The relationship between leaf area and crop load and its effect on fruit quality of Red Globe grapevines

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Abstract: This investigation was conducted for two successive seasons (2013 & 2014) on mature Red Globe grapevines to disclose the relationship between leaf area and crop load and its effect on fruit quality of Red Globe grapevines. The chosen vines were ten-year-old, grown in a sandy loam soil, located at El-Khatatba, Menoufiya governorate; spaced at 2 X 3 meters apart and irrigated by the drip irrigation system, cane-pruned to 120 buds per vine (10 canes x 12 buds/cane) and trellised by Spanish Parron system. Four different degrees of cluster thinning treatments were applied after berry set as follows; control (without cluster thinning, adjusted to 30 clusters/vine), removing 10% of the total number of clusters/vine (27 clusters retained), removing 20% of the total number of clusters/vine (24 clusters retained) and removing 30% of the total number of clusters/vine (21 clusters retained). The results revealed that all cluster thinning treatments ensured the best vegetative growth expressed shoot length, number of leaves, total leaf area/vine and total leaf area/crop load ratio. The critical limit of cluster thinning was determined by removing 20% of the total number of clusters/vine so as 24 clusters are retained, which it can be recommended as the best effective treatment. The slight decrease in the yield obtained from this treatment could be compensated by improving vegetative growth and enhancing leaf content of total chlorophyll and cane content of total carbohydrates, which reflected afterwards in increasing cluster weight and improving berry physical attributes, as well as achieving a higher percentage of TSS, better colouration and a lower percentage of acidity in the juice. From the obtained results, it can be concluded that the optimum total leaf area per vine (m^2)/yield per vine (kg) index was obtained from cluster thinning by removing 20% of the total number of clusters/vine, which it revealed that one kg of yield requires 2.25m^2 of total surface leaf area per vine to obtain a remarkable enhancing in cluster and berry quality attributes of Red Globe grapevines.

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1. Introduction

Red Globe grape cultivar is considered one of the most promising new cultivars planted in Egypt, late ripening seeded variety with colored berries. The good production of yield of this cultivar faces some challenges; depression of vegetative growth, which in turn is reflected on increasing the possibility of berry exposure to sunburn damage and irregular colouration of the berry, there defects are undoubtedly reflected on reducing cluster quality.

The fruiting capacity of grapevines is largely determined by their total leaf area and by the percentage of the total leaf surface area that is exposed to full sunlight, a wide range of leaf area/crop weight ratios were investigated by different degrees of cluster thinning of grape cultivars (**Kliewer and Nick, 2005**).

Cluster thinning is a common practice carried out by table grape growers which when achieved, leads to the reduction of the yield to be within the limits of the normal load so that high quality (**Morinaga *et al*., 2000; Palliotti *et al*., 2000; Ezzahouani and Williams 2001; Naor and Bravdo 2002; Abd El-Baki 2003; Cheema *et al*., 2003; Ezzahouani and Williams 2003; Fawzi and Abd El-Moniem 2003; Cus *et al*., 2004; Nuzzo 2004 and Rubio *et al*., 2004**).

The time of cluster thinning had a major influence on berry size and cluster quality. However, the highest fruit quality was reached when cluster thinning was performed near fruit set (**Schalkwyk *et al*., 1995 and Rizk-Alla 2006**).

The goal of this investigation was to disclose the optimum leaf area/crop load ratio for requirement in improving growth, yield and fruit quality attributes of Red Globe grapevines.

2. Materials and Methods

This investigation was conducted for two successive seasons (2013 & 2014) on mature Red Globe grapevines to disclose the effect of cluster thinning as a method for crop adjusting on growth, yield and fruit quality attributes of Red Globe grapevines. The chosen vines were ten-year-old, grown in a sandy loam soil, located at El-Khatatba, Menoufiya governorate; spaced at 2 X 3 meters apart and irrigated by the drip irrigation system, cane-pruned to 120 buds per vine (10 canes x 12 buds/cane) and trellised by Spanish Parron system.

Four different degrees of cluster thinning treatments were applied after berry set as follows; control (without cluster thinning, adjusted to 30

clusters/vine), removing 10% of the total number of clusters/vine (27 clusters retained), removing 20% of the total number of clusters/vine (24 clusters retained) and removing 30% of the total number of clusters/vine (21 clusters retained).

Forty-eight uniform vines were chosen. Each four vines acted as a replicate and each three replicates were treated by one of the conducted treatments.

