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Effect of cane regulation and GA_3 spray on berry thinning in 'Thompson Seedless' grape (*Vitis vinifera* L.)

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ABSTRACT

A field trial was conducted during 2013-14 and 2014-15 fruiting seasons in growers' vineyards around Nashik, Maharashtra, India to improve efficacy of GA_3 sprays in berry-thinning. As smaller clusters have fewer berries, cluster compactness derived at by number of berries per unit length (cm) of rachis, and, berry-diameter were considered as a measure of berry-thinning. As GA_3 effect in berry-thinning is stage-specific, canes uniformly thick in a vine only were retained to achieve uniformity in flowering, by inducing uniform bud-break. Cane regulation did not result in uniformity in bud-break or flowering. Blanket spray of GA_3 thrice @ 20g a.i./ha, each coupled with either removal of non-uniform canes or retention of all the canes could effectively reduce cluster compactness by reducing number of berries per cluster, without increasing total length of the rachis/cluster or berry diameter. Vine yield and quality in terms of total soluble solids and acid content were not affected by the treatments. Considering cluster-compactness, yield and ease of cultural operations, retention of all the canes in a vine, coupled with three blanket sprays each of GA_3 @ 20g a.i/ha, on alternate days commencing from initiation of the bloom, is recommended for 'Thompson Seedless'.

Key words: Cane regulation, GA_3 spray, uniform flowering, cluster compactness, 'Thompson Seedless'

INTRODUCTION

'Thompson Seedless' is the predominant variety of grape grown in India for table and raisin purposes. This variety is grown in over 70% of the total area under grape in the country. Clusters in this variety are very compact, prone to berry cracking and rotting, during ripening, transit and storage. Hence, berry-thinning is necessary. Berry-thinning is achieved with blanket sprays of GA_3 prior to bloom under temperate viticulture. Response to GA_3 for berry-thinning is highly stage-specific. According to Turner (1972), the effective stage is three days to one day prior to initiation of bloom. Phenological development stages in the panicle are uneven on any given day under tropical conditions of peninsular India, owing to uneven bud-break after fruit pruning. Hence, growers in this region resort to GA_3 sprays during the bloom, supplementing it with manual thinning. Manual thinning is not only labour-intensive, but also time-consuming. Delayed thinning deprives the berries retained from gaining in size (Winkler *et al*, 1974; Coombe, 1960). Moreover, manual thinning often leaves unseen bruises on the berries retained, which are then prone to decay in transit and storage (Chadha and Shikhamany, 1999). In view of the importance of chemical thinning, a field trial was undertaken with an aim to improve the efficacy of blanket pre-bloom sprays of GA_3 on berry-thinning by inducing uniform flowering through cane regulation. Uniformity in flowering depends mainly on uniformity in bud-break which, in turn, depends on uniformity in thickness of the canes in a vine. Bud-break was found to be earlier in thin canes compared to the thick ones (Reddy and Shikhamany, 1990; Shikhamany and Manjunath, 1992). Hence, removal of non-uniform canes was attempted, to induce uniform flowering, mediated through uniform bud-break in the vine.

MATERIAL AND METHODS

This trial was conducted during the cropping season of 2013-14 and 2014-15 on six/seven – yearold 'Thompson Seedless' grapevines in farmers' vineyards at two locations (Mohadi and Pimpalgaon) around Nashik (Maharashtra). All the experimental vines were spaced at 2.7m X 1.5m grafted on 'Dogridge' rootstock, and trained on extended Y trellis. These were pruned for fruiting in the second week of October, and grapes were harvested on 140th day after pruning. The vines were subjected to uniform viticulture practices, namely, ethrel sprays for pre-pruning defoliation, hydrogen cyanamide application for promoting bud-break, and GA_3 sprays for cluster elongation.

