

Original Research Paper

Increasing the Efficacy of GA₃ Sprays in Cluster Elongation and Berry Thinning in Tas-A-Ganesh Grape (*Vitis vinifera* L.) in Tropical Viticulture

S.D. Shikhamany*, V. Swapnil. Borade, K. Sanjay Jeughale and Suryakant Y. Patil

R&D Division, Maharashtra State Grape Growers' Association, Manjri Farm Post, Pune - 411 032, India.

*E-mail: sdshikhamany@gmail.com

ABSTRACT

In view of the stage specificity for the efficacy of blanket sprays of GA₃ for berry thinning, a field trial was laid out to achieve uniform flowering in Tas-A-Ganesh grapevines subjected to chemical defoliation prior to and hydrogen cyanamide application at fruit pruning in the double pruning and single cropping system during 2013-14 and 2014-15 fruiting seasons in growers' vineyards around Nashik, Maharashtra by removing the un-uniformly thick canes. GA₃ at different doses was sprayed two or three times to address the variation in uniform flowering, if any in cluster elongation and reducing the berry number/cluster. Cane regulation and GA₃ sprays were used to achieve uniformity in bud break and flowering. Cluster compactness was derived by multiplying the number of berries/ cm length of rachis with berry diameter. Regression analysis of the variation has revealed that the cane diameter, through uniformity in bud break, influenced the uniformity in flowering which in turn influenced the cluster compactness through increased efficacy of blanket GA₃ sprays in reducing the berry number/cluster. Based on the optimum values of the contributory factors to cluster compactness, cane removal coupled with two blanket sprays of GA₃ @ 30 g a.i./ha or retention of all canes coupled with three blanket sprays of GA₃ @ 20 g a.i./ha was found to be ideal to obtain loose to well filled clusters. Taking together into account the effect of treatments on cluster compactness, yield and quality, retention of all canes coupled with three sprays of GA₃ @ 20 g a.i./ha was considered appropriate for table grape production in Tas-A-Ganesh cv. of grapes.

Key words: Cane regulation, uniform flowering, GA₃ sprays, cluster compactness, Tas-A-Ganesh

INTRODUCTION

Tas-A-Ganesh is a bud sport of Thompson Seedless grape. Similar to Thompson Seedless, clusters are compact in this variety. Blanket sprays are given at the appropriate stage to obtain loose to well filled clusters of Thompson Seedless in temperate viticulture (Weaver and pool, 1967). Whereas, growers in the tropical viticulture in peninsular India have resorted to repeated selective dipping of the panicles followed by thinning of the set berries, manually to obtain required berry thinning in table grape production, since the ideal stage of panicles is scattered over a period of 8-10 days. According to Turner (1972), the ideal stage for effective berry thinning by GA₃ is 1-3 days prior to full bloom (Initiation of calyptras-opening of a flower). Effective concentration varies with the phenological stage of flowers in a cluster. While the early application of GA₃ at a given

concentration leads to the death of flower buds, application at full bloom results in increased set and shot berry formation (Dass and Randhawa, 1968). Selective treatment is labour intensive and manual thinning is not only labour intensive but also time consuming. Delayed thinning deprives the retained berries from gaining size (Winkler *et al.*, 1974; Coombe, 1960). Moreover, manual thinning often leaves unseen bruises on the retained berries which are prone to decay in transit and storage (Chadha and Shikhamany, 1999). Lack of uniformity in the phenological development of clusters is attributed to uneven bud break, which in turn to un-uniform thickness of canes in a vine. Bud break was found to be faster in thin canes compared to thick canes (Reddy and Shikhamany, 1990; Shikhamany and Manjunath, 1992). Considering the importance of uniform flowering for chemical thinning and that of uniform bud break for uniform flowering, a field trial was

conducted to assess the efficacy of removing the un-uniform thick canes (cane regulation) in a vine in achieving uniform flowering through inducing uniform bud break coupled with varying number and dose of GA₃ sprays at the specified stage on berry thinning, eventually reducing the cluster compactness in Tas-A-Ganesh grape.

