DOI : 10.5958/0974-0112.2017.00010.X

Indian J. Hort. 74(1), March 2017: 33-39

Response of 2A Clone grape to GA_3 sprays for berry thinning as influenced by cane regulation on two training systems under tropical conditions

S.D. Shikhamany[*], Sanjay K. Jeughale and Kailas N. Khapre

Maharashtra State Grape Growers' Association, Manjri Farm, Pune 411 032

ABSTRACT

With an aim to minimize manual thinning in 2A Clone of 'Thompson Seedless' grapevine trained on bower and extended Y trellis and grafted on "Dogridge" rootstock, investigations were carried out in growers' vineyards around Nashik, Maharashtra during 2013-14. Gibberellic acid (GA_3) was sprayed at 10 ppm thrice or 15 ppm twice. Since the response to GA_3 for berry thinning is stage specific, attempts were made to induce uniform bud break by retaining the canes of uniform diameter, consequently achieve uniformity in the stage of panicles that is ideal for GA_3 sprays. Efficacy of GA_3 sprays in reducing the cluster compactness on different training systems (bower or extended Y trellis) and with cane regulation was assessed. Less cane diameter but more uniform bud break was observed on extended Y trellis and cane regulated vines. Uniformity in the stage of panicle was not influenced by either the training system or cane regulation. Clusters were less compact in spite of the larger berries on Y trellis with two sprays of GA_3 @ 15 ppm. Although this combination was highly effective in reducing the cluster compactness, clusters in all the treatments were in the range of loose to well-filled. Cane regulation coupled with two sprays of GA_3 @ 15 ppm or retention of all canes coupled with three sprays @ 10 ppm resulted in more yield. These interactions were more pronounced on bower. Total soluble solids content and berry specific gravity were more on extended Y trellis while the titratable acids content was less on this trellis in cane-regulated vines. Taking cluster compactness, yield and quality into consideration, two sprays of GA_3 at 15 ppm on extended Y trellis but three sprays @ 10 ppm on bower, with or without cane regulation were found best.

Key words: 2A Clone, berry thinning, gibberellic acid, grapes, tropics.

INTRODUCTION

'2A Clone' is a mutant of 'Thompson Seedless' developed at Kearney Agricultural Experiment Station, University of California, Davis and extensively cultivated in Maharashtra as a table grape. Like Thompson Seedless, its clusters are compact with many small berries. Hence, berry thinning is essential in '2A Clone' also, not only to reduce cluster compactness but also to increase berry diameter to meet the export standards. While berry thinning is achieved with GA_3 sprays in temperate regions, growers in tropical region of India have resorted to manual thinning because GA_3 sprays were found to be ineffective in berry thinning. Major reason being the stage specificity of GA_3 for its pollenicidal action through which berry thinning is achieved (Weaver and McCune, 11). Disadvantages associated with manual thinning are: i) non-availability and high cost of skilled labour, ii) undue delay, consequently skipping the ideal stage for thinning in large vineyards, and iii) physical injury to the berries resulting in berry rot in transit and storage. For effective berry thinning, GA_3 sprays are required to be given four to one day prior to initiation of anthesis (Turner, 10). Panicles in a vineyard are at different stages prior to anthesis under peninsular Indian conditions. This could be due to uneven bud break. Although it is a common practice in the vineyards in this region to defoliate the canes before fruit pruning and apply hydrogen cyanamide to achieve early and uniform bud break, consequently the stage of panicle development are not uniform. Bud break was slow and un-uniform in thick canes compared to relatively thin canes (Reddy and Shikhamany, 7). Hence, the present investigations were carried out to assess the effect of removing un-uniform canes to achieve reasonably uniform stage of panicles in a vine and blanket sprays of GA_3 at varying number and concentrations to take care of minor un-uniformity, if any, starting at a stage corresponding to four days prior to initiation of anthesis in majority of clusters in the experimental vineyard.

