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Variation in relation between yield and yield attributes in 'Thompson Seedless' grape and its clones

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ABSTRACT

To study variation in the relationship between yield and yield attributes in 'Thompson seedless', 'Tas-A-Ganesh' and '2A clone' vines grafted onto Dogridge rootstock and trained on the extended Y training system, data collected from 120 vines in each variety were subjected to correlation and regression analysis. Numbers of clusters per vine was the main contributing factor for yield in all these varieties. It determined the yield by 87.9, 42.0 and 51.5%, respectively, in 'Thompson Seedless', 'Tas-A-Ganesh' and '2A clone', with the optimum number of clusters at 27.3, 43.1 and 46.5, respectively. Contrary to that in vars. Thompson Seedless and Tas-A-Ganesh, increase in number of canes was associated with higher cluster/cane ratio. Yield depended upon cluster weight in 'Thompson Seedless', mediated through number of clusters, but was not a contributory factor as evidenced by a negative correlation between cluster-weight and yield. Increase in cluster weight was associated with increase in number of berries in all the varieties. Increase in berry weight was related to cluster weight in only Thompson Seedless and Tas-A-Ganesh. While berry number and berry weight together determined cluster weight by 96.3 and 92.4%, respectively, in vars. Thompson Seedless and Tas-A-ganesh, this value was just 39.0% in '2A clone'. These studies provide a clue that for realizing higher yield, cluster size needs to be greater while limiting the number of canes/vine in vars. Thompson Seedless and Tas-A-Ganesh. Increase in the number of canes would benefit '2A clone' by adopting suitable cultural practices.

Key words: Correlation, variation, yield, yield attributes, Thompson Seedless, Tas-A-Ganesh, 2A clone

INTRODUCTION

Yield in grapevine is determined by number of clusters and mean weight of the cluster. Number of clusters in a vine, in turn, is determined by the number of canes, and cane-productivity as measured by cluster/cane ratio. Earlier studies have revealed that increase in number of canes does not result in proportionate increase in cluster number on a vine. Cane density of 5 to 6/m^2 was found as optimum in bower-trained 'Thompson Seedless' vines with reference to cane-productivity and number of clusters/vine. Higher number of canes/unit area gave a reduced cluster/cane ratio, eventually reduced number of clusters/vine (Shikhamany, 1983). Cluster/cane ratio is an outcome of the number of fruitful buds on a cane. Mutual shading of shoots in a dense vine canopy hampers incident light required for fruit-bud formation in 'Thompson Seedless' which requires over 3600 ft. candles of light (Buttrose, 1970). Since varietal variation was observed in requirement of light for fruit-bud formation (Buttrose, 1969), optimum cane density may be different for Tas-A-Ganesh and 2A Clone, for Thompson seedless even, when vines are trained on extended Y trellis to afford open canopies.

Mean cluster weight, the other yield attribute, is determined by number of berries in a cluster and mean berry-weight.

Variation in relation of the above stated yield attributes to yield, in the different varieties studied, can provide guidelines for formulating specific sets of cultural practices for each variety to obtain higher yields, since, all these attributes are amenable to regulation by cultural operations.

MATERIAL AND METHODS

The present investigation was carried out on 'Thompson Seedless', 'Tas-A-Ganesh' and '2A clone' in 2013-2014 cropping season in growers' vineyards around

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Nashik, Maharashtra. Details of the vineyards selected are given below:

Thompson Seedless vineyards of:

1. Shri Suresh Kalamkar, Mohadi

2. Shri Arun More, Pimpalgaon

Tas-A-Ganesh vineyards of:

1. Shri Ashokrao Gaikwad, Palkhed

2. Shri Jagannathrao Khapre, Kothure

2A Clone vineyards of:

1. Shri Kailashrao Bhosale, Sarole Khurd

2. Shri Manikrao Patil, Khedgaon

Tas-A-Ganesh and 2A Clone are mutants of Thompson Seedless. The former was identified by the Late Vasantrao Arve, a progressive grower in 1976, in his vineyard at Borgaon, Sangli district, Maharashtra, the latter was identified at Kearney Experimental Station, UC Davis, California, USA. Tas-A-Ganesh is cultivated widely in Maharashtra, whereas, 2A Clone was introduced only in 1999, and is gaining popularity.

To work out variation in the relation of yield attributes to yield in these varieties, 120 vines (60 from each vineyard, under each variety) were selected at random. All the vines selected were in the age group of 6-7 years, grafted onto Dogridge rootstock, spaced uniformly at 2.7 x 1.8m, trained on extended Y training system, grown under similar agro-climatic conditions and subjected to similar cultural practices, including sub-cane development; application of Ethrel for pre-pruning defoliation, hydrogen cyanamide for bud-break, GA_3 sprays for cluster elongation, girdling and dipping in CPPU solution for berry sizing. Data were collected on the following yield-attributes and yield, separately for each vine:

No. of canes/vine: Number of canes left on the vine after Forward Pruning.