MATERIAL AND METHODS

This trial was conducted during cropping season of 2013-14 and 2014-15 on six/seven year old Tas-A-Ganesh grapevines in farmers' vineyards in two locations (Palkhed and Kothure) around Nashik (Maharashtra). All the experimental vines were spaced at 2.70 x 1.50 m, grafted on Dogridge rootstock and trained to extended Y trellis. They were pruned for fruiting in the second week of October and grapes were harvested uniformly on the 140th day after pruning. Uniform viticulture practices, namely ethrel sprays for pre-pruning defoliation, hydrogen cyanamide application for promoting bud break, GA₃ sprays for cluster elongation and growth regulator treatment for berry sizing were undertaken in the vineyards under experimentation. No manual thinning was done in any treatment.

Experiment was laid out in a Factorial A x B x C randomized block design replicating the following treatments thrice in each vineyard.

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

Factor B - Location: L1 (Palkhed) and L2 (Kothure)

Factor C - Treatments (cane regulation coupled with GA₃ sprays):

T1 - Cane regulation coupled with three sprays of GA₃ @ 20 g a.i./ha each.

T2 - Cane regulation coupled with two sprays of GA₃ @ 30 g a.i./ha each.

T3 - Retention of all canes coupled with three sprays of GA₃ @ 20 g a.i./ha each.

T4 - Retention of all canes coupled with two sprays of GA₃ @ 30 g a.i./ha each.

T5 - Control (Growers' practice of retaining all the canes and spraying GA₃ @80 g a.i./ha at 50 per cent bloom.

Cane regulation, the removal of un-uniform canes in a vine, was done immediately after fruit pruning. The first spray of GA₃ was given three days prior to full bloom (approximately at the initiation of calyptra opening in a panicle) stage, repeating on alternate days. GA₃ at specified dose was sprayed with blower assisted sprayer irrespective of the volume of spray solution.

Observations were recorded on canes retained on vines after regulation, cane diameter, uniformity in bud break and flowering, total rachis length and number of berries/cluster, mean berry diameter, yield/vine, mean weight of cluster and total soluble solids and acids content of berries were recorded. Cluster compactness index was calculated using the values of rachis length, berries/cluster and berry diameter.

Uniformity in bud break

Number and position of buds breaking on five canes selected at random were 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 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'

Uniformity in flowering

The stage of inflorescence development specified for giving the first spray of GA₃ for thinning was used as the reference. Observations were recorded on the number of inflorescences attaining this stage from the 30th day after pruning on the selected canes. The day on which highest number of panicles attained this stage was taken as the standard (D-day) and given 100 score for each panicle. 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

It was derived by multiplying the number of berries per cm of the total length of rachis by berry diameter. Berry count and total length of rachis were

recorded after removing the berries in five clusters selected at random from each plot. Berry thinning was found to increase the size of retained berries in a cluster (Coombe, 1960; Winkler et al., 1974). Hence, berry diameter was included in the factors determining the cluster compactness in these studies. Compactness index for different grades of cluster filling were as follows.

Compactness index	cluster filling
>35	Compact
30-35	Well-filled
25-30	Loose
<25	Straggly

Statistical analysis

Significance of the difference in the means of the factors of uniform flowering, cluster compactness, yield and quality as influenced by the treatments was tested by the Analysis of variance in factorial A x B x C (2 x 2 x 5) design with twenty treatment combinations and three replications. Treatments were evaluated with reference to their effect on the parameters contributing to the reduced cluster compactness. Their effects were compared by the critical difference in the analysis of variance. Quadratic functions were fitted for the relationship of the factors of cluster compactness, namely cane diameter, uniformity in bud break, uniformity in flowering and berry diameter with cluster compactness. X-optimum and Y- maximum were derived from these functions. Multiple linear regression function was fitted for cluster compactness. Quadratic and multiple linear regression analyses were performed by the Microsoft Excel data analysis package.