MATERIALS AND METHODS

These investigations were carried out during 2013-14 cropping season on six-year-old '2A Clone' grapevines in farmers' vineyards in Nashik district at two locations. '2A Clone' was introduced, multiplied and supplied by the Maharashtra State Grape

*Corresponding author's E-mail : sdshikhamany@gmail.com

Growers' Association, Pune. The experimental vineyards of '2A Clone' were established on 'Dogridge' rootstock. The vines at first location (village Sarole Khurd) were trained on bower system while on extended Y trellis at the second location (village Khedgaon). The distance between rows and within rows was 2.70 and 1.50 m, respectively. Vines were pruned for fruiting in the second week of October, 2013 and grapes were harvested in the first week of March, 2014. All the vines were subjected to pre-pruning defoliation by spraying ethrel @ 1500 ppm, hydrogen cyanamide application to the buds @ 1.5 per cent and GA_3 sprays @ 10 and 15 ppm, respectively at parrot green stage and a week later for cluster elongation.

Experiment at each vineyard (on each training system) was laid out in a Factorial A × B randomized block design with the following treatments, *i.e.* Factor A: Cane regulation (a) Canes regulated: Removal of canes with diameter less than 6 and more than 9 mm and (b) Canes not regulated: Retention of all canes on the vine; Factor B: GA_3 sprays: (a) Three sprays of GA_3 @ 10 ppm each and (b) Two sprays of GA_3 @ 15 ppm each. The first spray of GA was given at a stage (Fig. 1), approximately four days prior to initiation of calyptra cracking, repeating on alternate days. GA_3 solution was sprayed @ one litre/vine, amounting to 2000 l / ha at each spray with high volume sprayer.

Number of canes left on the vine after forward pruning and cane regulation were counted and recorded. Diameter at the middle length of five selected canes was measured and the average diameter was calculated. Number and position of buds breaking on each selected cane was recorded every day from the 5^{th} to 12^{th} day after pruning. The day on which highest number of buds broke was taken as the standard (D-day) and given 100 score for each bud. For one day deviation in bud break from the D-day; either early or late, was given 75 for each bud, 50 for each bud deviating by two days and 25 for each deviating by 3 days. The sum of scores was divided by the total number of broken buds and expressed as 'per cent uniformity of bud break'. For computing the uniformity in flowering, the stage of inflorescence development specified for giving the first spray of GA_3 for thinning (Fig. 1) was used as the reference. Observations were recorded on the number of inflorescences attaining this stage from the 30^{th} day after pruning on the selected canes was counted. The day on which highest number of panicles attained this stage was taken as the standard (D-day) and given 100 score for each bud. For one day deviation from the D-day; either early or late, a score of 75 was given for each panicle, 50 for each deviating by two days and 25 for each deviating by 3 days. The sum of scores was divided by the total number of panicles and expressed as 'per cent uniformity of flowering'.

Cluster Compactness Index was derived by multiplying the number of berries per cm of the total length of rachis by the mean berry diameter in a cluster. Berry count and total length of rachis were recorded after removing the berries in five clusters selected at random from each plot. Mean diameter of five berries selected from each cluster was used to arrive at the index. Clusters with >35 index were classified as compact, 31-35 well filled, 25-30 loose and <25 straggly.

Average yield of 10 vines in a plot was recorded in kg at harvest and the mean weight of five clusters selected at random from each plot was calculated. Average number of berries was counted in five selected clusters and the test weight of berries was derived by the average weight of 25 berries selected at random from five selected clusters, at the rate of five from each. Average diameter of 25 berries, was measured at middle length of the berry using calipers. Specific gravity of berries was derived by dividing the total weight of 25 berries by their volume determined by water displacement method. Per cent total soluble solids (TSS) content was determined in the juice extracted by crushing the 25 selected berries using hand refractometer and the titratable acid content was determined by titrating an aliquot of 10 ml juice against 0.1N NaOH using phenolphthalein indicator and expressed as gram equivalent tartaric acid in 100 ml juice.

