7	160.50^{e}	16.30^{d}	18.50^{dc}	26.90^{bc}	21.30^{c}	0.56^{a}	6.20^{d}
T8	200.90^{c}	17.70^{b}	18.80^{c}	27.40^{b}	21.10^{c}	0.50^{f}	7.70^{b}
T9	111.70^{h}	13.90^{f}	16.70^{f}	24.30^{f}	20.10^{d}	0.48^{g}	4.60^{g}
CV %	2.999	1.946	1.678	1.704	1.619	1.611	2.806
LSD 5%	8.727	0.556	0.538	0.781	0.617	0.014	0.312
Significances	**	**	**	**	**	**	**

Note: - CV- Coeff Var, LSD – Least Significances Difference, The values are means those marked with different letters of the alphabet in the same column are significantly different at $P \leq 0.05$

TSS was maximum (23.9° Brix) when 20 ppm GA_3 (40% WSG) was applied (Table 1). Bhavya *et al*. [3] reported significantly influenced sugar content and acidity in Bangalore blue grapes. Jawanda *et al*. [12] and Fathi *et al*. [6] considered the increased TSS and low acidity when other growth regulators such as Para chlorophenoxy acetic acid sprayed on different grape cultivars. Yield/ha was significantly increased with the application of various concentrations of GA_3 (40 % WSG) as well as CPPU (1% SP) in all the treatments. The highest yield/vine (8.70 kg) was recorded with the application of 40 ppm GA_3 (40 % WSG) along with 2 ppm CPPU (1% SP). Yield/vine is a result of bunch weight and no. of buches on vine. Brix yield is said to be a key decisive factor for considering yield of vine, Somkuwar and Ramteke [23].

Effect of GA_3 and CPPU foliar spraying on photosynthetic activities and Gas exchange parameters

Gas exchange parameters play an important role in determining the ability of plants to utilize water efficiently for photosynthesis at the level of a single leaf. The gas exchange parameters are presented in the Table 2. The rate of photosynthesis was higher in Thompson Seedless vines when treated by spraying of various concentrations of GA_3 (40% WSG) in combination with CPPU (1% SP). Higher photosynthesis (12 umol $cm^{-2}S^{-1}$) and stomatal conductance (0.15 cm S^{-1}) were found with application of 40 ppm GA_3 (40 % WSG) along with 2 ppm CPPU (1% SP). These results are aligned with Somkuwar *et al*. [24] reported that, photosynthesis (11.51 umol $cm^{-2}S^{-1}$) at harvest stage and Poni *et al*. [17] reported that stomatal conductance has been increased when fruit was present on the grapevine. Transpiration rate (3.32 mmol$H_2Om^{-2}S^{-1}$) was also found to be increased by the application of 40 ppm GA_3 (40 % WSG) along with 2 ppm CPPU (1% SP).

Table 2
Effect of GA_3 and CPPU foliar spraying on photosynthetic activities and gas exchange parameters in Thompson Seedless grapes

Treatment	*Photosynthesis (umol $cm^{-2}S^{-1}$)*	*Stomatal conductance (cm S^{-1})*	*Internal CO2 (ppm)*	*Transpiration rate (mmol $H_2Om^{-2}S^{-1}$)*	*(WUE) (μmol/mmol)*
T1	9.40^{e}	0.09^{dc}	187.81^{f}	1.80^{f}	5.22^{c}
T2	12.00^{a}	0.15^{a}	208.15^{bc}	2.97^{b}	4.04^{g}
T3	10.90^{c}	0.14^{b}	219.27^{a}	2.23^{d}	4.89^{d}
T4	12.30^{a}	0.13^{b}	200.07^{de}	3.32^{a}	3.70^{h}
T5	8.40^{f}	0.08^{d}	153.67^{g}	1.48^{g}	5.68^{b}
T6	9.70^{e}	0.09^{dc}	193.2^{fe}	2.06^{e}	4.71^{e}
T7	10.30^{d}	0.10^{c}	213.89^{ba}	1.96^{e}	5.26^{c}
T8	11.50^{b}	0.13^{b}	204.63^{dc}	2.58^{c}	4.46^{f}
T9	7.90^{g}	0.06^{e}	138.72^{h}	1.33^{h}	5.94
CV %	2.305	5.731	2.430	3.245	2.011
LSD 5%	0.409	0.010	8.036	0.123	0.169
Significances	**	**	**	**	**