- The following parameters were adopted to evaluate the tested treatments:-

***1.* Yield and physical characteristics of clusters:**

Representative random samples of nine clusters/vine were harvested at maturity when TSS reached about 16-17% according to **Tourky *et al.*, (1995)**.

Yield/vine (kg) was determined as number of clusters/vine X average cluster weight (g). Average cluster weight (g) and average cluster dimensions (length and width) (cm) were determined.

***2.* Physical properties of berries:**

Average berry weight (g), average berry size (cm^3) and average berry dimensions (length and diameter) (cm) were determined.

***3.* Chemical properties of berries:**

Total soluble solids (T.S.S.) percentage in berry juice was determined by hand refractometer and total titratable acidity expressed as tartaric acid (%) was also determined according to **A.O.A.C. (1985)**. TSS/acid ratio and total anthocyanin content of the berry skin (mg/100g fresh weight) were calculated according to methods described by **Husia *et al.*, (1965)**.

***4.* Some characteristics of vegetative growth**

- **Morphological studies**

At growth cessation, the following morphological and chemical determinations were carried out on four fruitful shoots / the considered vine:

1- Average shoots length (cm).

2- Average number of leaves/shoot.

3- Total leaf area/vine (m^2)

Average leaf area (cm^2) was taken from the apical 5th and 6th leaves using a CI-203- Laser Area-meter made by CID, Inc., Vancouver, USA. Then total leaf area/vine (m^2) was determined by multiplying average number of leaves/shoot by average leaf area then by the number of shoots per vine.

4- Total leaf area per vine (m^2)/yield per vine (kg) index.

- **Leaf content of total chlorophyll and cane content of total carbohydrates**

***1-* Leaf content of total chlorophyll (SPAD)**

Samples of leaves were taken from the apical 5th and 6th leaves at growth cessation and were measured by using nondestructive Minolta chlorophyll meter SPAD 502 (**Wood *et al.*, 1992**).

***2-* Cane content of total carbohydrates (%)**

Samples of canes were taken at winter pruning (during the third week of January) and were measured according to **Smith *et al.*, (1956)**.

Statistical analysis:

The complete randomized blocks design was adopted for the experiment. The statistical analysis of the present data was carried out according to the methods described by **Snedecor and Cochran (1980)**. Averages were compared using the new LSD values at 5% level.

3. Results and Discussion

***1.* Yield and physical characteristics of clusters**

As shown in Tables (1), data revealed that effect of cluster thinning treatments on yield and physical characteristics of clusters including cluster weight and dimensions. As for yield, it is worth mentioning that the vine yield was significantly reduced by all thinning treatments in comparison with the control in both seasons of the investigation. Vines thinned by removing 10% of the total number of clusters/vine had the highest yield followed by vines thinned by removing 20% of the total number of clusters/vine, while the lowest one was obtained by removing 30% of the total number of clusters/vine compared with the other thinning treatments.

These results are in harmony with those obtained by **Sorokowsky (2000)**; **Naor and Bravdo (2002)**; **Ferree *et al.*, (2003)** and **Keller *et al.*, (2005)**, they found that cluster thinning reduced the vine yield as compared with control.

Regarding cluster weight, it is found that all thinning treatments had the highest values of cluster weight in comparison with the control in both seasons of the investigation. Highest significant cluster weight was obtained from vines thinned by removing 30% of the total number of clusters/vine followed by vines thinned by removing 20% of the total number of clusters/vine. No significant differences were notice between vines thinned by removing 30% and 20% of the total number of clusters/vine. On the other hand, unthinned vines and vines thinned by removing 10% of the total number of clusters/vine resulted in the lowest values of this one.

Concerning cluster dimensions, express length and width, taking a closer look at the data, it appears that all thinning treatments had no statistically significant effect on cluster dimensions in both seasons of the study.

These results are in agreement with those obtained by **Morinaga *et al.*, (2000)**; **Palliotti *et al.*, (2000)**; **Cheema *et al.*, (2003); Fawzi and Abd El-Moniem (2003); Ferree *et al.*, (2003)** and **Rizk-Alla (2006)** who stated that bigger cluster weight was obtained from cluster thinning.