Cluster/cane ratio: This is an index of vine productivity, derived by dividing the number of clusters borne on a vine by the number of canes retained on it.

No. of clusters/vine: Number of clusters borne on each vine, counted at harvest.

Cluster weight: Mean weight of the cluster was derived by dividing mean yield/vine by mean number of clusters/vine.

Yield/vine: Recorded in kg for each vine at harvest

No. of berries/cluster: Average number of berries in five bunches selected at random in each vine

Mean berry weight: Average weight of 25 berries selected at random in five selected clusters, at the rate of five berries from each cluster

Berry diameter: Average diameter of 25 berries, measured at middle length of the berry, using callipers

Statistical analysis: Correlation was worked out to assess the relation of yield and cluster-weight to their respective attributes. Multiple regression equations for these parameters, with all their respective attributes as independent variables, were also worked out. Optimized models and optimum values for the critical attribute for yield, cluster-weight and cluster-compactness were derived.

RESULTS AND DISCUSSION

Yield/vine

Yield correlated positively with number of canes/vine in 2A Clone, cluster/cane ratio in 'Thompson Seedless', and number of clusters/vine in all the varieties, but, was negatively correlated with cluster-weight in 'Thompson Seedless' (Table 1). Among the yield attributes studied, number of clusters/vine correlated significantly with yield in all the varieties. While cane is a unit of vine productivity, cluster/

Table 1. Correlation between yield and yield attributes

Correlation	Correlation coefficient		
	Thompson Seedless	Tas-A-Ganesh	2A clone
1. Yield/vine vs. no. of canes/vine	-0.048	0.160	0.226**
2. Yield/vine vs. Cluster/cane ratio	0.211*	-0.042	0.152
3. Yield/vine vs. no. of clusters/vine	0.940**	0.643**	0.696**
4. Yield/vine vs. cluster weight	-0.255**	-0.001	0.125
5. Yield/vine vs. betty TSS	-0.713**	-0.479**	-0.535**
6. Clusters/vine vs. no. of canes/vine	-0.104	0.185	0.330**
7. No. of clusters/vine vs. cluster/cane ratio	0.235*	-0.065	0.286**
8. Cluster weight vs. no. of canes/vine	0.204*	-0.019	0.081
9. Cluster weight vs. cluster/cane ratio	-0.221*	-0.152	0.052
10. Cluster weight vs. no. of clusters/vine	-0.314**	0.073	0.169
11. Cluster/cane ratio vs. no. of canes/vine	-0.234*	-0.222*	0.427**

Significance of 'r' value at 5% = 0.195, and at 1% = 0.254
(0.361 and 0.463, respectively, at 5% and 1% for yield/vine vs. berry TSS)

Table 2. Variation in yield attributes

Attribute	Thompson Seedless			Tas-A-Ganesh			2A Clone		
	Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.	Mean
Yield/vine(kg)	1.1	18.8	9.14	5.1	16.5	10.7	4.4	28.0	17.37
No. of canes/vine	17	53	32.7	10	52	25.9	18	62	44.1
Cluster/cane ratio	0.8	2.0	1.41	0.4	2.4	1.68	1.2	2.8	1.81
No. of clusters/vine	4	66	26.3	11	62	32.7	11	73	47.4
Cluster weight (g)	137.3	791.9	380.3	162.6	534.5	335.5	184.7	580.1	367.4

cane ratio is a measure of cane-productivity. An inverse relationship of cane number with cluster/cane ratio was reported, with optimum cane-density of 5/m^2, in bower-trained vines of 'Thompson Seedless' (Shikhamany, 1983). This was attributed to inadequate intensity of light received by the vines for fruit-bud formation.

However, the relation of number of canes to cluster/cane ratio was not significant in 'Thompson Seedless' or 'Tas-A-Ganesh'. This could be due to exposure of the canes to more sunlight in an open canopy in vines trained on extended Y training system in the present study, where, increase in cane-density did not impair fruit-bud differentiation and, consequently, cluster/cane ratio. Data in Table 2 corroborating with vine spacing of 4.9m^2 reveals that cane density was 6.7 in 'Thompson Seedless', 5.3 in 'Tas-A-Ganesh' and 9.0 in '2A Clone'. It is pertinent to note that in spite of a higher number of canes/vine and a higher cane-density (9/m^2), cluster/cane ratio and number of clusters/vine were highest in '2A Clone' compared to the other two varieties. Moreover, i) the relationship of number of clusters/vine with number of canes/vine was not significant in 'Thompson Seedless' or 'Tas-A-Ganesh', but was significant in '2A Clone', and ii) Cluster/cane ratio correlated negatively with number of canes/vine in the two former varieties, but correlated positively and highly significantly in '2A Clone' (Table 1). Number of clusters/cane ratio, a measure of cane-productivity, depends upon the inherent ability of a variety to develop fruitful buds on the canes under a given set of agro-climatic conditions. Despite having higher number of canes/vine, cane-productivity was higher in '2A Clone'. These results imply that higher cane density of up to 9/m^2 is not detrimental to cane-productivity and yield/vine in '2A Clone', unlike in 'Thompson Seedless' and Tas-A-Ganesh.