Data were analyzed in factorial A × B × C (2 × 2 × 2) design with eight treatment combinations and three replications. Where, A-was the training systems, B-cane regulation and C-GA_3 sprays. Percentages of uniformity in bud break, uniformity of flowering and TSS content were transformed into angular values for statistical analysis

RESULTS AND DISCUSSION

Uniformity of the stage of all clusters in a vineyard is a prerequisite for effective berry thinning by GA_3 sprays. Uniformity of bud breaks, in turn, for uniform flowering. Number and thickness of canes and the exposure of panicles is different in different training systems. Therefore, the variation in response to GA_3 sprays on bower and extended training systems was also assessed in the present investigations.

Cane diameter, uniformity of bud break, uniformity of flowering, berry diameter and GA_3 sprays are the factors contributing to cluster compactness. Significance of cane diameter lies in the fact that cane diameter was inversely correlated with uniformity in bud break as well as flowering (Shikhamany, unpublished data). Significantly more cane diameter was observed in bower trained vines as compared to the vines trained on extended Y trellis. Cane regulation also resulted in significantly less cane diameter (Table 1). Interaction of training system × cane regulation influenced cane diameter significantly. While cane regulation did not result in significant difference in cane diameter on extended Y trellis, it reduced significantly in bower (Table 1a). It implies that canes in vines on Y trellis were of more uniform diameter than on bower.

Uniformity in bud break is the basis for uniformity in the phenology of panicle development. Bud break was significantly more uniform on extended Y trellis. It was also more uniform in cane regulated vines (Table 1). Interaction of training system with cane regulation resulted in more uniform bud break in cane regulated vines on Y trellis when compared to vines trained to bower and in which all canes were retained (Table 1b). This variation could be attributed to the less cane diameter observed in vines on Y trellis and cane regulated ones. More uniform and early bud break in relatively thin canes was also observed by Reddy and Shikhamany (7).

Uniformity in flowering is the prerequisite for chemical thinning because, the pollenicidal effect of GA_3 is stage specific. According to Turner (10) GA_3 application 4-1 days prior to initiation of anthesis is most effective. Hence, for blanket sprays of GA_3 to be most effective in berry thinning, uniformity in the stage of panicle development is very essential. Neither the training systems nor cane regulation could influence the uniformity of flowering significantly. Although bud

Table 1. Effect of cane regulation and GA_3 sprays on attributes of cluster compactness in '2A Clone' on different training systems.

Treatment	Cane dia. (mm)	Bud break uniformity (%)	Flowering uniformity (%)	Berry dia. (mm)	Cluster compactness index
A. Training system					
Bower	7.7**	82.3 (65.1)	82.5 (65.4)	16.9	30.6*
Extended Y	7.3	84.6 (66.9)*	85.2 (67.5)	17.7**	27.3
CD 5%	0.3	(1.4)	NS	0.3	2.7
B. Cane regulation					
Yes	7.2	84.5 (66.9)*	85.2 (67.4)	17.3	29.9
No	7.8**	82.3 (65.2)	82.5 (65.5)	17.3	28.0
CD 5%	0.3	(1.4)	NS	NS	NS
C. GA treatment					
10 ppm thrice	7.6	82.6 (65.4)	85.0 (67.3)	17.3	30.7*
15 ppm twice	7.4	84.2 (66.6)	82.7 (65.7)	17.3	27.4
CD at 5%	NS	NS	NS	NS	2.7
Interaction A × B	**	*	NS	NS	NS
A × C	NS	NS	NS	**	NS
B × C	NS	NS	NS	NS	*
A × B × C	NS	NS	NS	NS	NS

Figures in the parentheses are the angular transformed values; *significant at p = 0.05; **Significant at p = 0.01

Table 1a. Interaction of training system (A) × cane regulation (B) on cane diameter (mm).

