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Influence of Cultural Practices on the Berry Size and Composition of Redglobe Table Grapes

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Introduction

Redglobe will likely become the most important seeded table grape cultivar grown in California sometime during the next decade. At present there are approximately 6,600 acres of Redglobe grapevines planted in the state, and new vineyards of the cultivar continue to be established. This is in contrast to the situation of other seeded table grape cultivars, such as Emperor (7900 acres) and Ribier (2600 acres), whose total acreages have been stagnant during the past decade and will probably decline in the future. The primary reason for the continued expansion of Redglobe acreage is the heavy demand for this cultivar in the far east. Redglobe produces the largest fruit among the table grape cultivars currently grown in California. Asian consumers covet large berries, probably because they peel the fruit before it is eaten, and the presence of seeds in the berries is not considered to be a problem.

The production of high quality Redglobe table grapes offers growers several challenges. Redglobe grapevines are usually of moderate vigor when planted on their own roots, and overcropping can be a problem. Overcropping can reduce fruit quality in the current season, and can also result in poor budbread, delayed growth, and reduced fruit yields the following season. Our observations indicate that a pattern of alternate bearing, in which vines oscillate from heavy to light yields in alternate years, can occur in some vineyards if crop load is not carefully managed. Fruit of this cultivar is also highly susceptible to sunburn damage, and the moderate vigor of the cultivar likely contributes to this problem.

During the past few years we have examined the effects of various cultural practices on the berry size, fruit composition, and vegetative growth of Redglobe table grapes. The primary objective of this work has been to improve our understanding of the impact of cultural practices on berry size and quality, and also to examine the impact of crop load and other management practices on long-term vine performance.

How does crop load influence fruit quality and subsequent vine growth?

Growers have reported that Redglobe vines which carry a large crop in one season often exhibit delayed budbread and reduced fruitfulness the following spring. In extreme cases, if crop load is not properly managed, the vines may enter into a pattern of alternate bearing in which fruit yields vary significantly between seasons. After observing these symptoms in 1990 and 1991, we decided to test the hypothesis that delayed growth and reduced vine fruitfulness were related to crop load in the previous season. An experiment was initiated in 1992 in a mature Redglobe vineyard located near Delano, CA. Vines were selected on the basis of uniform vigor and fruit development. Crop load was adjusted to either 10, 20, 30 or 40 clusters per vine immediately after fruit set. Care was taken to assure uniform crop distribution (i.e. cluster number per cordon was equal), and each treatment was replicated 8 times using single vine plots in a randomized complete block design. Cultural operations were performed in accordance with standard commercial practices for Redglobe table grapes. The treatments were repeated on the same vines for two consecutive seasons (1992-1993).

The influence of crop load on the total, packable and cull yield of Redglobe grapevines is presented in Figure 1. Total yield per vine increased linearly, from approximately 30 to over 100 pounds per vine, as crop load increased from 10 to 40 clusters per vine (Figure 1, upper graph). Packable yield increased from approximately 25 pounds to 80 pounds per vine, while cull yield increased from 5 pounds to 30 pounds per vine, respectively, as crop load increased from 10 to 40 clusters per vine (Figure 1, middle graph). Approximately 80% of the fruit produced on vines thinned to 10 clusters was packable compared to 69% of the fruit produced on vines thinned to 40 clusters (Figure 1, lower graph). The percentage of total yield culled due to rot declined slightly as cluster number per vine increased. No significant difference in mean cluster weight was found among the treatments (data not shown).

Berry fresh weight (as well as berry diameter) was greatest when crop load ranged between 20 and 30 clusters per vine, or when total yield per vine was between 60 and 80 pounds (Figure 2, upper and middle graphs, respectively). When crop load was expressed on a leaf area basis, berry fresh weight was greatest when the leaf area:fruit weight ratio was approximately 12 cm^2 per gram fruit fresh weight. Fruit soluble solids content declined linearly as cluster number and total yield per vine increased (data not presented).

In the spring of 1993 we recorded the number of clusters and shoots on the vines in each treatment. The influence of cluster number per vine in 1992 on vine fruitfulness in 1993 is presented in Figure 3. A negative relationship was found between cluster number per vine in 1992 and vine fruitfulness in 1993, while shoot number per vine was similar among the treatments (data not presented). Although we observed a negative correlation between cluster number per vine in 1992 and vine fruitfulness in 1993, we failed to duplicate the symptoms of delayed growth we believe to be typical of overcropped Redglobe grapevines. We are currently analyzing plant tissue samples collected from each treatment at the beginning of dormancy for carbohydrate content. We also plan to evaluate budbreak, vine fruitfulness, and tissue carbohydrate levels again next spring to determine the cumulative effects of these treatments after two consecutive seasons on the same vines.