Experiments in each vineyard were laid out in Factorial A x B x C Randomized Block Design, with the following treatments replicated thrice:

Factor A - Season: **S1**: 2013-14 and **S2**: 2014-15

Factor B - Location: L1 (Mohadi) and L2 (Pimpalgaon)

Factor C - Treatments (Removal of abnormally thin or abnormally thick canes within a vine, coupled with GA_3 sprays):

T1 - Cane removal, coupled with three sprays each of GA_3 @ 20g a.i./ha

T2 - Cane removal, coupled with two sprays each of GA_3 @ 30g a.i./ha

T3 - Retention of all canes, coupled with three sprays each of GA_3 @ 20g a.i./ha

T4 - Retention of all canes, coupled with two sprays each of GA_3 @ 30g a.i./ha

T5 - Control (growers' practice of retaining all the canes, and spraying GA_3 @ 80g a.i./ha at 50% bloom)

The first spray of GA_3 was applied three days prior to full bloom stage (approximately at initiation of calyptras-opening in a panicle), repeated on alternate days. GA_3 at specified dose was sprayed with a blower-assisted-sprayer irrespective of the volume of spray solution.

Observations recorded: Observations were recorded on five canes tagged in each of the five vines selected at random in each replication/ treatment

Number of canes/vine: Number of canes left on the vine after forward-pruning in T3, T4 and T5, and, after cane removal in T1 and T2

Cane diameter: Diameter at the middle of each cane was measured, and the average diameter calculated.

Uniformity in bud-break: Number and position of buds opening on selected canes was recorded every day from the 5th to 12th day after pruning. The day on which highest number of buds broke was taken as the standard (D-day) and a score of 100 was given for each bud. For deviation in bud-break by a day from the D-day, either early or late, a score of 75 was given for each bud; a score of 50 for each bud deviating by two days, and a score of 25 for each bud deviating by 3 days. The sum of the scores was divided by the total number of broken buds, and expressed as 'per cent uniformity in bud-break'.

Uniformity in flowering: The stage of inflorescence-development specified for applying the first spray of GA_3 for thinning was used as a reference. Observations were recorded on the number of inflorescences attaining this stage from the 30th day after pruning, on selected canes. The day on which highest number of panicles attained this stage was taken as the standard (D-day), and was given a score of 100 for each panicle. For deviation by one day 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 in flowering'.

Cluster Compactness Index: This was derived by dividing the number of berries per cm of the total length of rachis. Berry-count and total length of rachis was recorded after removal of berries in five clusters selected at random from each plot. Berry-thinning has been found to increase the size of berries retained in a cluster (Coombe, 1960; Winkler *et al*, 1974). Hence, berry diameter was included in factors determining cluster compactness in these studies.

Total length of rachis: Sum of the length of main rachis and all its branches was measured in cm.

Number of berries/cluster: Average number of berries was counted in five, selected clusters.

Berry diameter: Average diameter of 25 berries was measured (at the middle of the berry, using callipers).

Yield/vine: Average yield of 10 vines in a plot was recorded in kg at harvest.

Cluster weight: Mean weight of five clusters selected at random from each plot was calculated.

Total soluble solids content (TSS): Soluble solids content was determined in °B using a hand-held refractometer in the juice extracted by crushing the 25 berries selected at random.

Titratable acids content: This was determined by titrating an aliquot of 10ml juice against 0.1N NaOH using phenolphthalein indicator and expressed as gram equivalent tartaric acid in 100ml juice.

Statistical analysis: Data were analyzed in factorial A x B x C (2 x 2 x 5) design, with eight treatment combinations and three replications, where 'A' denotes the season, 'B' location and 'C' treatment.

RESULTS AND DISCUSSION

Reducing cluster compactness was a major objective in our trial, therefore, greater emphasis is laid on presenting this parameter. Any treatment reducing cluster compactness should not result in reduction of any yield or quality attribute/s. Hence, treatment effects on these attributes are also presented.

Effect on cluster compactness

Number of berries per cm length of the rachis is a recognized measure of cluster compactness (Chadha and Shikhamany, 1999), but berry-size also contributes to cluster compactness. At a given number of berries/cm length of rachis, a cluster with berries of 20mm diameter will be more compact, for example than one with 16mm berry diameter.