Increase in yield/vine was associated with reduced total soluble solids (TSS) content in the berry in all the varieties studied (Table 1). Depressing effect of yield on TSS content in berry is a well-established fact in several varieties of grape (Chadha *et al*, 1974; Lider *et al*, 1974; Purohit *et al*, 1979; Chittiraichelvan *et al*, 1985).

Table 3. Regression of yield attributes on yield in various varieties

Regression equation	Variety		
	Thompson Seedless	Tas-A-Ganesh	2A clone
Intercept	2.66	0.59	-5.8
Slope of x_1(no. of canes/vine)	0.03	0.009	0.045
Slope of x_2 (cluster/cane ratio)	0.96	-0.091	-0.58
Slope of x_3 (no. of clusters/vine)	0.29	0.142	0.27
Slope of x_4 (cluster weight)	0.04	-0.009	-0.003
Slope of x_5 (berry weight)	0.095	0.08	0.81
Slope of x_6 (no. of berries/cluster)	-0.014	0.04	0.0001
Slope of x_7 (berry diameter)	-0.16	0.313	0.44
Determination Co-efficient (R^2)	0.885	0.44	0.53

Number of clusters/vine

Number of clusters/vine is dependent on number of canes/vine and the cluster/cane ratio, and was correlated positively with number of canes/vine in '2A Clone' but not in the other two varieties (Table 1). Probable reason for this variation in relationship is the inherent character of a variety in converting growth into productivity, as explained earlier. Number of clusters/vine had a positive relationship with cluster/cane ratio in 'Thompson Seedless' and '2A Clone', but not in 'Tas-A-Ganesh' (Table 1). From the data presented in Table 2, estimated number of clusters/vine (product of number of canes and cluster/cane ratio) is 46.1, 43.5 and 79.82 in 'Thompson Seedless', 'Tas-A-Ganesh' and '2A Clone', respectively; whereas, number of clusters observed is 26.3, 32.7 and 47.4, respectively. Thus the percentage of observed number of clusters to estimated number of clusters works out at 57.0, 75.2 and 59.4, respectively. This implies that the proportion of productive canes was higher in 'Tas-A-Ganesh' compared to that in the other two varieties. Hence, the deviation in relationship.

In multiple regression analysis involving seven yield-attributes, it was observed that all these yield attributes could together determine yield by 88.5% in 'Thompson Seedless', but only by 44% in 'Tas-A-Ganesh' and 53% in '2A Clone' (Table 3). Number of clusters/vine was the major contributing factor in determining yield in all the varieties. Optimized regression model revealed that 87.9% of the yield was determined by number of clusters/vine in 'Thompson

Seedless', while, the corresponding values were 42.0 and 51.5%, respectively, for 'Tas-A-Ganesh' and '2A Clone. Values of 27.3, 43.1 and 46.5 clusters/vine were optimum, respectively, for 'Thompson Seedless', 'Tas-A-Ganesh' and '2A Clone' (Table 4).

Cluster weight

Cluster weight correlated positively with number of canes/vine, but negatively with number of clusters/vine, cluster/cane ratio and yield/wine in 'Thompson Seedless', but not in 'Tas-A-Ganesh' or '2A Clone' (Table 1).

The positive relationship observed between number of canes/vine and cluster weight can be explained by a negative relationship of canes/vine with cluster/cane ratio, coupled with the negative relationship of cluster weight with cluster weight with cluster/cane ration (Table 1). When cluster/cane ratio simultaneously correlated negatively with number of canes number of cluster/vine and cluster weight, the latter two parameters would correlate positively.

While the number of cluster/cane ratio denotes the physiological sink, carbohydrate reserves and the current metabolites in a cane denote the source. Similarly number of clusters/vine denote the sink and its corresponding source is the total carbohydrate reserves in a vine. At a given level of source, increasing number of sinks result in a reduced size (weight) of an individual sink (cluster). This is the reason for a negative correlation of cluster weight with number of clusters/vine and number of clusters cane ratio.

