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Estimating cluster compactness in Yaghouti grapes

by

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Beurteilung der Beerendichte bei der Rebsorte Jaghouti

Zusammenfassung. — Die Beerendichte der Jaghouti-Trauben wurde als der prozentuale Anteil des Festvolumens am Gesamtvolumen der Traube definiert und gemessen. Das Gesamtvolumen ist das Festvolumen (Beeren mit Traubengerüst) und der Zwischenraum zwischen den Weinbeeren. Dieses Maß der Beerendichte wurde dazu verwendet, um die Brauchbarkeit anderer Methoden zur Schätzung der Beerendichte zu beurteilen. Es wurde festgestellt, daß sich der Quotient aus Festvolumen und Gesamtlänge der Traubenachse und der Seitenäste 1. Ordnung für die Schätzung der Beerendichte am besten eignet.

Introduction

Yaghouti is a seedless variety of *Vitis vinifera* L. grown in Iran. Here it is one of the earliest grapevines. The only main disadvantage of Yaghouti ist the compactness of the cluster to such an extent that it interferes with washing the fruit for consumption. Variation in compactness has been brought about by the use of growth regulators, especially gibberellic acid. In the works reported so far, however, the degree of compactness has been determined mainly by visual rating (Christodoulou *et al.* 1968, Barritt 1970, Bertrand and Weaver 1972, Looney 1974, Dass *et al.* 1977, Looney and Wood 1977). Christodoulou *et al.* (1968) and Kuykendall *et al.* (1970) have estimated compactness by the number of berries per cm of rachis. Funt and Tukey (1977) have used the length of the rachis as a measure of compactness. Weaver and Pool (1971) estimated compactness by the number and weight of berries per cm of rachis and weight of berries per g of rachis. Tafazoli (1977) working with Yaghouti grapes has observed the effect of GA_3 on compactness; however, no kind of measurement was applied. It should be mentioned that loosening the cluster was not a main objective in his work.

The purpose of this work is to: (i) achieve a quantitative definition of compactness and a corresponding way of measuring it, (ii) find relations between compactness so defined and functions involving easily measurable characters leading to an indirect but easier way of estimating it, and (iii) evaluate the suitability of visual rating and some of the other common methods of estimating compactness.

Materials and methods

To ensure a rather wide range of cluster characters, clusters from a preliminary experiment on the effect of GA_3 on Yaghouti grapes were used. The experiment involved rates of GA_3, stages of the cluster development at which the hormone was applied, and cluster thinning. At harvest, 30 vines were picked at random and from each vine one cluster was used for taking different measurements.

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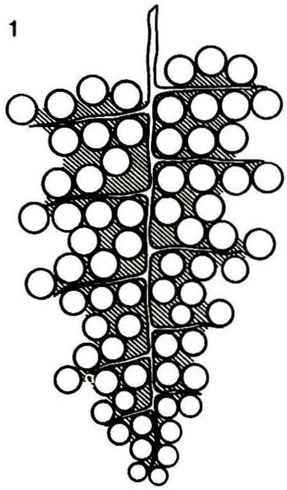

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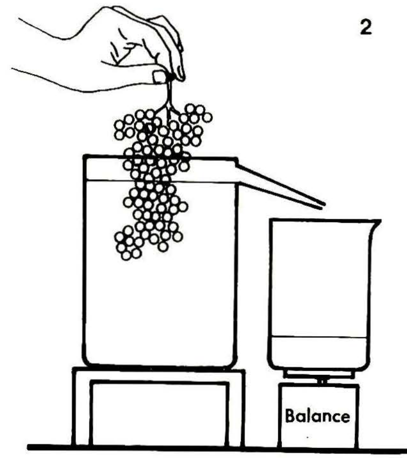

Fig. 1: Schematic drawing of a grape cluster indicating the space between the berries (shaded area).

Fig. 2: Measuring volume by water replacement.

Abb. 1: Schematische Darstellung einer Weintraube; die schraffierte Fläche zeigt den Zwischenraum zwischen den Beeren.

Abb. 2: Volumenmessung durch Wasserverdrängung.