Cluster compactness differed significantly with season, location and treatment (Table 1) being low less in 2014-15 (S2) compared to that in 2013-14 (S1). This can be attributed to an increased total length of rachis, and reduced number of berries/cluster. Less compactness in S2, despite greater berry-diameter is an indication of greater cluster elongation and/or a

Table 1. Effect of Cane Regulation and GA treatment on components of cluster compactness

Factor	Cluster compactness index	Rachis length (cm)	No. of berries/ cluster	Berry diameter (mm)
A. Season				
1. 2013-14	34.5[b]	47.6[a]	79.0[b]	17.9[a]
2. 2014-15	32.0[a]	64.6[b]	66.2[a]	18.8[b]
S.Em ±	0.52	1.21	1.61	0.11
C.D. *(P=0.05)*	1.5	3.5	4.6	0.3
B. Location				
1. L1	32.2[a]	63.9[b]	66.1[a]	18.0[a]
2. L2	34.3[b]	48.2[a]	79.2[b]	18.8[b]
S.Em ±	0.52	1.21	1.61	0.11
C.D. *(P=0.05)*	1.5	3.5	4.6	0.3
C. Treatment				
1. T1	29.9[a]	51.4[a]	69.0[a]	18.3
2. T2	33.2[b]	59.8[b]	72.2[a]	18.3
3. T3	30.3[a]	53.8[a]	68.4[a]	18.5
4. T4	35.9[c]	54.8[a]	75.0[a]	18.4
5. T5	36.8[c]	60.6[b]	78.5[b]	18.3
S.Em ±	0.82	1.91	2.55	0.17
C.D. *(P=0.05)*	2.3	5.5	7.3	NS
Interaction				
A X B	*	**	**	**
A X C	*	NS	NS	NS
B X C	**	**	**	NS
A X B X C	*	NS	NS	NS

NS= Non-significant

reduction in berry-number per cluster in this season. When locations were compared, cluster compactness was less in the vineyard at Mohadi (L1) than in the one at Pimpalgaon (L2). Contributory factors for less compactness at L1 were: comparatively longer rachis, reduced number of berries/cluster, and lower berry diameter. These results indicate that the general practice of growers for cluster elongation and treatments imposed to reduce number of berries/cluster were more effective in S2 and in the vineyard at L1. On the other hand, practices for increasing berry diameter were more effective in S2 and in the vineyard at L2.

All the treatments were effective in reducing number of berries/cluster, but owing to less elongation of rachis, cluster compactness was not low in T4 (retention of all canes, coupled with two sprays of GA_3 @ 30g a.i/ha). However, the rest of the treatments more effectively reduced compactness, compared to that in the Control. Variation in rachis length cannot be attributed to treatments, because, neither cane removal before initiation of growth nor GA_3 sprays applied between three to one day prior to bloom, have any effect on rachis elongation. The ideal stage for GA_3 application for cluster elongation has been found to be 25 days prior to full-bloom (Turner, 1972). Berry diameter was not affected by treatments. Reduced berry number in the treatments did not result in increased berry-size. The reason for ineffectiveness of GA_3 treatments in increasing berry-diameter is the mode of action of GA_3 and its stage of application. GA_3 increases berry length but not berry diameter. The ideal stage for GA_3 application for berry elongation is from five to ten days after full-bloom (Turner, 1972). Hence, application of GA_3 just before bloom was ineffective in increasing berry-diameter. The growers' practices for increasing berry-diameter appear to have masked treatment effect, if any.

Effect of the treatments on cluster compactness varied with season and location. Interaction of season with treatments influenced cluster compactness only, but not rachis length, number of berries/cluster, or berry diameter. In individual effects of treatments, all the treatments, excepting T4 (retention of all canes, coupled with two sprays of GA_3 @ 30g/ha) greatly reduced compactness, compared to the Control (T5-growers' practice). However, all the treatments, including T4, reduced compactness in S1; whereas, in S2, only T3 (retention of all canes, coupled with three sprays of GA_3 @ 20g/ha) reduced the compactness, compared to that in Control, consistently, over the years (Table 1a). Location x Treatment interaction also