RESULTS AND DISCUSSION

Effect on cane Diameter

Cane diameter was more in 2013-14 compared to 2014-15. It was not influenced either by the location or treatments (**Table 1**). It was also influenced by the season x treatment interaction. It was significantly more in the first season in T3, T4 and T5, but at par in both the seasons in T1 and T2 (**Table 3A**). It could be due to removal of un-uniformly thin canes in T1 and T2 in 2014-15. The optimum cane diameter for the factors of cluster compactness ranged from 6.49 to 7.67 mm in the present investigations (**Table 6**). The resultant minimum and maximum cane diameter as influenced by the season, location, treatment and the season x treatment interaction were within the optimum range.

Effect on uniform bud break

Uniformity in bud break was significantly less in 2014-15 compared to 2013-14 (**Table 1**). However, this reduced uniformity was within the optimum range (**Table 6**). The main effects of either the location or treatments were not significant nor were their interaction effects significant on the uniformity in bud break.

Effect on uniform flowering

Uniformity in flowering was less at L1 compared to L2 and in 2013-14 compared to 2014-15 (**Table 1**). Interaction of season with location influenced it. It was reduced significantly in the season-I at L1 compared to other season and location combinations (**Table 2A**). Treatments had no effect on uniform flowering. However the interaction of treatments with location and with season x location influenced the uniformity in flowering. T1 at L1 reduced the uniformity compared to control at L2, but T1 was on par with control at L1 and L2 (**Table 4A**), indicating the masking effect of location (grower's practices). The very fact that all treatments reduced the uniformity at L1 in season-I compared to L1 in season-II indicates the dominating effect of season than location (**Table 5A**). This could be due to differential rate of flower development influenced by the weather conditions during flower development (Christensen, 1969; Negi and Randhawa, 1974). Less ratio of uniform flowering to uniform bud break (0.93) in 2013-14 compared to 1.17 in 2014-15 reveals the adverse effect of weather on flower development in 2013-14. When the main effects of treatments on cane diameter, uniformity in bud break and uniform flowering considered, none of the treatments differed significantly with the control. As seen from the table 6, the values of these parameters contributing for uniform flowering and uniform flowering itself in control were in the optimum range. This indicates that the growers' practices in inducing uniform bud break were apt for achieving adequate uniformity in flowering required for berry thinning.

Number of berries per cm length of the rachis is the 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 18 mm diameter will be more compact than the one with 16 mm berry diameter. Hence the effect of treatments in increasing the rachis length and reducing the number of berries /cluster and the berry diameter were considered.

Table 1: Effect of cane regulation and blanket sprays of GA₃ on the factors of cluster compactness, yield and quality in Tas-A-Ganesh