1. Compactness and its measurement

In a grape cluster two volumes can be considered: (i) the volume of the solid (V_s), i.e. that of the berries and the rachis, (ii) the total volume (V_t), i.e. V_s plus the space between the berries (Fig. 1).

Compactness is here defined as the percentage of the total volume (V_t) occupied by the solid volume (V_s). That is, $C_v = (V_s/V_t)100$. The index "v" is used here to indicate measurement by volume.

V_s was easily measured (in g) by water replacement (Fig. 2). A little detergent was added to the water to reduce the surface tension. To measure V_t, the clusters were immersed in melted paraffin (Fig. 3 a). To reduce the melting point of the paraffin, it was mixed with equal weight of liquid paraffin. The beaker containing the paraffin and the cluster was put in the refrigerator till the paraffin solidified (Fig. 3 b). The excess paraffin was removed with a knife (Fig. 3 c). Then a hot metal rod was run over the paraffin till the berries emerged (Fig. 3 d). For further refinement the clusters were immersed in hot water for a few seconds and immediately dipped in ice water. The volume of this "paraffin moulded" cluster (i.e. V_t) was measured as in the case of V_s.

2. Estimations of compactness

The technique explained above, although it gives a fairly accurate measure of compactness, as defined, is tedious. It is used here only to judge the usefulness of other possible means of estimating compactness. This was done by running a rank correlation between the scores resulting from each estimator and the corresponding

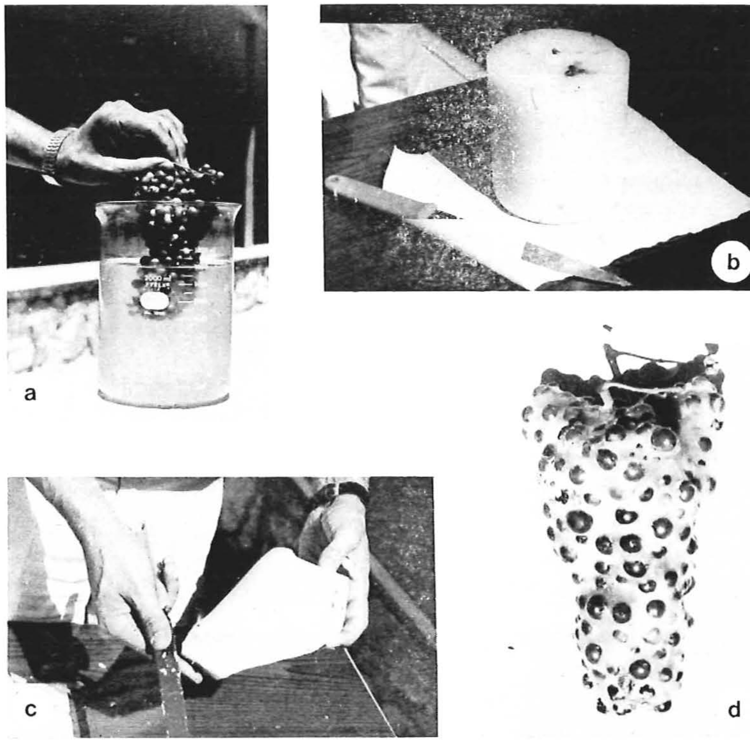

Fig. 3: Steps in preparing a "paraffin-moulded" cluster: a) Immersing the cluster in melted paraffin, b) solidified paraffin containing the cluster, c) removing the excess paraffin, d) the "paraffin moulded" cluster.

Paraffineinbettungsverfahren für Weintrauben: a) Eintauchen der Traube in flüssiges Paraffin, b) erstarrter Paraffinblock mit der darin enthaltenen Traube, c) Entfernen des überschüssigen Paraffins, d) die in Paraffin eingebettete Traube.

C_V scores. The estimations of compactness tried in this work can be divided into three classes:

a) By ranking. — The clusters were ranked by 7 persons. To determine the degree of agreement among the judges, the coefficient of concordance was calculated as explained by Edwards (1967). To assess the judging ability of each person the rank correlation coefficient (r') between the ranks given by him and the corresponding C_V scores (i.e. the ranks of the scores) was calculated.

b) By simple functions of characters. — It is evident that, the other characters being equal, compactness has a direct relation to the solid volume (V_s) and to the number of the primary laterals on the rachis (NL); and a reverse relation to the total length of the rachis and its primary laterals (TLR). Also, the more easily measureable weight of the cluster (WC) and the weight of the rachis (WR) are logical substitutes for V_s and TLR respectively. It should be mentioned that in a Yaghouti cluster there are practically no sizable secondary laterals. A number of pedicels are usually grouped together and join the primary lateral at a single point (Fig. 4). That is why in calculating TLR the length of the secondary laterals is not considered.