Table 1a. Season x Treatment effect on cluster compactness index

Season	Treatment				
	T1	T2	T3	T4	T5
2013-14	29.2[a]	35.4[de]	30.7[ab]	36.9[e]	40.2[f]
2014-15	30.5[ab]	31.0[a]	29.9[a]	34.9[cde]	33.5[bcd]

S.Em ± 1.16; CD *(P=0.05)* = 3.3

influenced cluster compactness. In its major effect, across locations, T2 (cane removal, coupled with two sprays of GA_3 @ 30g a.i./ha) reduced compactness greatly, compared to Control; But, at L1 it could not do so. At L2, all the treatments (except T4) reduced compactness greatly compared to the Control. T1 (cane removal, coupled with three sprays of GA_3 @ 20g a.i./ha) and T3 were consistent in their effect in reducing the compactness, over the Control, at both the locations (Table 1b). Rachis length was also influenced by Location x Treatment interaction. When effects of the treatments over the season and location were considered, rachis length was greater in Control, but at par with T2. Similar was the trend at L1; but, at L2, all the treatments were at par with Control. Although GA_3 spray at initiation of bloom had little effect on rachis elongation, rachis length was consistently greater in T2 over locations (Table 1c). Interaction effect of Location x Treatment revealed that T1 and T4 were more effective at L1 than at L2, in reducing number of berries/cluster (Table 1d), although all the treatments were effective over locations and seasons (Table 1). Effect of the treatments in reducing number of berries/cluster seems to have been deviated by comparison with the inherently small clusters obtained in T1 and T4 at L1, and in Control at L2 (Table 1e). In addition to the berry-thinning effect of GA_3 sprays, inherent size of the cluster appears to be the reason for reduced number of berries/cluster.

Interaction of treatments with season and location also influenced cluster compactness significantly. Interactions of S1L1T1, S1L1T3, S2L1T1, S2L1T3, S2L2T2 and S2L2T3 resulted in lower compactness, than that of S1L1T5, S1L2T4 or S1L2T5 (Table 1e).

Table 1b. Location x Treatment effect on cluster compactness index

Location	Treatment				
	T1	T2	T3	T4	T5
L1	27.8[a]	34.2[efg]	29.5[abcd]	32.2[de]	37.2[gh]
L2	31.9[cde]	32.2[de]	31.2[bcde]	39.5[h]	36.5[fgh]

S.Em ± 1.16; CD *(P=0.05)* = 3.3

Table 1c. Location x Treatment effect on rachis length (cm)

Location	Treatment				
	T1	T2	T3	T4	T5
L1	53.4[b]	68.4[cd]	63.9[c]	61.5[c]	72.4[d]
L2	49.4[ab]	51.2[ab]	43.7[a]	48.1[ab]	48.8[ab]

S.Em ± 2.70 CD *(P=0.05)* = 7.7

Table 1d. Location x Treatment effect on number of berries/cluster

Location	Treatment				
	T1	T2	T3	T4	T5
L1	57.7[a]	69.1[bc]	66.8[abc]	61.4[ab]	75.3[cde]
L2	80.2[def]	75.4[cde]	70.1[bcd]	88.5[f]	81.8[ef]

S.Em ± 3.60 CD *(P=0.05)* = 10.3

Table 1e. Season x Location x Treatment effect on cluster compactness index

	2013-14		2014-15	
Treatment	L1	L2	L1	L2
T1	25.7[a]	32.8[fghijk]	30.0[abcdefgh]	31.1[bcdefgh]
T2	34.1[ghijkl]	36.7[jkl]	34.3[hijkl]	27.7[abcd]
T3	29.3[abcdef]	32.2[defghij]	29.6[abcdefg]	30.2[abcdefgh]
T4	32.0[cdefghi]	41.7[mn]	32.5[efghij]	37.3[klm]
T5	42.3[n]	38.0[lmn]	32.0[cdefgi]	35.0[ij]

S.Em ± 1.63 CD *(P=0.05)* = 4.7

In the overall analysis, considering variation due to season and location in the effects of treatments on rachis length, number of berries/cluster and the berry diameter, it can be concluded that T1 and T3 were equally effective in reducing cluster compactness over the Control.