Table (1): Effect of crop load on yield/vine and physical characteristics of clusters in 2013 and 2014 seasons								
	Yield/vine (kg)		Cluster weight (g)		Cluster length (cm)		Cluster width (cm)	
	2013	2014	2013	2014	2013	2014	2013	2014
Control	22.93	23.45	764.2	781.8	20.4	20.9	12.2	12.6
Removing 10% clusters	21.25	21.54	786.9	797.6	20.5	20.8	12.3	12.7
Removing 20% clusters	19.08	19.55	795.2	814.5	20.3	20.5	12.1	12.3
Removing 30% clusters	17.04	17.53	811.3	834.9	20.4	20.7	12.2	12.4
New L.S.D. at (0.05) =	1.67	1.89	24.1	20.7	N.S.	N.S.	N.S.	N.S.

***2.* Physical characteristics of berries**

Results presented in Table (2) revealed that all berry physical characteristics including berry weight, size and dimensions (length and diameter) were significantly increased by all thinning cluster treatments in comparison with the control in both seasons of the investigation. Vines thinned by removing 30% of the total number of clusters/vine had the highest values of these parameters followed by vines thinned by removing 20% of the total number of clusters/vine. No significant differences was found between vines thinned by removing 30% and 20% of the total number of clusters/vine, while unthinned vines and vines thinned by removing 10% of the total number of clusters/vine resulted in the lowest values of these ones.

These results could be explained by the beneficial effect of cluster thinning that coincides with the still active cell division in the pericarp of the berries resulting in the rapid normal berry growth, and with the maximum content of carbohydrates in the shoots. The possible interpretation for the aforementioned increase in berry dimensions lies in the fact that under thinning, leaf/cluster ratio is increased with the result of which carbohydrates manufactured in the leaves are ready to immigrate rapidly towards berries.

These results are in line with those obtained by **Sorokowsky (2000)**; **Naor and Bravdo (2002)**; **Ferree *et al.*, (2003)**; **Keller *et al.*, (2005) and Rizk-Alla (2006)**, who found that the maximum berry weight and dimensions were achieved by cluster thinning.

Table (2): Effect of crop load on physical characteristics of berries in 2013 and 2014 seasons								
	Berry weight (g)		Berry size (cm^3)		Berry length (cm)		Berry diameter (cm)	
	2013	2014	2013	2014	2013	2014	2013	2014
Control	8.48	8.59	8.21	8.31	2.79	2.81	2.69	2.72
Removing 10% clusters	8.57	8.68	8.29	8.39	2.83	2.85	2.71	2.75
Removing 20% clusters	8.69	8.79	8.43	8.52	2.86	2.89	2.75	2.81
Removing 30% clusters	8.81	8.93	8.54	8.67	2.90	2.94	2.78	2.85
New L.S.D. at (0.05) =	0.13	0.15	0.12	0.16	0.05	0.06	0.04	0.05

***3.* Chemical characteristics of berries:**

As shown in Table (3), all thinning treatments were significantly improved of chemical characteristics of berries including TSS, acidity, TSS/acid ratio and anthocyanin content of berry skin in comparison with the control in both seasons of the investigation. The highest fruit quality of these parameters including an increase of TSS, TSS/acid ratio and anthocyanin content of berry skin and a decrease of acidity was obtained from vines thinned by removing 30% or 20% of the total number of clusters/vine. However, no significant differences were detected between vines thinned by removing 30% and 20% of the total number of clusters/vine. On the other hand, unthinned vines and vines thinned by removing 10% of the total number of clusters/vine had the lowest values of TSS, TSS/acid ratio and anthocyanin content of berry skin and the highest values of total acidity in berry juice.

The obtained results are in accordance with those obtained by **Sorokowsky (2000); Naor and Bravdo (2002)**; **Ferree *et al.*, (2003)**; **Keller *et al.*, (2005) and Rizk-Alla (2006)** who found that cluster thinning increased TSS in berry juice and provided a better subjection to light, which is essential for anthocyanin synthesis.

***4.* Some characteristics of vegetative growth**

- **Morphological studies**

Data in Table (4) show that morphological characteristics of vegetative growth expressed as shoot length, number of leaves/shoot, total leaf area/vine and total leaf area/vine (m^2) / yield/vine (kg) index were significantly increased by all thinning cluster treatments in comparison with the control in both seasons of the investigation. Vines thinned by

removing 30% of the total number of clusters/vine resulted in the highest values of these parameters followed by vines thinned by removing 20% of the total number of clusters/vine. No significant differences was found between vines thinned by removing 30% and 20% of the total number of clusters/vine, while unthinned vines and vines thinned by removing 10% of the total number of clusters/vine resulted in the lowest values of these ones.