Factor	Canes/ vine	Cane diameter (mm)	Uniform bud break (%)	Uniform flowering (%)	Rachis length (cm)	Berries/ cluster	Berry Diameter (mm)	Cluster Compactness Index	Yield/vine (kg)	Weight/ cluster (g)	T.S.S. content (°B)	Acids content (g/100ml)
A. Season												
1. 2013-14	26.7 ^a	7.31 ^b	82.8 ^b	77.2 ^a	45.2	57.5	17.4	32.6	10.48	340.5	16.6	0.564
2. 2014-15	28.5 ^b	6.87 ^a	79.5 ^a	93.4 ^b	45.1	57.7	17.2	30.7	10.51	380.6	17.1	0.556
S. EM ±	0.4	0.04	0.7	0.7	1.1	1.2	0.4	0.9	0.22	51.2	0.3	0.006
CD at 5%	1.2	0.13	2.1	1.9	NS	NS	NS	NS	NS	NS	NS	NS
B. Location												
1. L1	30.7 ^b	7.14	81.3	83.5 ^a	47.8 ^b	47.8 ^a	17.8	31.9	11.94 ^b	329.5	16.3 ^a	0.559
2. L2	24.5 ^a	7.05	80.9	87.1 ^b	42.5 ^a	67.4 ^b	16.9	31.4	9.05 ^a	391.6	17.4 ^b	0.561
S. EM ±	0.4	0.04	0.7	0.7	1.1	1.2	0.4	0.9	0.22	51.2	0.3	0.006
CD at 5%	1.2	NS	NS	1.9	3.2	3.4	NS	NS	0.68	NS	0.9	NS
C. Treatments												
1. T1	23.8 ^a	7.13	79.4	84.3	47.3	60.3 ^{bc}	17.8	33.8 ^{bc}	10.38 ^{ab}	326.1	16.5	0.562
2. T2	22.4 ^a	7.07	81.7	85.4	45.1	54.7 ^a	17.5	28.9 ^a	9.91 ^a	496.1	17.6	0.554
3. T3	30.4 ^b	7.03	83.2	86.2	43.0	55.1 ^{ab}	16.0	30.0 ^{ab}	11.03 ^b	312.5	16.8	0.570
4. T4	30.6 ^b	7.07	80.8	86.5	43.7	56.7 ^{abc}	17.4	31.3 ^{abc}	9.82 ^a	318.7	16.7	0.552
5. T5	30.9 ^b	7.17	80.4	84.0	46.5	61.3 ^c	17.8	34.5 ^c	11.33 ^b	349.4	16.7	0.561
S. EM ±	0.6	0.07	1.1	1.1	1.8	1.9	0.6	1.4	0.34	81.0	0.5	0.009
CD at 5%	1.8	NS	NS	NS	NS	5.4	NS	4.1	0.98	NS	NS	NS
Interaction												
A x B	*	NS	NS	*	**	**	NS	NS	NS	NS	NS	**
A x C	NS	**	NS	NS	NS	NS	NS	NS	*	NS	NS	NS
B x C	**	NS	NS	*	NS	NS	NS	NS	NS	NS	NS	*
A X B X C	**	NS	NS	**	NS	NS	NS	NS	NS	NS	*	NS

Means super-scripted with the same alphabet within column do not differ significantly at P=0.05

Effect on Rachis Length

Rachis elongation is a desirable effect with respect to reduced cluster compactness. Rachis length was more at L1 than L2. Neither the season nor treatments could increase the rachis length. But season x location interaction influenced it (**Table 1**). Rachis length at L1 was more than L2 in season-I, but was at par in season-II (**Table 2B**). GA₃ sprays given through the treatments just at the initiation of calyptra opening had no effect in rachis elongation. GA₃ is effective in rachis elongation only when given a week after cluster emergence (Turner, 1972). In light of this, pre-bloom sprays at L1 were more effective in season-I, and season-II which was more favourable to cluster development.

Effect on Berries/Cluster

Reduced number of berries/ cluster is also a desirable character in reducing the cluster compactness. The real effect of GA₃ included in the treatment is assessed by the reduction in berry number. While not influenced by the season, berries/cluster was less at L1 compared to L2 (**Table 1**). Relative reduction in berry number with reference to rachis length of a cluster is a better indicator of GA₃ effect than the absolute reduction in reducing the cluster compactness. Reduced number of berries/cluster in spite of its increased length at L1 indicates the higher efficacy of GA₃ sprays at this location. Among the treatments, removal of un-uniformly thick canes coupled with two sprays of GA₃ @ 30g/ha (T2) or retention of all canes coupled with three sprays of GA₃ @ 20g/ha (T3) reduced the number of berries compared to T5-the growers' practice (**Table 1**). On par efficacy of less number of sprays in T2 could be attributed to the increased uniformity in flowering due to removal of un-uniformly thick canes. Interaction of Season x location also influenced the berries/cluster significantly. In addition to reduced berry number in both the seasons at L1, it was further reduced in season-II while increased at L2 (**Table 2C**). It clearly indicates the absolute effect of location, but not the season and confirms the higher efficacy of GA₃ sprays at L1 in reducing the berry number.