Effect on uniformity in flowering

Uniformity in flowering is considered to be the basic requirement for blanket sprays of GA_3 to be effective in reducing number of berries/cluster. A perusal of variation in uniformity in flowering and number of berries /cluster within seasons and locations, would reveal that greater uniformity in flowering was associated with a lower number of berries/cluster. Treatment effects on uniform flowering were influenced by season and location, as evidenced by a significant effect of Season x Treatment and Location x Treatment interactions (Table 2). Considering their main effects and interaction effects with season and location, treatments comprising cane removal (T1 and T2), envisaged at increasing the uniformity in bud-break (eventually increasing uniformity in flowering), failed to do so (Tables 2a, 2b and 2c). Uniformity in flowering was concordant with uniformity in bud-break only in the case of season but not location or treatment (Table 2). Interaction of Season x Treatment also influenced uniformity in bud-break significantly. This could be due to a differential rate of flower development, influenced by weather conditions during flower development (Christensen, 1969; Negi and Randhawa, 1974). However, the component of cane removal in T1 and T2 did not result in increased uniformity in bud-break (Table 2d).

Cane diameter was higher in T1 and T2 where uneven canes were removed (Table 2). This implies that it was the undersized canes that were removed in T3 and T4. Cane diameter was influenced by Season x Treatment interaction, being higher in T1 and T2 in 2014-15, but not in 2013-14 (Table 2e). Increased cane diameter in T1 and T2 did not result in increased uniformity of bud break (Table 2d) or flowering (Table 2a). In addition to uniformity in cane thickness, uniformity in bud-break depends on pre-pruning defoliation, diurnal variation in temperature after pruning (Shikhamany and Manjunath, 1992), and use of chemicals that promote bud-break (Shulman *et al*, 1983; Williams, 1987). Effect of cane removal on inducing uniform bud-break could have been masked by growers' practice of using Ethrel for pre-pruning defoliation, pruning when temperature is conducive for bud-break, and using hydrogen cyanamide for inducing increased and uniform bud-break.

These results point at the futility of cane-regulation in inducing uniform flowering under viticulture practices followed by growers in the course of our experimentation.

Effect on yield

Yield/vine was higher in 2014-15 compared to that in 2013-14, and higher at L1 than at L2. Yield did not differ significantly among treatments. However, interaction of Treatment x Location (Table 2 f)and Treatment x Season x Location (Table 2 g) influenced yield significantly. Yield/vine was greater in T3 compared to T1 and T2 at L1, but not at L2 (Table 3 a,b,c). Treatments T3 and Control fared better at L2, than at L1 (Table 3a). Yield /vine is a function of number of canes/vine, number of clusters/ cane and mean weight of the cluster. Increased yield in 2014-15 over that in 2013-14 can be attributed to increased number of canes and higher weight of cluster. In spite of mean bunch-weight being the same (Table 3), and cane number/vine being lower (Table 2), yield at L1 was higher. Similarly, mean weight of cluster and number of canes/vine was lower in T1compared to T3, T4 or T5, but, yield was not lower (Table 3). This could be attributed to a greater number of clusters/cane, which depends on conditions being favourable for fruit-bud formation during the vine growth season.

Effect on quality

Quality of grapes, as judged by the total soluble solids (TSS) and acids content did not differ significantly among treatments. However, TSS content varied with season and location, and, acid content with the location only. Interaction of Season x Location also influenced both quality-components (Table 3). TSS content is primarily a varietal character, often modified by diurnal variation in temperature during the ripening period (Coombe, 1992). It is mainly controlled by Genotype x Environment interaction. Similarly, acid content is also determined by Genotype x Environment interaction.

Results of this trial indicate that: i) T1 and T3 are equally effective in reducing cluster compactness; ii) cane regulation did not result in significant improvement in uniformity of bud-break or flowering; iii) None of the treatments influenced yield or quality. In overall analysis, T3 (retention of all the canes in a vine, and spraying GA_3 thrice @ 20g a.i./ha on alternate days, commencing from initiation of the bloom) is recommended for reducing cluster compactness, without compromising yield or quality in ‘Thompson Seedless’ grape.