How does harvest date influence vine performance?

The results of the above study led us to a new hypothesis regarding the relationship between crop load and the delayed growth of Redglobe grapevines. It was suggested that large crops are less detrimental to subsequent vine growth if harvest is completed early enough to allow sufficient carbohydrates to be produced and stored prior to the onset of dormancy. In the spring of 1993 we established an experiment to examine the interaction between crop load (15 or 30 clusters per vine) and harvest date (early-September, late-September, and mid-October). The study was conducted in an own-rooted Redglobe vineyard located near Delano, CA. Crop loads were established immediately after berry set, and care was taken to assure uniform crop distribution per vine. Each treatment was replicated 8 times using single vine plots in a randomized complete block design. Cultural operations were performed in accordance with standard commercial practices for Redglobe table grapes.

The effects of crop load and harvest date on the packable and cull yield of Redglobe table grapes are presented in Figure 4. The figure reveals that the packable yield of vines with high (30 clusters) crop loads increased over time due to a reduction in the amount of fruit culled due to inadequate color. Figure 5 reveals that berry weight and berry diameter changed little for either crop load treatment during the season, while the fruit soluble solids content of both treatments increased significantly over time.

We plan to evaluate the effects of these treatments on budbreak, vine fruitfulness, and tissue carbohydrate levels in the spring of 1994. If our hypothesis is correct, heavy crops should have a greater effect on subsequent vine growth when harvest occurs in the late fall compared to when harvest occurs in the early fall.

Does crop distribution influence berry growth?

In 1992 we established an experiment to determine if crop distribution among the cordons had a significant effect on vine yield, fruit quality, and subsequent vine growth. We were particularly interested to see if the symptoms we associated with overcropping could be isolated on a localized area of the vine. The trial was conducted in an own-rooted Redglobe vineyard located near Delano, CA. Twenty-four vines were selected following berry set on the basis of uniform vigor and fruit development. Each vine was adjusted to 24 total clusters and assigned to one of the following crop distribution treatments: 12 clusters per cordon (uniform cluster distribution); 18 clusters on one cordon, 6 clusters on the other cordon; 24 clusters on one cordon, 0 clusters on the other cordon. The treatments were applied at berry set, and each treatment was replicated 8 times using single vine plots in a randomized complete block design. Cultural operations were performed in accordance with standard commercial practices for Redglobe table grapes. Table 1 reveals that cluster distribution had little effect on total yield per vine. Total yield per vine was slightly greater when cluster number per cordon was uniform (12/12) compared to the 18/6 and 24/0 treatments. The difference in total yield among the treatments was not significant, and likely reflects that smaller clusters were retained to achieve the desired cluster number as crop load per cordon was increased. Cluster distribution per cordon had no effect on berry fresh weight or berry diameter (Table 2). However, the soluble solids content of fruits grown on a cordon with 6 clusters was greater compared to fruits grown on cordons with 12, 18 or 24 clusters.

The effects of these treatments on budbreak and vine fruitfulness were evaluated in the spring of 1993. Significant differences in shoot or cluster numbers per vine were not found among the treatments (data not presented). We concluded that crop distribution had little effect on the fruit yield, fruit quality, or subsequent growth of Redglobe table grapes.

Do fruit set and cluster size influence berry growth?

In most seedless table grape cultivars berry set, or the number of berries set per unit shoulder length, has a strong effect on berry growth. Experiments performed on Perlette, for example, have shown that berry size increases significantly as the number of berries retained per centimeter shoulder length is reduced. This is likely the result of reduced competition for carbohydrates, hormones, and other nutrients among the berries retained within a cluster. Last season we conducted an experiment at the Kearney Agricultural Center to examine the effects on fruit set on the berry growth of Redglobe. We adjusted shoulders to either ½, 1, 2, or 3 berries per centimeter shoulder length immediately following fruit set. Fifty berries were retained on each cluster. Each treatment was replicated 12 times using single cluster replicates. The results of the study are presented in Figure 6. Maximum berry size (weight and diameter) was obtained when shoulders were adjusted to 1 berry per centimeter shoulder length. Berry size was reduced when set was reduced to ½ berry per centimeter shoulder length, or when set was increased to 2 or 3 berries per centimeter shoulder length. Figure 6 indicates that while berry growth is influenced by berry density within the cluster, the impact of this parameter on berry size is relatively minor.