Training system	Cane regulation	
	Yes	No
Bower	7.1[a]	8.3[b]
Extended Y	7.2[a]	7.3[a]
CD at 5%	0.3	

Table 1b. Interaction of training system (A) × cane regulation (B) on uniformity in bud break (%).

Training system	Cane regulation	
	Yes	No
Bower	82.4 (65.2)[a]	82.2 (65.0)[a]
Extended Y	86.6 (68.5)[b]	82.5 (65.3)[a]
CD at 5%	2.0	

Figure in parentheses are the angular transformed values.

break was more uniform in vines on extended Y and in cane-regulated vines, uniformity of flowering was not more. This implies that, the minor difference in the uniformity got evened up during the period of panicle development. Neither the cane diameter, uniformity in bud break nor the uniformity in flowering was influenced significantly by GA_3 sprays. It is quite logical, because these parameters were determined before the sprays.

Cluster compactness index is the inverse measure of berry thinning. It was significantly less on extended Y trellis and with two sprays of GA_3 @ 15 ppm (Table 1). Effect of pre-bloom GA_3 application on berry thinning was also reported by Dokoozlian and Peacock (3). Higher efficacy of GA_3 on Y trellis could be attributed to better exposure of panicles to sprays. Although compactness was relatively more on bower and with three sprays of GA_3 @ 10 ppm, the clusters were in the range of loose to well filled (25-35 compactness index), but not compact. Interaction of cane regulation with GA_3 sprays influenced the cluster compactness significantly. Two sprays @ 15 ppm resulted in less compact clusters than three sprays at 10 ppm in cane regulated vines but not so in vines in which all canes were retained (Table 1c). It could be attributed to the indirect effect of shade on berry shattering and thinning. Because of relatively more shade in vines, in which all the canes were retained and low concentration of GA_3 (10 ppm) could have reduced the berry number at par with higher concentration (15 ppm). Role of shade in increasing the flower bud and berry drop has been reported by Domingos *et al.* (4). Variation in cluster compactness due to training systems and GA_3 sprays would reveal that i) the effect of GA_3 sprays was more pronounced on Y trellis, ii) stage of panicles was more uniform on Y trellis and hence, two sprays were adequate and iii) GA_3 at 10 ppm is adequate in dense canopies, but 15 ppm for relatively open canopies.

Berry diameter is a contributory factor to cluster compactness. It was significantly more on extended Y trellis than on bower. Neither cane regulation nor GA_3 sprays could influence the berry diameter significantly (Table 1). GA_3 was found to be highly effective in berry enlargement (Weaver and McCune, 11) only when sprayed after berry set and the effect was stage specific (Turner,10). In the present study, GA_3 was sprayed at pre-anthesis stage and low concentrations. However, the interaction of training system × GA_3 sprays influenced the berry diameter significantly. Two sprays @ 15 ppm were more effective in Y trellis than in bower and also than three sprays @ 10 ppm on both the systems of training (Table 1d). On the other hand, neither the cluster weight nor the cluster compactness were more with two sprays @ 15 ppm (Table 1). Thus, it implies that two sprays of GA_3 @ 15 ppm were more effective in reducing the number of berries in a cluster.

In order to assess the depressing effects of reduced cane number due to cane regulation and excessive berry thinning by GA_3 sprays, if any, directly on yield and quality of grapes or indirectly through their attributes, effect on number of canes, yield/ vine, mean cluster weight, test weight of berries, berry specific gravity, total soluble solids (TSS) and titratable acids contents of berries was studied. Cane is a unit of vine productivity. Number of canes was significantly more in bower trained vines when compared to vines trained on Y trellis. Cane regulation also reduced significantly, the number of canes/ vine (Table 2).