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Table 2. Effect of season on vine growth characters

Factor	Canes/vine	Cane diameter (mm)	Uniformity in bud break (%)	Uniformity in flowering (%)
A. Season				
1. 2013-14	33.4[a]	7.13[a]	83.1[b]	79.7[a]
2. 2014-15	35.2[b]	7.46[b]	77.2[a]	91.7[b]
S.Em ±	0.34	0.032	0.52	0.73
C.D. *(P=0.05)*	1.0	0.09	1.5	2.1
B. Location				
1. L1	30.3[a]	7.33	81.7[b]	88.4[b]
2. L2	38.2[b]	7.26	78.6[a]	83.1[a]
S.Em ±	0.34	0.032	0.52	0.73
C.D. *(P=0.05)*	1.0	NS	1.5	2.1
C. Treatment				
1. T1	29.5[a]	7.44[b]	81.3[b]	84.4[ab]
2. T2	30.1[a]	7.49[b]	79.3[ab]	83.2[a]
3. T3	35.5[b]	7.16[a]	80.4[ab]	86.6[bc]
4. T4	38.8[c]	7.18[a]	80.9[ab]	89.7[c]
5. T5	37.4[c]	7.19[a]	78.7[a]	84.7[ab]
S.Em ±	0.54	0.050	0.82	1.16
C.D. *(P=0.05)*	1.6	0.14	2.3	3.3
Interaction				
A X B	**	**	NS	NS
A X C	NS	**	**	*
B X C	**	NS	NS	**
A X B X C	**	NS	NS	*

NS= Non significant

Table 2a. Season x Treatment effect on uniformity in flowering (%)

Season	Treatment				
	T1	T2	T3	T4	T5
2013-14	78.9[ab]	76.0[a]	81.5[b]	86.2[cde]	76.0[a]
2014-15	89.9[defg]	90.3[efg]	91.7[fg]	93.3[g]	93.4[g]

S. Em ± 1.64 CD *(P=0.05)* = 4.7

Table 2b. Location x Treatment effect on uniformity in flowering (%)

Location	Treatment				
	T1	T2	T3	T4	T5
L1	84.9[a]	83.2[a]	91.4[b]	96.4[c]	85.9[a]
L2	83.9[a]	83.1[a]	81.8[a]	83.0[a]	83.5[a]

S.Em ± 1.64 CD *(P=0.05)* = 4.7

Table 2c. Season x Location x Treatment effect on uniformity in flowering (%)

	2013-14		2014-15	
Treatment	L1	L2	L1	L2
T1	79.8[a]	78.0 [a]	90.0 [bcd]	89.8 [bcd]
T2	74.6 [a]	77.5 [a]	91.9 [bcde]	88.8 [b]
T3	87.3[b]	75.7 [a]	95.5[cde]	87.8 [b]
T4	96.7[e]	75.7 [a]	96.2[de]	90.4 [bcde]
T5	78.5 [a]	73.5[a]	93.3 [bcde]	93.6 [bcde]

S.Em ± 2.31 CD *(P=0.05)* = 6.6

Table 2d. Season x Treatment effect on uniformity in bud-break (%)

Season	Treatment				
	T1	T2	T3	T4	T5
2013-14	83.4[e]	84.2[e]	84.3[e]	85.7[e]	77.8[bcd]
2014-15	79.3[cd]	74.4[a]	76.5[abcd]	76.2[abc]	79.7[d]

S. Em ± 1.16 CD *(P=0.05)* = 3.3

Table 2e. Season x Treatment effect on cane diameter (mm)

Season	Treatment				
	T1	T2	T3	T4	T5
2013-14	7.18[abc]	7.08[ab]	7.04[a]	7.20[abc]	7.12[abc]
2014-15	7.71[d]	7.90[d]	7.29[c]	7.16[abc]	7.25[bc]