Cluster tipping is a common practice used by table grape growers to adjust berry number per cluster and crop load. In 1993 we conducted a trial to determine if the number of berries retained per cluster had a significant impact on berry size. Clusters were adjusted to either 25, 50, 75 or 100 berries immediately following fruit set. Each treatment was replicated 12 times using single cluster replicates. We found little correlation between the number of berries retained per cluster and berry weight at harvest (Figure 7, upper graph), while fruit soluble solids content at harvest declined slightly as the number of berries per cluster increased (Figure 7, lower graph). These results suggest the number of berries retained per cluster has little impact on berry growth.

Can girdling be used to increase berry size?

We have limited experience with the application of girdles for increasing the berry size of Redglobe. Growers are generally hesitant to girdle own-rooted Redglobe grapevines due to their often moderate vigor. In addition, previous work has indicated that berry set girdles are only marginally effective for increasing the size of seeded table grape cultivars. Another factor which should be considered is that fruit on vines girdled at berry set is believed to be more sensitive to sunburn than fruit on ungirdled vines. The latter is especially critical for Redglobe due to the cultivar's high susceptibility to fruit sunburn damage.

In 1992 we conducted an experiment to determine the influence of trunk girdle timing on Redglobe table grapes. The trial was conducted in an own-rooted Redglobe vineyard located near Exeter, CA. Vines girdled at berry set (sizing girdle) and at fruit softening (maturity girdle) were compared to ungirdled vines. Each treatment was replicated 10 times using single vine plots in a randomized complete block design. Cultural operations were performed in accordance with standard commercial practices for Redglobe table grapes. The berry weight of vines girdled at berry set was approximately 8% greater than the berry weight of vines girdled at fruit softening and ungirdled vines (Table 3). These results are consistent with those of previous studies which indicated that the weight of seeded table grape cultivars may be increased by approximately 10% by girdles applied at fruit set. Due to the increased vigor of Redglobe vines planted on rootstocks, fruit set girdles may become more popular in the future.

Can gibberellic acid (GA) be used to increase berry size?

Whole-vine applications. A Special Local Need (SLN) Permit allows gibberellic acid (GA) to be applied to Redglobe table grapes in the southern-half of the San Joaquin Valley. Up to 20 grams of GA may be applied per acre following fruit set for increasing berry size. In 1992 we evaluated the effects of whole-vine GA applications (20 grams/acre) on Redglobe table grapes. The trial was conducted in a Redglobe vineyard located near Exeter, CA. Each treatment (GA treated and control) was replicated 8 times using single vine plots in a randomized complete block design. We found that GA increased berry size by approximately 5% over the untreated control (Table 4). This data suggests that whole-vine applications of 20 grams/acre are of limited value for increasing berry size. When more than 20 grams of GA are applied per acre, vines may exhibit delayed vine growth and reduced fruitfulness the following season. For these reasons we do not recommend whole-vine GA applications for Redglobe table grapes.

Cluster-dip applications. Cluster-dip applications of GA can be more effective than whole-vine applications because higher rates of GA may be applied to the fruit without the potential detrimental effects on vine growth and yield the following season. The impact of GA cluster-dip applications on the berry weight of Redglobe berries is presented in Table 5. The data reveals that berry weight can be increased by almost 20% with a 80 ppm cluster-dip application. When the data in Table 5 is placed in a graph (Figure 8, upper graph) it becomes clear that the response of Redglobe berries to GA saturates at about 40 ppm. The middle graph in Figure 8 shows the relationship between seed number per berry and GA concentration on the response of Redglobe berries to GA. The figure shows that the response to GA declines as the number of seeds per berry increases. Our previous studies have shown that about 80% of the berries within a Redglobe cluster contain either 3 or 4 seeds. The interaction between seed number per berry and GA concentration on the berry size of Redglobe is summarized in the bottom graph of Figure 8. The figure indicates that the size of berries with 1 to 4 seeds can be increased by approximately 10, 15, and 20%, respectively, when treated with GA concentrations of 20, 40, and 80 ppm. It should be noted that the latter GA concentrations often retard berry coloration.