Effect on Berry Diameter

Berry diameter, the yet another component of cluster compactness was not influenced by the season, location or treatments. GA₃ sprays included in the treatments might have had an indirect effect on berry diameter by reducing the number. But the effect, if

any, was masked by treatment with BA, homobrassinolide or CPPU combined with GA given commonly by the growers to increase the berry diameter to 17±1mm required for export.

Effect on Cluster Compactness

Cluster compactness was influenced neither by the season nor the location, but by the treatments (**Table 1**). Similar to the number of berries/cluster, cluster compactness was reduced by T2 and T3 compared to the growers' practice. Thus reduction in the cluster compactness was the outcome of reduced number of berries/unit length of the rachis which was enhanced by inducing uniformity in cluster development by the treatments in the present investigation.

Contributory factors of cluster compactness

Major emphasis was given to the identification of contributory factors and their optimum values for the reduced compactness of clusters. Regression analysis indicated the contribution of uniform flowering in reducing the cluster compactness across the GA₃ doses and its number of sprays; although the determination co-efficient was poor. Uniform flowering in turn was dependant on uniform bud break which in turn was dependant on cane diameter. The multiple regression function $Y = 2.616 + 3.404X_1 + 0.013X_2 - 0.127X_3 - 0.449X_4 + 0.02X_5 + 1.945X_6$ was found to determine the cluster compactness by 39.2 per cent, Where Y = Cluster compactness, X₁ = Cane diameter (mm), X₂ = Uniformity in bud break (%), X₃ = Uniformity in flowering (%), X₄ = Rachis length (cm)/cluster, X₅ = Berries/cluster and X₆ = Berry diameter (mm).

Cane diameter of 7.67 mm, uniformity of 80.8 per cent in bud break, uniformity of 79.4 per cent in flowering, and berry diameter of 18.4 mm were associated respectively with the maximum cluster compactness index of 32.9, 34.1, 32.4 and 32.5. These compactness indices being in the range (30-35) of well-filled clusters, the above values of cane diameter, uniformity in bud break and flowering and berry diameter can be considered optimum. Maximum values of uniform flowering associated with the optimum values of cane diameter (6.72 mm) and uniform bud break (71.1 per cent) respectively were 92.1 and 93.4 per cent. On the other hand the maximum uniformity in bud break was associated with a cane diameter of 6.49 mm (**Table 6**). Thus, a cane diameter in the range of 6.49 – 7.67 mm seems ideal for

obtaining the well filled clusters by blanket sprays of GA₃ in this variety. Similarly the uniform bud break in the range of 71.1 – 80.8 per cent and uniform flowering of 79.4 per cent were found optimum.

Effect on yield

Efforts were also made to identify the merit of a treatment in sustaining/enhancing the yield and quality of grape in addition to reducing the compactness, because, canes which are the units of yield have been removed in T1 and T2.

Yield/vine was not different in the seasons studied, but was more at L1 than L2. Treatments T4 and T2 reduced the yield compared to the control, while T3 and T1 were at par with it (**Table 1**). Interaction of season x treatment also affected the yield/vine. While all treatments were at par with control in season-I, yield was reduced by all treatments except T3 in season-II (**Table 3B**). Mean weight of cluster and the number of clusters/vine determine the yield. None of the treatments or their interaction with season or location could influence the cluster weight (**Table 1**). This suggests that the yield differences were due to the number of clusters/vine. Number of canes was less in 2013-14 and at L2 compared respectively to 2014-15 and L1. It was reduced as result of removal of un-uniformly thick canes in T1 and T2 (**Table 1**). Cane-number was influenced by the interaction of season x location, location x treatment and Season x location x treatment. Season's influence was significant at L1 but not at L2 (**Table 2E**). While, cane-number in T2 was at par with T1 at L1, it was less at L2 (**Table 4C**). Similarly, T1 and T2 were at par with control in cane-number at L2, but had less number at L1 in 2014-15 and also at L1 and L2 in 2013-14 (**Table 5C**).