Yield is the major consideration in commercial viticulture. Yield/vine did not vary significantly either on different training systems, by cane regulation or GA_3 sprays. But the interaction of training system × GA_3 sprays, cane regulation × GA_3 sprays and training system × cane regulation × GA_3 sprays influenced significantly. Yield on extended Y trellis with three sprays of GA_3 @ 10 ppm and on bower with two sprays @ 15 ppm was less when compared to yield on bower with three sprays @ 10 ppm (Table 2a). Higher yields on bower at low concentration of GA_3 can be attributed to more number of canes (Table 2) and less loss of panicles at low concentration of GA_3. Reduced yield on bower with two sprays of GA_3 @ 15 ppm can be attributed only to loss of panicles due to higher concentration of GA_3 in shade under bower. Toxic effects of higher concentration of GA_3 to young panicles were documented by Cheng *et*

Table 1c. Interaction of training system (A) × GA_3 treatment (C) on berry diameter (mm).

Training system	GA_3 Treatment	
	10 ppm thrice	15 ppm twice
Bower	17.1[ab]	16.7[a]
Extended Y	17.4[b]	18.0[c]
CD at 5%	0.4	

Table 1d. Interaction of cane regulation (B) × GA_3 treatment (C) on cluster compactness index.

Training system	GA Treatment	
	10 ppm thrice	15 ppm twice
YES	33.5[b]	26.4[a]
NO	27.9[a]	28.1[a]
CD at 5%	3.8	

Figure in parentheses are the Angular transformed values.

al. (1). Cane regulation coupled with two sprays of GA_3 @ 15 ppm or no regulation with three sprays @ 10 ppm resulted in significantly more yield than the other combinations. This interaction effect was more pronounced on Bower than on extended Y trellis (Table 2b). Interaction effect of cane regulation × GA_3 sprays was not significant on yield/vine in extended Y trellis. But on Bower, two sprays of GA_3 @ 15 ppm reduced the yield significantly in vines, where all canes were retained, compared to cane regulated vines and also when compared to 10 ppm sprayed thrice either in cane regulated or not regulated vines (Table 2c). Yield variation is not through cluster weight as evidenced by the non significant differences in it due to the main or interaction effects of training systems, cane regulation or GA_3 sprays. Yield reduction could be attributed to the reduction in cluster number due to the toxic effect of GA_3 at higher concentration on clusters under shade. It appears that 15 ppm GA_3 was toxic under the shade level caused by retaining all the canes in bower trained vines resulting in loss of panicles. But the same concentration in cane regulated vines on bower was not toxic nor 10 ppm in Bower trained vines with all canes intact.

Mean cluster weight, a yield attribute did not differ significantly due to training systems, cane regulation or GA_3 sprays. But test weight of berries, in turn an attribute of cluster weight, was significantly more on extended Y trellis. The non-significant difference in cluster weight, but significantly more weight of berries on extended Y trellis is an indication to the reduced number of berries as a result of more efficient action

Table 2. Effect of cane thinning and GA_3 treatments on yield and quality attributes in '2A Clone' on different training systems.

Treatment	Canes/ vine	Yield/vine (kg)	Cluster wt. (g)	25-berry wt. (g)	Berry specific gravity	TSS (%)	Acidity (g/100 ml)
A. Training system							
Bower	48.7**	18.3	369.3	116.1	1.055	15.3 (23.0)	0.543
Extended Y	39.8	16.3	360.0	136.4**	1.071*	17.0 (24.3)**	0.559
CD at 5%	2.9	NS	NS	6.1	0.013	0.4	NS
B. Cane regulation							
Yes	40.6	17.7	363.3	128.4	1.063	16.1 (23.6)	0.561
No	47.9*	16.9	366.0	124.0	1.063	16.3 (23.8)	0.542
CD 5%	2.9	NS	NS	NS	NS	NS	NS
C. GA3 treatment							
10 ppm thrice	43.2	17.7	367.2	124.9	1.062	16.0 (23.5)	0.565
15 ppm twice	45.3	16.9	362.1	127.5	1.064	16.4 (23.8)	0.538
CD at 5%	NS	NS	NS	NS	NS	NS	NS
Interaction A × B	NS	NS	NS	NS	NS	NS	*
A × C	NS	*	NS	NS	NS	NS	NS
B × C	NS	*	NS	NS	NS	NS	NS
A × B × C	NS	*	NS	NS	NS	**	NS