Note: - CV- Coeff Var, LSD – Least Significances Difference, The values are means those marked with different letters of the alphabet in the same column are significantly different at $P \leq 0.05$

Effect of GA_3 and CPPU foliar spraying on biochemical Changes

The data recorded on various biochemical changes in Thompson Seedless grapes was presented in Table 3. Significant difference in reducing sugar, protein, total phenol, starch and total carbohydrate were recorded. Reducing sugar (215.6 mg/g) and protein (7.92 mg/g) were found higher with application of 40 ppm GA_3 (40% WSG). Comparable results were reported by Somkuwar *et al.* [24]; Gupta and Kaur [8]. On the other hand, higher starch (3.95 mg/g) and total carbohydrate (207.4 mg/g) were recorded with the application of 40 ppm GA_3 (40% WSG) along with 2 ppm CPPU (1% SP). Grape berries acts as a typical sink organ which on the use of available carbohydrate produced by photosynthesis to support their growth and development. The results obtained in conflict with Fischer and Ludders [7]; Davies and Robinson [5]; Zhang *et al.* [26] reported that, carbohydrates produced during photosynthesis are exported from the leaf as sucrose and elated in phloem to the berry cluster.

Table 3
Effect of GA_3 and CPPU foliar spraying on biochemical Changes in Thompson Seedless grapes

Treatment Details	*Reducing Sugar (mg/g)*	*Protein (mg/g)*	*Total Phenols (mg/g)*	*Starch (mg/g)*	*Total Carbohydrate (mg/g)*
T1	191.40^{d}	5.89^{f}	1.54^{f}	2.56^{e}	153.2^{f}
T2	215.6^{a}	7.92^{a}	1.71^{e}	3.81^{ab}	193.8^{b}
T3	207.1^{b}	7.08^{c}	2.46^{b}	3.23^{c}	178.3^{c}
T4	208.4^{b}	7.83^{a}	1.79^{e}	3.95^{a}	207.4^{a}
T5	199.6^{c}	5.11^{g}	1.66^{ef}	2.01^{f}	142.7^{g}
T6	200.1^{c}	6.63^{d}	1.93^{d}	2.97^{d}	160.6^{e}
T7	209.3^{b}	7.35^{b}	2.14^{c}	3.14^{c}	169.5^{d}
T8	195.2^{cd}	6.21^{e}	2.89^{a}	3.73^{b}	190.1^{b}
T9	173.6^{e}	5.06^{g}	1.37^{g}	1.82^{g}	131.6^{h}
CV %	1.793	2.162	4.039	3.141	2.246
LSD 5%	6.209	0.245	0.135	0.164	6.599
Significances	**	**	**	**	**

Note: CV- Coeff Var, LSD – Least Significances Difference, The values are means those marked with different letters of the alphabet in the same column are significantly different at $P \leq 0.05$

Concerning the effect of spraying of various concentrations of GA_3 (40 % WSG) as well as CPPU (1% SP) significant and positive correlation was obtained by berry length, berry diameter, bunch weight (Table 4) whereas, photosynthesis, stomatal conductance and transpiration rate with yield. These results agree with those reported by Naor *et al.* [16]. Also biochemical parameters like starch and total carbohydrate had positively correlated with yield.

CONCLUSION

From this study it can be concluded that, the foliar spraying of CPPU (1% SP) when applied alone or in combination with GA_3 (40 % WSG) at the various growth stages and concentration, significantly increased leaf photosynthesis, berry biochemical parameters, quality parameters namely berry length, berry diameter, bunch weight, T.S.S., acidity and also the yield of Thompson Seedless grapes. However, foliar spraying of 40 ppm GA_3 (40 % WSG) along with 2 ppm CPPU (1% SP) was found most superior treatment with respect to leaf photosynthesis, biochemical changes in berries, quality and yield attributes of Thompson Seedless grapes.