GA application timing. In 1991 and 1992 we conducted a trial at the Kearney Agricultural Center to examine the influence of application timing on the efficacy of GA cluster-dip applications on Redglobe table grapes. The trials were conducted by dipping individual clusters in GA (40 ppm) at various intervals following berry set. Figure 9 reveals that the maximum increases in berry weight and berry diameter were obtained when clusters were treated approximately 2 weeks following berry set, or when average berry diameter was approximately 16 mm.

Can GA be used to induce seedlessness?

A seedless berry with the size of a natural Redglobe berry would have strong appeal to both domestic and foreign consumers. There are several reports in the literature which suggest that high concentrations of GA (150 ppm) can be used to induce seedlessness in seeded table grape cultivars. During the past few years we have conducted trials at the Kearney Agricultural Center to determine if GA can be used to induce seedlessness in Redglobe. The results of this work are summarized in Table 6. While prebloom cluster-dip applications of GA resulted in nearly seedless berries, these berries were significantly smaller than natural Redglobe berries. Subsequent experiments indicated that repeated GA applications could not restore the size of these berries to the size of natural Redglobe berries. As indicated in Table 6, prebloom GA applications also resulted in excessive berry set and shot berry formation. Berry shatter at harvest was also a significant problem. Research on this topic will continue, but at present it does not seem likely that GA induced seedlessness will become a viable commercial practice for Redglobe.

Conclusions

1. Crop load (cluster number per vine, berry number per cluster, or the number of berries per centimeter shoulder length) appears to have little effect on berry growth, but plays a prominent role in fruit color and soluble solids content. At present we have not been able to establish a correlation between crop load and delayed growth in the spring. Studies to examine the interaction between crop load and harvest date on subsequent vine performance are currently in progress.

2. Trunk girdles applied at berry set increased the berry weight of Redglobe by approximately 10% compared to ungirdled vines. However, berry set girdles may be risky on vines of moderate vigor, and may also increase fruit susceptibility to sunburn.

3. Whole-vine GA applications (20 grams per acre) have little effect on berry size and are not recommended. GA cluster-dip applications are effective for increasing berry size, and the sizing response of Redglobe berries to GA appears to saturate at a concentration of approximately 40 ppm. The optimum timing for GA applications is about two weeks following berry set, or when berry diameter reaches 15-16 mm. GA applications generally retard berry color development.

Acknowledgements

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Table 1. Influence of Crop Distribution on the Yield of Redglobe Table Grapes.

Crop distribution per cordon		Fruit yield per cordon (lbs.)	Total fruit yield per vine (lbs.)
(%)	Clusters		
50/50	12 12	38 38	76
75/25	18 6	46 16	62
100/0	24 0	67	67

Table 2. Influence of Crop Distribution on the Fruit Growth and Composition of Redglobe Table Grapes.

Crop distribution per cordon		Berry weight (g)	Soluble solids (°Brix)
(%)	Clusters		
50/50	12 12	14.2 13.9	17.9 18.0
75/25	75 25	13.5 18	17.9 18.7
100/0	100 0	13.9	18.1

Table 3. Influence of Trunk Girdle Timing on the Berry Weight of Redglobe Table Grapes- 1992.

Treatment	Berry weight (g)
Berry set gridle	12.8b</TD.< tr>
Color-break girdle	11.8a[1]</TD.< tr>
Ungirdled control	12.1a </TD.< tr>

[1]Numbers followed by the same letter are not significantly different at the 5% confidence level (DMRT)

Table 4. Influence of GA_3 Whole-Vine Applications on the Berry Weight of Redglobe Table Grapes- 1992. GA_3 applications were performed two weeks following fruit set.

Treatment	Berry weight (g)
20 grams/acre GA_3	11.6</TD.< tr> 11.0
Untreated control	</TD.< tr>
p>F	*</TD.< tr>

*Treatment means significantly different at the 5% confidence level.

Table 5. Influence of GA_3 Cluster Dip Applications on the Berry Weight of Redglobe Table Grapes- 1992. GA_3 applications were performed at 12-14 mm berry diameter.

GA_3	Berry weight (g)	Increase in berry weight over untreated control (%)
0	11.9	---
20	12.9	8
40	13.9	17
80	14.2	19

Table 6. Influence of GA_3 on Redglobe Table Grapes. GA_3(150 mg/l) was applied as a cluster dip at the stages of fruit development designated below.