Figures in the parentheses are the angular transformed values; *significant at p = 0.05; **Significant at p = 0.01

Table 2a. Interaction of training system (A) × GA_3 treatment (C) on yield/ vine (kg).

Training system	GA_3 treatment	
	10 ppm thrice	15 ppm twice
Bower	19.8[b]	16.7[a]
Extended Y	15.5[a]	17.2[ab]
CD at 5%	2.9	

Table 2b. Interaction of cane regulation (B) × GA_3 treatment (C) on yield/vine (kg).

Cane regulation	GA_3 treatment	
	10 ppm thrice	15 ppm twice
YES	16.8[ab]	18.6[b]
NO	18.5[b]	15.2[a]
CD at 5%	2.9	

Figure in parentheses are the Angular transformed values.

Table 2c. Interaction of training system (A) × cane regulation (B) × GA_3 treatment (C) on yield/vine (kg).

GA_3 treatment	Bower		Extended Y	
	Canes regulated	Not regulated	Canes regulated	Not regulated
10 ppm thrice	18.5^{b}	21.2^{b}	15.2^{ab}	15.8^{ab}
15 ppm twice	20.7^{b}	12.7^{a}	16.6^{ab}	17.7^{b}
CD at 5%		4.1		

of GA_3 sprays in berry thinning on this trellis. Specific gravity of berries is considered to be a measure of pulp content and firmness of berries. High specific gravity indicates more accumulation of metabolites and less water and *vice-versa*. Berries on extended Y trellis had significantly more specific gravity than on Bower (Table 2). It could be partly due to more TSS observed on Y trellis. Total soluble solids content was more in vines on extended Y trellis, but did not vary significantly due to cane regulation or GA_3 sprays (Table 2). Variation in ripening and the rate of accumulation of sugars in different grape varieties was also reported by Shikhamany *et al.* (9) and Saroj *et al*. (8). Clusters on Y trellis are more exposed to diffused light. Role of light regimes in increasing the rate of sugaring in grape berries is well documented (Martinez de Toda and Balda, 6). Interaction of training system × cane regulation × GA_3 sprays also influenced the TSS content significantly. Interaction effect of regulation × GA_3 sprays was not significant on the TSS content on extended Y trellis, but significant on Bower. Within the bower trained vines, lowest TSS content was observed when all the canes were retained and GA_3 sprayed thrice @ 10 ppm (Table 2d). It could be attributed to the highest yield obtained in this combination of treatments. Depressing effect of higher yields on TSS content is a well established fact (Coombe, 2).

Titratable acids content was not influenced significantly either by the training systems, cane regulation or GA_3 sprays. However, the interaction of training system × cane regulation influenced it. Acids content was less on bower when all canes were retained; but it was so on extended Y trellis when canes were regulated (Table 2e). Neither exposure of clusters nor the crop load seems to have any influence on the reduction of acids during berry ripening in this variety. However, variation in the reduction of acids in berries on different training systems was also reported (Kliewer, 5; Shikhamany *et al*., 9; Saroj *et al*., 8).

Table 2e. Interaction of training system (A) × cane regulation (B) on titratable acids content of berries (g/100 ml).

Training system	Cane thinning	
	Yes	No
Bower	0.572^{b}	0.515^{a}
Extended Y	0.550^{a}	0.568^{b}
CD at 5%	0.046	

Figures in parentheses are the Angular transformed values

Results of these investigations revealed that two sprays of GA_3 @ 15 ppm on extended Y trellis, but three sprays @ 10 ppm on Bower, with or without cane regulation, were the best, considering the cluster compactness, yield and quality of grapes in 2A clone.