Total leaf area per kg of yield for all treatments ranged from 1.76 to 2.56 m^2/kg. Moreover, vines thinned by removing 30% had the greatest total leaf area per kg of yield (2.56 and 2.52 m^2/kg) followed by vines thinned by removing 20% (2.25 and 2.24 m^2/kg) in both seasons respectively. No significant differences was found between them, while vines thinned by removing 10% and control had the lowest one.

The results in this respect are in line with those of **Abd El-Baki (2003)** who found that number of leaves/shoot and leaf area tended to increase with decreasing the number of clusters/vine of Ruby seedless grapevines.

Table (3): Effect of crop load on chemical characteristics of berries in 2013 and 2014 seasons

	TSS (%)		Acidity (%)		TSS/acid ratio		Total anthocyanin (mg/100g F.W.)	
	2013	2014	2013	2014	2013	2014	2013	2014
Control	16.5	16.8	0.59	0.56	28.0	30.0	30.7	33.1
Removing 10% clusters	16.6	16.9	0.58	0.56	28.6	30.2	31.4	33.8
Removing 20% clusters	16.9	17.2	0.54	0.51	31.3	33.7	36.5	38.9
Removing 30% clusters	17.1	17.3	0.53	0.49	32.3	35.3	37.4	39.5
New L.S.D. at (0.05) =	0.3	0.2	0.02	0.03	1.4	1.7	1.1	0.9

Table (4): Effect of crop load on morphological characteristics of vegetative growth in 2013 and 2014 seasons

	Shoot length (cm)		Number of leaves/shoot		Total leaf area (m^2/vine)		Total leaf area / yield index (m^2/ kg)	
	2013	2014	2013	2014	2013	2014	2013	2014
Control	159.4	165.5	26.9	28.8	40.3	41.7	1.76	1.78
Removing 10% clusters	160.1	167.9	27.3	29.5	41.7	42.9	1.96	1.99
Removing 20% clusters	164.5	171.3	27.8	30.1	42.9	43.8	2.25	2.24
Removing 30% clusters	168.3	174.1	28.3	30.6	43.7	44.2	2.56	2.52
New L.S.D. at (0.05)=	3.9	3.2	0.7	0.9	1.6	1.2	0.33	0.29

- **Leaf content of total chlorophyll and cane content of total carbohydrates**

As shown in Table (5), all thinning treatments were significantly enhanced of leaf content of total chlorophyll and cane content of total carbohydrates in comparison with the control in both seasons of the investigation. Highest significant leaf content of total chlorophyll and cane content of total carbohydrates was obtained from vines thinned by removing 30% of the total number of clusters/vine followed by vines thinned by removing 20% of the total number of clusters/vine. No significant differences was notice between vines thinned by removing 30% and 20% of the total number of clusters/vine. On the other hand, unthinned vines and vines thinned by removing 10% of the total number of clusters/vine resulted in the lowest values of these ones.

These results might be attributed to the positive effect of thinning treatments on improving the nutritive status of the retained organs and the Mg element, which incorporate in the chlorophyll molecular as mentioned, by **Weaver and Nelson (1959)** and **Weaver (1976)** who mentioned that early cluster thinning soon after they emerged without removing leaves increased leaf chlorophyll content. Moreover, **Winkler (1962)** and **Weaver (1976)** stated that there was a strong relationship between the number of clusters retained after thinning treatments and the carbohydrates manufactured in the leaves. This means that the increase of ratio of leaves / cluster ratio has brought about better supply of food materials and subsequently increased the storage carbohydrates content of the ripened current season's shoots.

Data illustrated in Figures (1&2&3) indicated the existence of a highly positive correlation between total leaf area per vine (m^2) and cluster weight (g) (r = 0.9864 & r = 0.9636), between total leaf area per vine (m^2) and total soluble solids content of berry juice (%) (r = 0.9678 & r = 0.9877) and between total leaf area per vine (m^2) and anthocyanin content of berry skin (mg/100g F.W.) (r = 0.9811 & r = 0.9915) in both seasons respectively.

In conclusion, it can be said that the quality of Red Globe grapes could be easily improved by cluster thinning (removing 20% of the total number of clusters/vine so as 24 clusters are retained), which it

can be recommended as the best effective treatment. However, one kg of yield requires 2.25m^2 of total surface leaf area per vine to obtain a remarkable enhancing in cluster and berry quality attributes of Red Globe grapevines.