Stage of fruit development	No. of seeds per berry	No. of normal berries per cluster	No. of shot berries per cluster	Berry weight (g)	Berry diameter (mm)
Prebloom	0.3a[1]	493c	379a	7.0c	20.4c
Berry set	2.2b	171b	35b	11.5b	25.6b
Berry set + 2 weeks	3.0c	130a	23b	13.4a	27.4a
Untreated	3.0c	148a	38b	11.0b	25.3b

[1]Numbers followed by the same letter within columns are not significantly different at the 5% level (DMRT).

Figure 1. Influence of crop load on total, packable, and cull yield (upper graph), cull yield categories (middle graph), and cull yield components expressed as a percentage of total yield (lower graph) of Redglobe table grapes.

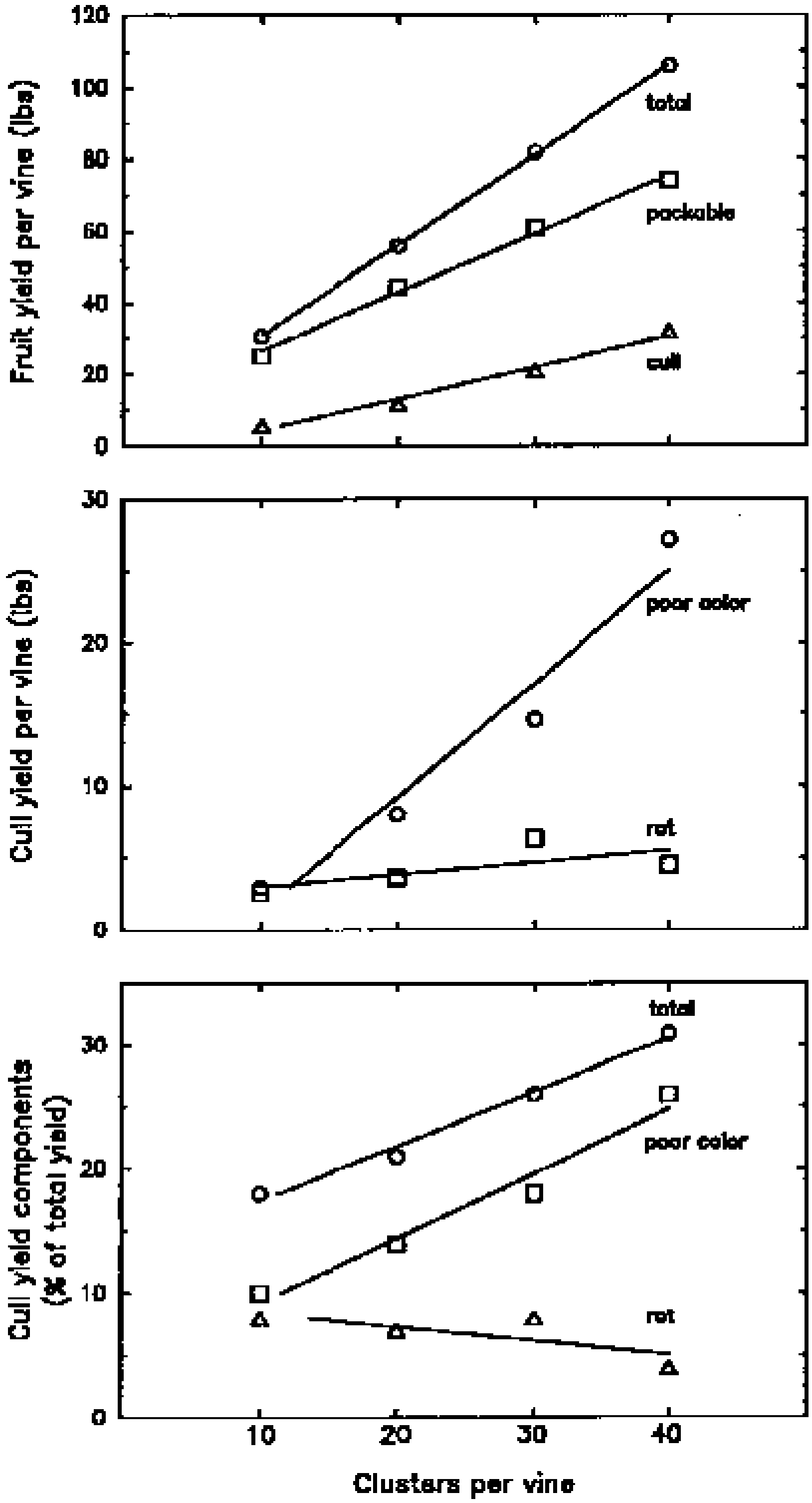


Figure 2. Influence of cluster number per vine (upper graph), total crop yield (middle graph), and leaf area:fruit weight ratio (lower graph) on the berry weight of Redglobe table grapes.