Based on these assumptions different simple functions of these characters were tried. Here again to assess the suitability of each function the rank correlation between the resulting scores from each function and the corresponding C_V scores was calculated.

c) By multiple regression. — Multiple regressions of C_V scores on different sets of characters were calculated. The characters were V_s, NL, TLR, WC and WR explained above plus:

NG = number of "good" berries, i.e. excluding the shot and the unripe berries,
BWd = average berry width, i.e. the average of 5 berries from the middle of the cluster, and
BWt = average berry weight, i.e. weight of good berries/NG.

Results

A number of characters were measured. Those being used in further calculations are presented in Table 1.

1. Compactness and its measurement

The C_V scores and ranks for the 30 clusters are presented in an ascending order in the 2nd and 3rd columns of Table 2. Every other one of the corresponding clusters is represented in Fig. 5.

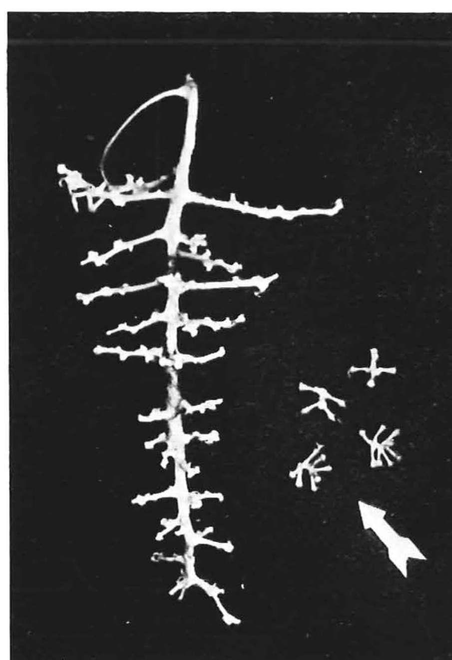

Fig. 4: Yaghouti cluster after the removal of the berries and the pedicels. The arrow indicates groups of pedicels.

Jaghouti-Traube nach dem Entfernen der Beeren und Beerenstiele. Der Pfeil weist auf Büschel von Beerenstielen hin.

Table 1

The minimum, average and maximum values of the characters investigated
Niedrigste, durchschnittliche und höchste Werte der untersuchten Merkmale

Character	Min.	Avg.	Max.
Volume of the solid (V_s) in g of replaced water	51.4	168.8	370.0
Total volume (V_t) in g of replaced water	124.1	362.5	761.8
Weight of the cluster (WC) in g	65.74	193.31	332.13
Number of good berries (NG)	71	283	490
Average berry weight (BWt) in g	0.33	0.54	0.74
Average berry width (BWd) in mm	8.1	10.2	11.2
Length of the rachis from the 1st lateral to the apex in cm	8.0	15.1	24.0
Number of primary laterals (NL)	20	34	56
Total length of the rachis and its primary laterals (TLR) in cm	15.8	60.2	139.8
Weight of the rachis (WR) in g	4.72	9.79	38.76

2. Estimations of compactness

a) By ranking

The coefficient of rank correlation between the ranks given by each judge and the corresponding C_v scores varied between 0.90 and 0.98. The coefficient of concordance, W = 0.94 (significant at the 1 % level) indicates a close agreement among judges.

The order of clusters based on the average of the ranks assigned by the 7 judges to each cluster would naturally be more reliable than that based on the ranks given by a single judge. The average of the ranks for each cluster is presented in the 4th column of the Table 2. These averages themselves were ranked and their corresponding ranks are presented in the 5th column of the table. The coefficient of rank correlation between the latter ranks and the C_v scores was 0.95.