In spite of reduced number of canes, yield was not reduced in T1 compared to control (**Table 1**). This could be attributed to more number of clusters/cane in T1 compared to control. It was 1.34 in T1 as against 1.05 in control when worked out based on the yield/vine, mean cluster weight and number of canes/vine. Thus, the reduction in yield in T2 was not only due to reduced number of canes/vine but also the less number of clusters/cane (0.89) compared to control. However, the variation in clusters/cane cannot be attributed to the treatments which were imposed at the beginning of the fruiting season, when the number of clusters in a cane are determined during the growth season in the double pruning single cropping system followed in the experimental vineyards.

Effect on berry quality

Total soluble solids (TSS) content of berries did not vary significantly with either season or treatment, but varied with the location. It was more at L2 than at L1 (**Table 1**). However, interaction of treatments with season x location influenced the TSS content. While it did not differ with any treatment compared to control at any location in 2013-14, It was more in T1 at L1, but less at L2 compared to control in 2014-15 (**Table 5B**). TSS content is primarily a varietal character, often modified by the diurnal variation in temperature during the ripening period, and is mainly controlled by the genotype x environment interaction (Coombe, 1960). Although crop load/vine was reported to influence the TSS content (Coombe, 1992) and yield/vine varied significantly with the treatments (**Table 1**), the variation seems to be inadequate to influence the TSS content.

Acids content of berries also did not differ with season, location or treatment (**Table 1**), but was influenced by the interaction of season x location. It was less at L1 in season-I but more in season-II (**Table 2D**). Interaction of location x treatment also influenced the acids content significantly. It was more in T3 compared to control at L1, but on par with that in control at L2. T2 resulted in less acids content compared to control at L2 (**Table 4B**). Acids are synthesized mainly in the leaves and very little in the berries. The extent of their translocation from leaves (Amerine, 1956; Hardy, 1969) and the ability of berries to synthesize acids (Hardy, 1968) during ripening are the main reasons for the variation in the acids content of berries.

Considering the effects of treatments together on cluster compactness, yield and quality, T3 (retention of all canes coupled with three sprays of GA₃ @ 20g a.i./ha) is recommended for Tas-A-Ganesh for table grape production for export.

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Table 2. Effect of season x location interaction

A. Uniform Flowering (%)		B. Rachis length (cm)		C. Berries/ cluster		D. Acids content (g/100 ml)		E. Canes/ vine	
2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
L1	74.5 ^a	92.6 ^c	50.5 ^c	45.1 ^b	L1	50.5 ^b	45.1 ^a	L1	0.545 ^a
L2	79.9 ^b	94.2 ^c	39.9 ^a	45.0 ^b	L2	64.5 ^c	70.3 ^d	L2	0.583 ^b
S.Em ± 0.95 CD@0.05 = 2.7		S.Em ± 1.58 CD@0.05 = 4.5		S.Em ± 1.68 CD@0.05 = 4.8		S.Em ± 0.0082 CD@0.05 = 0.024		S.Em ± 0.57 CD@0.05 = 1.6	

Means super-scribed with same alphabet under a parameter do not differ significantly

Table 3. Effect of season x treatment interaction

A. Cane diameter (mm)		B. Yield/ vine (kg)		
2013-14	2014-15	2013-14	2014-15	
T1	7.25 ^{defg}	7.01 ^{bcd}	T1	10.67 ^{bc}
T2	7.12 ^{cedf}	7.02 ^{bcd}	T2	10.56 ^{abc}
T3	7.31 ^{e'fg}	6.74 ^{ab}	T3	10.70 ^{bc}
T4	7.49 ^g	6.64 ^a	T4	10.11 ^{abc}
T5	7.40 ^{fg}	6.95 ^{bc}	T5	10.35 ^{abc}
S.Em ± 0.098 CD@0.05 = 0.28		S.Em ± 0.486 CD@0.05 = 1.39		

Means super-scribed with same alphabet under a parameter do not differ significantly