ACKNOWLEDGEMENTS

The authors are grateful to the office bearers and the Chairman, Central Research Committee of the Maharashtra State Grape Growers' Association, Pune for supporting these studies. Thanks are due to Shri Kailash Bhosale (Sarole Khurd) and Shri Manik Patil (Khedgaon) for facilitating these studies in their vineyards. The support given by Prof. T.S. Mungare and Shri T.S. Shelke and the guidance provided by the Research Advisory Committee of the Association are gratefully acknowledged.

Table 2d. Interaction of training system (A) × cane regulation (B) × GA_3 treatment (C) on TSS content of berries (%).

GA_3 treatment	Bower		Extended Y	
	Canes regulated	Not regulated	Canes regulated	Not regulated
10 ppm thrice	15.3 (23.4)^{bc}	14.5 (22.3)^{a}	16.1 (23.6)^{bc}	17.5 (24.7)^{c}
15 ppm twice	14.7 (22.6)^{ab}	16.3 (23.8)^{c}	17.6 (24.8)^{c}	16.8 (24.2)^{c}
CD at 5%		0.9		

Figures in parentheses are the Angular transformed values

REFERENCES

1. Cheng, C., Xu, X., Singer, S.D., Li, J., Zhang, H., Gao, M., Wang, L., Song, J. and Wang, X. 2013. Effect of GA_3 treatment on seed development and seed-related gene expression in grape. *Plos One*. doi.org/10.1371/journal.pone.0080044

2. Coombe, B.G. 1992. Research on development ripening of the grape berry. *American J. Enol. Vitic*. **43**: 101-10.

3. Dokoozlian, N.K. and Peacock, W.L. 2001. Gibberellic acid applied at bloom reduces fruit set and improves size of 'Crimson Seedless' table grapes. *HortSci.* **36**: 706-09.

4. Domingos, S., Scafidi, P., Cardoso, V., Leitao, A.E., Lorenzo, R.D., Oliveira, C.M. and Goulao, L.F. 2015. Flower abscission in *Vitis vinifera* L. triggered by gibberellic acid and shade discloses differences in the underlying metabolic pathways. *Front. Plant Sci*. **6**: 457. doi: 10.3389/fpls.2015.00457.

5. Kliewer, W.M. 1973. Berry composition of cultivars as influenced by photo and nycto-temperature during maturation. *J. American Soc. Hort. Sci*. **98**: 153-59.

6. Martinez de Toda, F. and Balda, P. 2014. Reducing the pH of wine by increasing grape sunlight exposure: a method to mitigate the effects of climate warming. *Vitis*, **53**: 17-20.

7. Reddy, N.N. and Shikhamany, S.D. 1990. Comparative efficacy of spray and dip treatments with H_2CN_2 on bud break in Thompson Seedless grapevines under tropical Indian conditions. *Gartenbauwissenchaft*, **55**: 27-30.

8. Saroj, P.L., Shikhamany, S.D. and Prakash, G.S. 1996. Variation in ripening of Thompson Seedless on different training systems. *Indian J. Agric. Res.* **30**: 127-32.

9. Shikhamany, S.D., Saroj, P.L. and Prakash, G.S. 1993. Comparison of ripening of Thompson Seedless and Arkavati grapes on different training systems. *Crop Res*. **6**: 276-83.

10. Turner, J.N. 1972. Practical use of gibberellin in agriculture and horticulture. *Outlook on Agriculture*, **1**: 14-20.

11. Weaver, R.J. and McCune, S.B. 1960. Further studies with gibberellin on *Vitis vinifera* grapes. *Bot. Gaz*. **121**: 155-62.

Received : July, 2015; Revised : December, 2016; Accepted : February, 2017