S. Em ± 0.071 CD *(P=0.05)* = 0.20

Table 2f. Location x Treatment effect on number of canes/vine

Location	Treatment				
	T1	T2	T3	T4	T5
L1	27.0[a]	26.2[a]	32.3[cd]	34.0[d]	32.0[bcd]
L2	32.0[bcd]	34.0[d]	38.7[e]	43.6[f]	42.8[f]

S.Em ± 0.0.77 CD *(P=0.05)* = 2.2

Table 2g. Season x Location x Treatment effect on number of canes/vine

	2013-14		2014-15	
Treatment	L1	L2	L1	L2
T1	26.7[a]	32.1[fghij]	27.3[abc]	31.9[efghij]
T2	26.9[ab]	30.0[bcdef]	25.5[a]	37.9[lm]
T3	33.1[ghijk]	35.2[kl]	31.6[defghij]	42.2[n]
T4	34.5[jk]	42.7[n]	33.6[hijk]	44.6[no]
T5	33.8[ijk]	38.9[m]	30.3[cdefg]	46.7[o]

S.Em ± 1.08 CD *(P=0.05)* = 3.1

Table 3. Effect of cane regulation and GA treatment on yield and quality attributes

Factor	Yield/vine (kg)	Weight/cluster (g)	T.S.S. content (°B)	Acid content (g/100ml)
A. Season				
1. 2013-14	9.01[a]	385.2[a]	16.9[b]	0.500
2. 2014-15	19.16[b]	423.6[b]	14.9[a]	0.490
S.Em ±	0.459	9.48	0.15	0.0060
C.D. *(P=0.05)*	0.31	27.2	0.4	NS
B. Location				
1. L1	15.35[b]	404.7	15.5[a]	0. 535[b]
2. L2	12.82[a]	404.1	16.4[b]	0.455[a]
S.Em ±	0.459	9.48	0.15	0.0060
C.D. *(P=0.05)*	0.31	NS	0.4	0.017
C. Treatment				
1. T1	13.26	372.2[a]	15.9	0.493
2. T2	14.44	417.1[bc]	15.9	0.491
3. T3	14.39	404.8[abc]	15.9	0.497
4. T4	13.93	392.5[abc]	15.8	0.495
5. T5	14.42	435.2[c]	16.1	0.501
S.Em ±	0.725	14.99	0.24	0.0095
C.D. *(P=0.05)*	NS	42.9	NS	NS
Interaction				
A X B	**	**	**	**
A X C	NS	NS	NS	NS
B X C	**	**	NS	NS
A X B X C	*	NS	NS	NS

NS= Non significant

Table 3a. Location x Treatment effect on yield/ vine (kg)

Location	Treatment				
	T1	T2	T3	T4	T5
L1	12.83[ab]	14.44[bcd]	17.60[e]	15.91[cde]	15.99[de]
L2	13.70[abcd]	14.44[bcd]	11.18[a]	11.94[ab]	12.84[ab]

S.Em ± 1.026 CD *(P=0.05)* = 2.94

Table 3b. Season x Location x Treatment effect on yield/vine (kg)

	2013-14		2014-15	
Treatment	L1	L2	L1	L2
T1	11.08[cdefg]	6.57[ab]	14.57[ghi]	20.83[mno]
T2	10.35[bcdef]	7.27[abcd]	18.53[ijklmn]	21.61[no]
T3	12.43[efgh]	7.09[abc]	22.77[o]	15.27[hi]
T4	13.29[fgh]	4.87[a]	18.53[ijklmn]	19.01[jklmno]
T5	11.37[defgh]	5.77[a]	20.62[lmno]	19.91[klmno]

S.Em ± 1.450 CD *(P=0.05)* = 4.15

Table 3c. Location x Treatment effect on weight of cluster (g)

Location	Treatment				
	T1	T2	T3	T4	T5
L1	321.3[a]	418.4[efgh]	428.6[gh]	376.9[abcdefg]	478.2[h]
L2	423.2[fgh]	415.9[defg]	381.1[abcdefg]	408.1[cdefg]	392.2[bcdefg]

S.Em ± 21.20 CD *(P=0.05)* = 60.7

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