Usually the ranking is done with respect to 3—5 classes (Weaver and Pool 1965, Christodoulou *et al.* 1968, Barritt 1970, Bertrand and Weaver 1972, Dass *et al.* 1977). Looney (1974) and Looney and Wood (1977) used 7 classes. To evaluate the loss of information due to the reduction in the number of classes, the scores for the average ranks (Table 2, column 4) were grouped into 5 classes. The rank correlation coefficient between the resulting values and the C_v scores was 0.94, indicating very little loss of information due to grouping.

b) By simple functions of characters

The following ratios were tried as estimators of compactness: V_s/TLR, WC/TLR, V_s·NL/TLR and WC·NL/TLR. The rank correlation coefficients between the resulting scores and the C_v scores were 0.91, 0.90, 0.84 and 0.80, respectively, all significant at the 1 % level. In the above ratios when TLR was replaced by WR (i.e. the weight of the rachis), the corresponding coefficients dropped to 0.42, 0.39, 0.15 and 0.12, respectively, indicating much poorer estimations. The suitability of two ratios used by some workers (Christodoulou *et al.* 1968, Kuykendall *et al.* 1970, Weaver and Pool 1971) namely, (i) weight of cluster/length of rachis, and (ii) number of berries/length of rachis were also checked. The corresponding rank correlation coefficients with C_v scores were 0.75 and 0.60, respectively. However, in the last ratio, when the length of the rachis was replaced by TLR, the coefficient increased to 0.81. The scores for V_s/TLR along with the corresponding ranks are presented in the 6th and 7th columns of Table 2.

Table 2

Compactness measured by volume (C_v) and three estimations of it: by average ranks, by V_s/TLR and through multible regression · At the bottom of the table the coefficient of rank correlation (r') between each of the estimations and C_v is given

Bestimmung der Beerendichte durch Volumenmessung (C_v) sowie ihre Schätzung mit Hilfe der durchschnittlichen Rangordnung, der Relation V_s/TLR und der multiplen Regression · Am Ende der Tabelle ist der Rangkorrelationskoeffizient (r') zwischen den einzelnen Schätzungen und C_v angegeben

Cluster no.	C_v Score	C_v Rank	Estimation of compactness by: Avg. ranks Score	Avg. ranks Rank	V_s/TLR Score	V_s/TLR Rank	Mult. regr. Score	Mult. regr. Rank
1	30.85	1	1.3	1	1.44	1	33.70	3
14	34.79	2	6.0	5	1.85	5	38.20	4
2	34.98	3	3.7	4	1.80	6	38.96	5
22	35.83	4	7.3	7	1.53	2	40.69	8
19	36.35	5	6.5	6	1.99	7	43.30	10
8	37.27	6	2.4	2	1.57	3	30.43	1
27	38.47	7	3.6	3	2.10	9	33.38	2
25	39.28	8	8.3	8	2.16	10	39.31	7
23	40.56	9	9.0	9	2.01	8	39.26	6
21	41.35	10	12.0	11	3.44	20	54.50	22
4	41.46	11	15.4	16	1.65	4	44.67	11.5
15	43.12	12	14.3	14	2.30	12.5	44.67	11.5
13	43.86	13	13.7	13	2.82	14	49.39	14
30	45.02	14	10.1	10	2.25	11	45.91	13
17	45.85	15	15.9	18	3.12	19	51.66	19
20	46.67	16	12.9	12	2.30	12.5	40.95	9
26	47.67	17	14.9	15	3.07	18	51.44	18
11	52.09	18	15.6	17	2.99	17	50.84	17
6	52.40	19	20.6	20.5	3.51	21	53.28	20
12	52.98	20	24.9	24	3.74	22	54.64	23
7	54.21	21	19.1	19	2.96	16	50.42	16
5	55.15	22	20.6	20.5	2.90	15	49.90	15
18	58.19	23	22.1	23	4.20	25	56.33	25
24	61.01	24	25.7	25	5.57	29	71.65	30
10	63.55	25	27.9	29	4.75	26	62.22	26
3	63.77	26	26.4	27	5.46	28	64.12	28
29	64.40	27	29.6	30	4.95	27	64.90	27
16	66.13	28	21.9	22	3.79	23	56.07	24
9	68.12	29	26.3	26	3.88	24	54.11	21
28	78.90	30	27.1	28	9.56	30	65.22	29
r'				0.95		0.91		0.88