Number of clusters/vine and cluster/cane ratio are attributes of yield and these correlated positively with yield/vine (Table 1). When these correlated negatively with the cluster weight, yield/vine would also correlate negatively.

Lack of negative correlation of cluster-weight to yield in 'Tas-A-Ganesh' and '2A Clone' indicates that contribution of cluster-weight in determining yield is much less in these varieties compared to that in 'Thompson Seedless' evidenced by the meagre values of slope of cluster-weight in the multiple regression function of yield in these varieties (Table 3). Physiologically, this can be explained by variation in source-sink relation among varieties. Cluster-size being larger in 'Thompson Seedless', any additional cluster on the cane can reduce cluster-weight more drastically than in the other two varieties (where clusters were relatively smaller). Positive correlation of cluster weight with number of canes/vine can be explained in the light of the inverse relationship of yield with cluster-weight, and, with the number of canes/vine. When the number of canes increases, yield decreases and there is a simultaneous increase in cluster-weight, resulting in a positive correlation between number of canes/vine and cluster-weight.

Cluster-weight is an important yield attribute in grape, alterable as desired by cultural operations, primarily with use of growth regulators. The main components of cluster weight are: number of berries in a cluster, and, mean berry-weight. Increase in the number of berries in a cluster was associated with increase in weight of the cluster. Correlation here was highly significant in all the varieties studied. Cluster-weight also varied significantly with mean berry weight in 'Thompson seedless' and 'Tas-A-Ganesh' but not in '2A Clone'. Number of berries in a cluster and mean berry-weight correlated negatively in all the varieties (Table 5). Although increase in the number of berries reduced mean berry-weight in '2A Clone', the reduction seemed to be inadequate in masking the positive effect of number of

Table 4. Determination of yield in various varieties

Variety	Per cent yield determination by no. of clusters/vine	Optimum number of clusters/vine
Thompson Seedless	87.9	27.3
Tas-A-Ganesh	42.0	43.1
2A clone	51.5	46.5

Table 5. Correlation between cluster weight and other attributes in various varieties

Attribute	Correlation coefficient		
	Thompson Seedless	Tas-A-Ganesh	2A clone
Cluster weight vs. no. of berries/cluster	0.661**	0.754**	0.449**
Cluster weight vs. mean berry weight	0.477**	0.296**	0.164
Mean berry weight vs. no. of berries/cluster	- 0.316**	- 0.349**	- 0.484**

Significance of 'r' value at 5% = 0.195, and at 1% = 0.254

Table 6. Variation in cluster attributes

Cluster attribute	Thompson Seedless			Tas-A-Ganesh			2A Clone		
	Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.	Mean
Cluster weight (g)	137.3	791.9	380.3	162.6	534.5	335.5	184.7	580.1	367.4
No. of berries/cluster	30	132	74.5	35	108	68.9	44	128	76.6
Berry weight (g)	2.41	8.63	5.21	3.23	7.52	4.97	3.51	6.84	4.86

Table 7. Regression of cluster weight attributes on cluster weight in different varieties

Regression equation	Thompson Seedless	Tas-A-Ganesh	2A clone
a) Intercept	-301.78	-213.07	-49.19
b) Slope of x_1 (berry weight)	68.03	57.82	47.61
c) Slope of x_2 (No. of berries/cluster)	5.14	4.56	3.04
Determination Coefficient (R^2)	0.963	0.924	0.39

Table 8. Determination of cluster weight in different varieties

Variety	Per cent determination of cluster weight	Optimum values	
		Number of berries	Mean berry weight
Thompson Seedless	96.3	85.7	7.32
Tas-A-Ganesh	92.4	84.5	4.96
2A clone	39.0	104.3	4.32

berries on cluster-weight. This assumption gains support from less variation seen in the number of berries in a cluster, berry-weight and cluster-weight in '2A Clone' (Table 6). Multiple regression function involving berry number and berry weight determined cluster weight by 96.3% in 'Thompson Seedless' and 92.4% in 'Tas-A-Ganesh', but only 39.0% in '2A Clone' (Table 7). A model optimized for cluster-weight indicated that 85.7 berries/cluster was optimum in 'Thompson Seedless', 84.5 in 'Tas-A-Ganesh' and 104.3 in '2A Clone'. Optimum weight of the berry was 7.32, 4.96 and 4.32 grams, respectively, for the three varieties in that order (Table 8).

Based on variation observed in the relation of yield-attributes to yield in various varieties in the present study, it can be inferred that for obtaining higher yields, cluster-size needs to be increased while limiting number of canes/vine in 'Thompson Seedless' and 'Tas-A-Ganesh'; but, an increase in number of canes in '2A clone' by appropriate cultural practices would be useful.

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