Table 4
Correlation among various quality, photosynthesis, biochemical parameters with yield in Thompson Seedless grapes

Pearson Correlation Coefficients, N = 9
Prob > |r| under H0: Rho=0

	Berry length	*Berry diameter*	*Average Bunch weight*	*photosynthesis*	*Stomatal Conductance*	*Internal CO2*	*Starch*	*Total Carbohydrate*	*Yield*
Berry length	1	0.945*	0.970**	0.941*	0.852*	0.669*	0.909*	0.956**	0.952**
Berry diameter		1	0.965**	0.976**	0.933*	0.787*	0.958**	0.979**	0.960**
Average Bunch weight			1	0.978**	0.907*	0.693*	0.953**	0.986**	0.994**
Photosynthesis				1	0.935*	0.818*	0.988**	0.994**	0.977**
Stomatal Conductance					1	0.817*	0.900*	0.910*	0.908*
Internal CO2						1	0.842*	0.781*	0.705*
Starch							1	0.982**	0.952**
Total Carbohydrate								1	0.988**
Yield									1

Note:
* Mean values bearing different superscript in a row differ significantly (P <0.05)
** Mean values bearing different superscript in a row differ significantly (P<0.01)

REFERENCES

Avenant, J. H. and E. Avenant (2006), Effect of gibberellic acid and CPPU on colour and berry size of 'Redglobe' grapes on two soil types. *Acta Hort.* 727:371-379.

Ben-Arie, R., P. Sang, Y. Cohen-Adhut, Y. Zutkhi, L. Sonego, T. Kapulonov and N. Lisker (1997), CPPU and GA3 effects on pre- and post-harvest quality of seedless and seeded grapes. *Acta Hort.* 463: 349-357.

Bhavya, H. K., N. V. Gowda, S. Jaganath, K. N. Sreenivas and N. B. Prakash (2012), Effect of foliar silicic acid and boron acid in Bangalore blue grapes. Proc. The 5th Int. Conference on Silicon in Agriculture, September 13-18, 2011, Beijing, China.

Casanova, L., R. Casanova, A. Moret and M. Agusti (2009), The application of gibberellic acid increases berry size of 'Emperatriz' seedless grape. *Spanish Journal of Agricultural Research.* 4: 919-927.

Davies, C. and S. P. Robinson (1996), Sugar accumulation in grape berries – cloning of two putative vacuolar invertase cDNAs and their expression in grapevine tissue. *Plant Physiology.* 111: 275-283.

Fathi, M.A, I. M. Azza, E. L. Bary and A. Abd (2011), Effect of Sitofex (CPPU) and GA3 spray on fruit set, fruit quality, yield and monetary value of "Costata" Persimmon. *Nature and Science.* 9(8): 40-49.

Fischer, G and P. Ludders (1997), Developmental changes of Carbohydrate in Cape 1 gooseberry (Physalis peruviana L.) fruit in relation to the calyx and the leaves. *Agronomia Colombiana.*, 14: 95-107.

Gupta, A.K. and N. Kaur (2000), Fructan metabolism in Jerusalem artichoke and chicory. In: Carbohydrate reserve in plants-synthesis and regulation.(Eds.: A.K. Gupta and N. Kaur). The Netherlands: Elsevier Science. pp 223-248.

Harrell, D. C. and L. E. Williams (1987), Net CO2 assimilation rate of grapevine leaves in response to trunk girdling and Gibberellic acid application. *Plant Physiol.*, 83: 457–459.

Ikeda, F., K. Ishikawa, S. Yazawa and T. Baba (2004), Induction of compact clusters with large seedless berries in the grape cultivar 'Fujiminori' by the use of streptomycin, gibberellins and CPPU. *Acta Hort.* 640: 361-368.