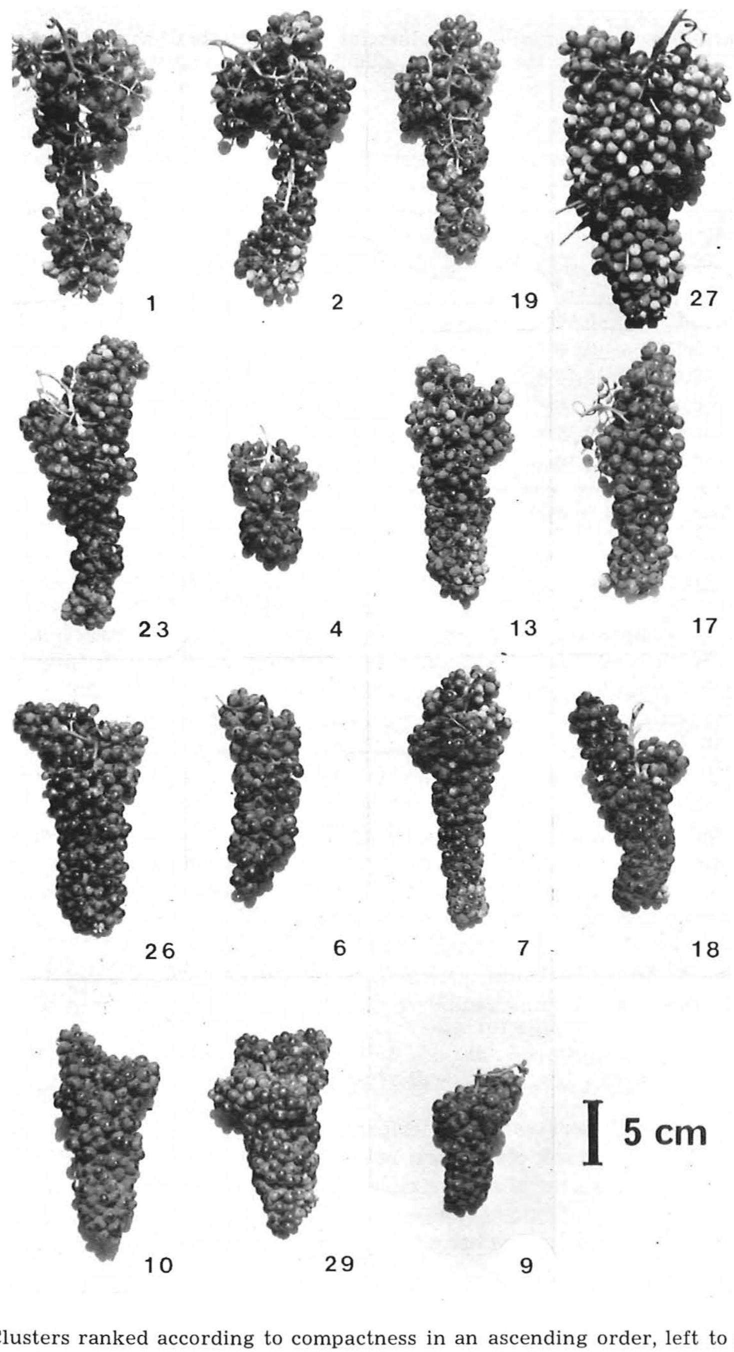

Fig. 5: Clusters ranked according to compactness in an ascending order, left to right, top to bottom.

Anordnung der Weintrauben nach zunehmender Beerendichte; Reihenfolge von links nach rechts und von oben nach unten.