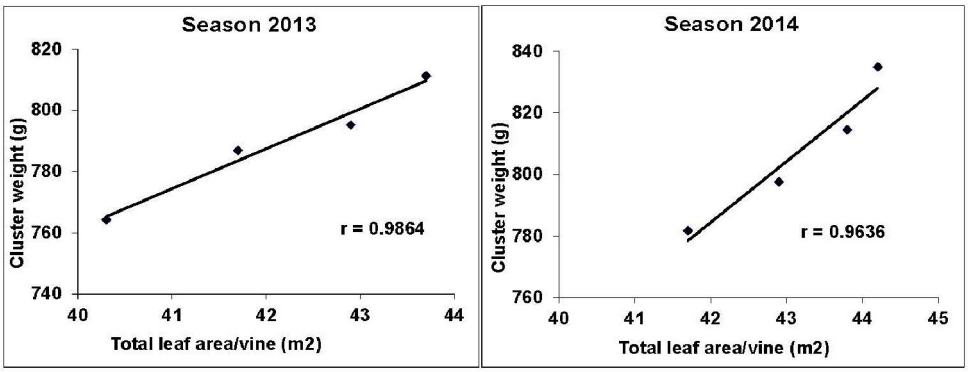

Fig (1): Relationship between total leaf area/vine (m^2) and Cluster weight (g) of Red Globe grape in 2013 and 2014 seasons

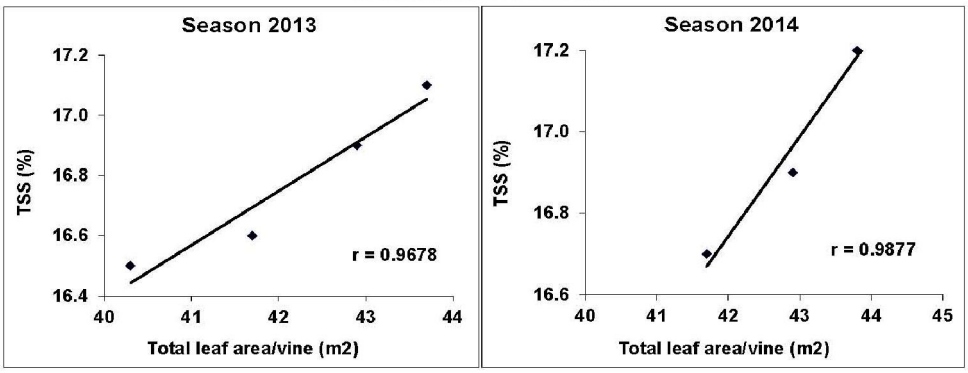

Fig (2): Relationship between total leaf area/vine (m^2) and TSS (%) of Red Globe grape in 2013 and 2014 seasons

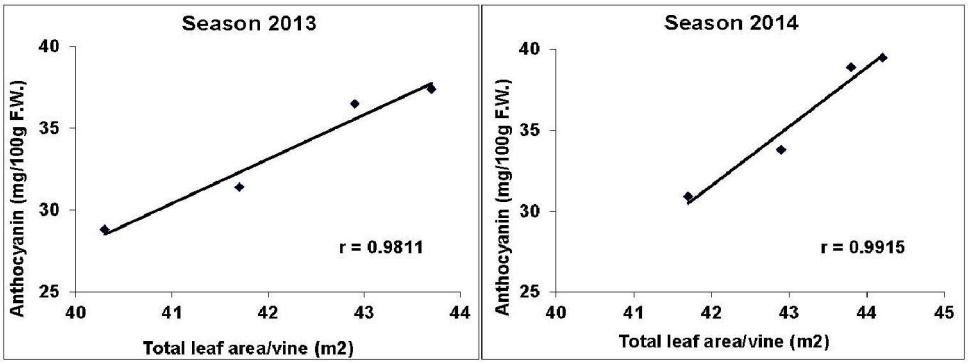

Fig (3): Relationship between total leaf area/vine (m^2) and berry skin anthocyanin (mg/100g F.W.) of Red Globe grape in 2013 and 2014 seasons

Table (5): Effect of crop load on leaf content of total chlorophyll and cane content of total carbohydrates in 2013 and 2014 seasons

	Total chlorophyll (SPAD)		Total carbohydrates (%)	
	2013	2014	2013	2014
Control	33.8	38.1	26.9	29.3
Removing 10% clusters	34.5	39.5	27.6	29.8
Removing 20% clusters	38.1	43.6	31.4	34.3
Removing 30% clusters	39.8	44.7	33.5	36.9
New L.S.D. at (0.05) =	1.9	1.5	2.3	2.7

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