Ishikawa, K., H. Takahashi, S. Yazawa, H. Takahashi and F. Ikeda (2003), Effect of gibberellins and CPPU on enlargement and characteristics of seedless berries induced be streptomycin in the 'Fujiminori' grape. Hort. Res. Japan. 2:209-213.

Jawanda, J. S, R. Singh and R. N. Pal (1974), Effect of growth regulators on floral bud drop, fruit characters and quality of Tas-A-Ganesh grapes (*Vitis vinifera* L.). Vitis. 13: 215-221.

Lowry, O.H, J. Rosebrough, L.A. Farr and R.J. Randael (1951), Protein measurement with folin phenol reagent. *Journal Biological.* Chemistry. 193: 265-275.

Lu, J, O. Lamikanra, and S.Leong (1995), Effects of Gibberellic acid on muscandine grape production. *Proc. Fla. State Hort. Soc.* 108: 360-361.

Mervet, A. K, Ali, Alia, H. Ibrahim and A. Isis Rizk (2001), Effect of Sitofex (CPPU) on yield and bunch quality of Thompson Seedless grapevines. *Egypt Journal Agriculture Research.* 79 (2) 531-550.

Naor, Y.G. and B. Bravdo (1997), Crop load affects assimilation rate, stomatal conductance, stem water potential and water relations of fieldgrown Sauvignon blanc grapevines. *J. Exp. Bot.* 48: 1675-1680.

Poni, S., C. Intrieri and O. Silvestroni (1994), Interactions of leaf age, fruiting and exogenous cytokinins in Sangiovese grapevines under non-irrigated conditions.l.Gas exchange. *American Journal of Enology and Viticulture.* 45: 71-78.

Rafaat. S.S. Elgendy, Ghada Sh. Shaker and Ola A. Ahmed (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.* 8(5): 21-34.

Roper, T.R. and L.E. Williams (1989), Net CO2 Assimilation and Carbohydrate Partitioning of Grapevine Leaves in Response to Trunk Girdling and Gibberellic Acid Application. *Plant Physiology.* 89: 1136-1140.

Sadashivam, S. and A. Manickam (1996), Biochemical Methods for Agricultural Sciences. New Age International (P) Limited .New Delhi: 1-251.

SAS 9.3 (2004) TS Level 1M0. Copyright © 2002-2010 by SAS Institute Inc., Cary. NC, USA. Licensed to India Agricultural Statistics Research Institute. Site11601386.

Singleton, V.N. and J.A. Rossi (1965), Colorimetry of total phenolics with phosphomolysodic - phosphotungstic acid reagents. *American Journal of Enology. Vitic.* 16: 144 -158.

Somkuwar, R.G and S.D. Ramteke (2006), Yield and quality in relation to different crop loads on Tas-A-Ganesh table grape (*Vitis vinifera* L.). *Journal of Plant Sciences.* 1:176-181.

Somkuwar, R.G., A. Bahetwar, I. Khan, J. Satisha, S. D. Ramteke, P. Itroutwar, A. Bhongale, and D. Oulkar (2014), Changes in growth, photosynthesis activities, biochemical parameters and amino acid profile of Thompson Seedless grapes (*Vitis vinifera* L). Journal of Environmental Biology.35:1157-1163.

Tuna. A. L., C. Kaya, M. Dikilitas and D. Higgs (2008), The combined effects of gibberellic acid and salinity on some antioxidant enzyme activities, plant growth parameters and nutritional status in maize plants. *Environmental and Experimental Botany.* 62: 1–9.

Zhang, X.Y., X. L. Wang, X. F. Wang, G. H. Xia, Q. H. Pan, R. C. Fan, F. Q. Wu, X. C. Yu and D. P. Zhang (2006). A shift of phloem unloading from symplasmic to apoplasmic pathway is involved in developmental onset of ripening in grape berry. *Plant Physiology.* 142: 220-232.

Zoffoli, J. P., B. A. Latorre and Naranjo, P. (2009), Preharvest applications of growth regulators and their effect on postharvest quality of table grapes during cold storage. *Postharvest Biology and Technology.* 51: 183-192.