Table 3

Partial regression coefficients of C_v values for different sets of characters: total length of rachis (TLR), volume of the solid (V_s), number of the primary laterals (NL), number of good berries (NG), average berry width (BWd) and average berry weight (BWt)

Partielle Regressionskoeffizienten der C_v-Werte für verschiedene Merkmalsgruppen: Gesamtlänge des Traubengerüstes (TLR), Festvolumen (V_s), Anzahl der Seitenäste 1. Ordnung (NL), Anzahl der wohlentwickelten Beeren (NG), mittlerer Beerendurchmesser (BWd) und mittleres Beerengewicht (BWt)

Set	Characters						Mult. correl. coeff
	TLR	V_s	NL	NG	BWd	BWt	
1	−0.42**	0.14**					0.86
2	−0.41**	0.14**	−0.01				0.86
3	−0.41**	0.14**				9.93	0.86
4	−0.41**	0.14**			2.07		0.87
5	−0.42**	0.15**		−0.01			0.86
6	−0.41**	0.10	−0.01	0.03	2.19	13.83	0.87

** = Significant at the 1 % level.

c) By multiple regression

Multiple regression of C_v scores on different combinations of some of the characters were tried. The largest multiple correlation coefficients (R) were obtained in cases when both TLR and V_s were included in the regression. Only such combinations are presented in Table 3. It can be noticed that the multiple regression with TLR and V_s as independent variables (set 1) resulted in an R = 0.86. Including BWd increased the R to only 0.87 (set 4), and further addition of the other two variables had no effect (set 6).

Here again, when TLR was replaced by WR, the R decreased appreciably. However, in sets 1 and 4, when V_s was replaced by WC (weight of the cluster), the coefficients did not decrease much. They were 0.83 and 0.84, respectively. The multiple regression equation for set 1 is:

$$C_v = 50.41 - 0.42\ TLR + 0.14\ V_s$$

The estimations (scores) of compactness for the 30 clusters using this equation along with the corresponding ranks are given in the last two columns of Table 2.

Discussion

In this work C_v was used as a criterion to judge the suitability of the other estimators through a rank correlation between the respective scores. The choice of a rank correlation rather than a simple correlation was based on the following reasons:

a) To avoid making a number of assumptions regarding the distribution of the C_v scores and those from the different estimators.

b) Only a rank correlation could be run between the estimations by ranking and the C_v scores. Thus, to be able to compare the resulting rank correlation coefficient (r') with other correlation coefficients the latters should also be in terms of r'.

c) More important is the nature of the error attached to the C_v scores. The main source of error is a human error related to the lack of uniformity in the extent to which the excess paraffin is removed from the clusters. This error could be of two kinds. It could be a random error independent of the degree of cluster compactness. On the other hand, it is likely that the error not only increases as compactness decreases, but is also biased. That is when the removal of the excess paraffin is done more thoroughly as compactness increases. It is with respect to the second kind of error that rank correlation is preferred to simple correlation. In other words, if such an error exists, it would not affect the order of the ranks, i.e. the value of r'.

The usual visual ranking resulted in the highest value of r' (bottom of Table 2). However, the accuracy of this technique is subject to sampling variation in the judging ability of the judges. If necessary, the judges can be chosen after checking their ability with clusters the C_V value of which could be measured.

The multiple regression correlation resulted in the lowest r' value. Moreover, the parameters in such an equation are not only affected by errors in C_V scores, they are also subject to sampling variation and should preferrably be determined separately for every experiment.

Thus it can be concluded that V_S/TLR or its substitute WC/TLR is a satisfactory estimator of compactness. Unfortunately WR did not prove to be a good substitute for TLR. This could be due to three reasons:

a) In this experiment the pedicels were not removed from the rachis. The weight of the rachis, without the pedicels, could be a good estimator of TLR and inversely related to compactness. Whereas the weight of the pedicels is an indication of the number of berries which has a direct relation to compactness.

b) It was noticed that the rachis tends to dry out over a number of days. The variation in WR due to drying could be another factor.

c) It was also noticed that GA_3, when applied only after berry set, results in an increase in the weight of the rachis with no effect or even an increase in compactness due to berry enlargement.

It is worth looking into the weight of the rachis as a substitute for TLR after the removal of the pedicels and prevention of its loss in weight.

Summary

Cluster compactness of Yaghouti grapes was defined and measured as the percentage of the total volume occupied by the solid volume. The total volume is the solid volume plus the space between the berries. This measure of compactness was used to judge the suitability of other means of estimating compactness. It is concluded that the ratio of the solid volume to the total length of the rachis plus that of its primary laterals is the most suitable estimator of compactness.

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