Table 4. Effect of location x treatment interaction

A. Uniform flowering (%)		B. Acids content (g/ 100 ml)		C. Canes/vine	
L1	L2	L1	L2	L1	L2
T1	79.7 ^a	88.9 ^e	T1	0.567 ^{abc}	0.557 ^{abc}
T2	83.6 ^{abcd}	87.3 ^{de}	T2	0.570 ^{abc}	0.538 ^a
T3	85.3 ^{bcd}	87.3 ^{de}	T3	0.580 ^{bc}	0.560 ^{abc}
T4	87.3 ^{de}	85.9 ^{cde}	T4	0.543 ^a	0.560 ^{abc}
T5	82.1 ^{abc}	91.4 ^{cde}	T5	0.533 ^a	0.588 ^c
S.Em ± 1.50 CD@0.05 = 4.3		S.Em ± 0.0129 CD@0.05 = 0.037		S.Em ± 0.9 CD@0.05 = 2.6	

Means super-scribed with same alphabet under a parameter do not differ significantly



Table 5. Effect of season x location x treatment interaction

A. Uniform flowering (%)				B. TSS content (° B)				C. Canes/vine					
2013-14		2014-15		2013-14		2014-15		2013-14		2014-15			
L1	L2	L1	L2	L1	L2	L1	L2	L1	L2	L1	L2		
T1	65.4 ^a	85.0 ^{ab}	94.0 ^{fg}	92.8 ^{fg}	15.9 ^{ab}	17.6 ^{bcd}	18.7 ^{cd}	13.9 ^a	T1	24.7	21.5	25.0	23.8
T2	74.4 ^b	79.4 ^{bcd}	92.8 ^{fg}	95.2 ^{fg}	16.4 ^{abc}	17.7 ^{bcd}	16.9 ^{bcd}	19.3 ^d	T2	22.5	17.8	27.8	21.6
T3	77.2 ^{bc}	80.7 ^{cd}	93.3 ^{fg}	93.8 ^{fg}	16.5 ^{abcd}	16.4 ^{abc}	15.3 ^a	18.9 ^{cd}	T3	33.5	25.0	34.5	28.8
T4	80.6 ^{cd}	76.1 ^{bc}	93.6 ^{fg}	95.8 ^g	15.8 ^{ab}	17.0 ^{bcd}	15.7 ^{ab}	18.2 ^{bcd}	T4	32.2	29.7	35.0	25.4
T5	74.7 ^{bc}	78.4 ^{bc}	89.5 ^{ef}	93.3 ^{fg}	16.0 ^{abc}	16.9 ^{bcd}	15.9 ^{ab}	17.8 ^{bcd}	T5	32.8	27.5	39.4	23.8
S.Em ± 2.13 CD@0.05 = 6.1				S.Em ± 1.005 CD@0.05 = 2.9				S.Em ± 1.3 CD@0.05 = 3.7					

Means super-scripted with same alphabet under a parameter do not differ significantly

Table 6. Quadratic equations of the relationship among cane diameter, uniformity in bud break and flowering and cluster compactness in Tas-A- Ganesh

X	Y	Equation	R ²	X-opt	Y-max
Cane Diameter	Uniform Bud break	Y = -193.8+84.7x-6.53x ²	0.080	6.49	80.8
Cane Diameter	Uniform flowering	Y = 400.98-91.98x+6.85x ²	0.080	6.72	92.1
Cane Diameter	Berrydiameter	Y = 21.63-1.234x+0.093x ²	0.003	6.63	17.5
Cane Diameter	Cluster compactness	Y = -92.4+32.69x-2.132x ²	0.033	7.67	32.9
Uniform Bud break	Uniform flowering	Y = 37.74+1.57x-0.011x ²	0.050	71.1	93.4
Uniform Bud break	Cluster compactness	Y = -331.53+9.05x-0.056x ²	0.066	80.8	34.1
Uniform flowering	Cluster compactness	Y = -118.83+3.81x-0.024x ²	0.230	79.4	32.4
BerryDiameter	Cluster compactness	Y = -180.93+23.21x-0.631x ²	0.020	18.4	32.5



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