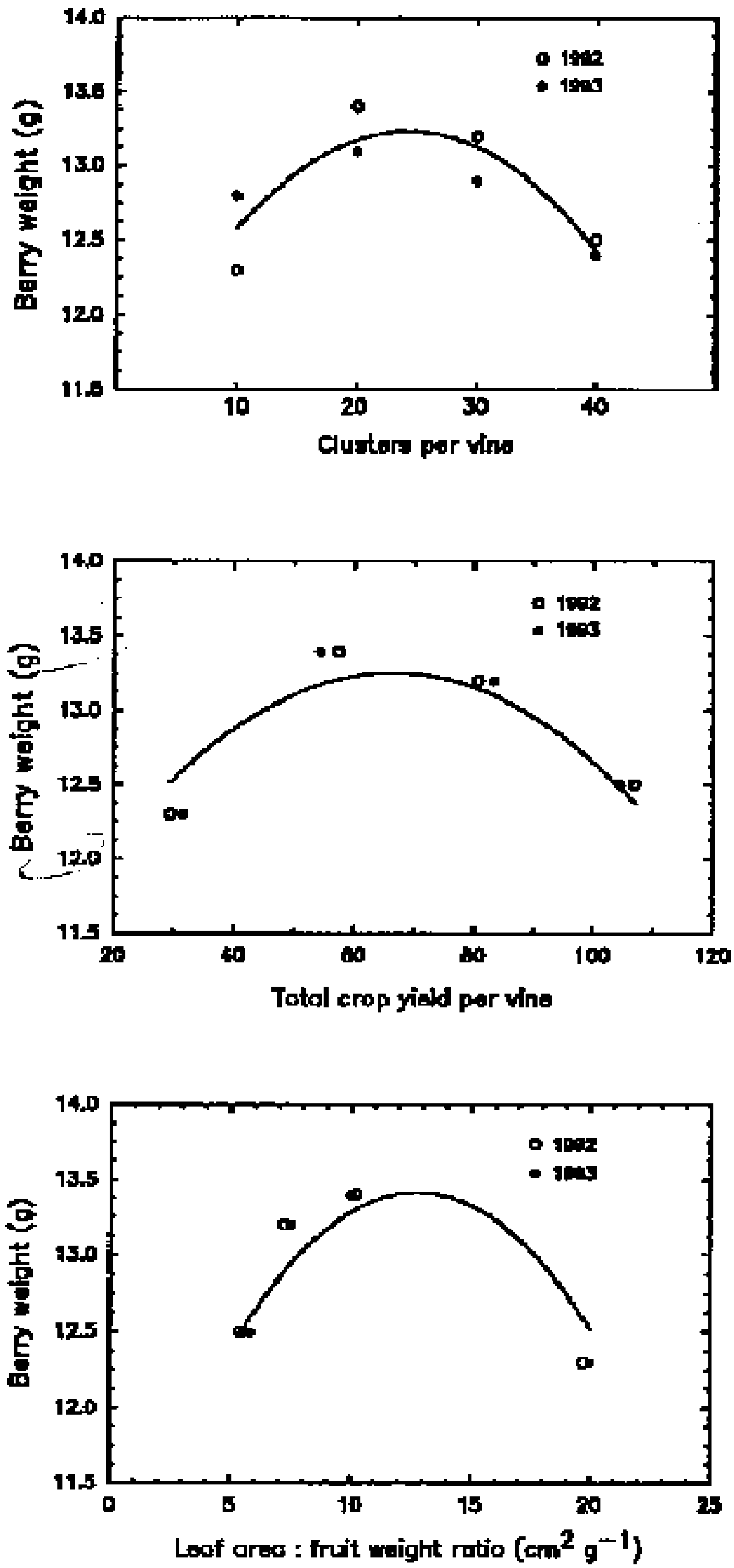


Figure 3. Influence of cluster number retained per vine in 1992 on the fruitfulness of Redglobe grapevines in 1993.

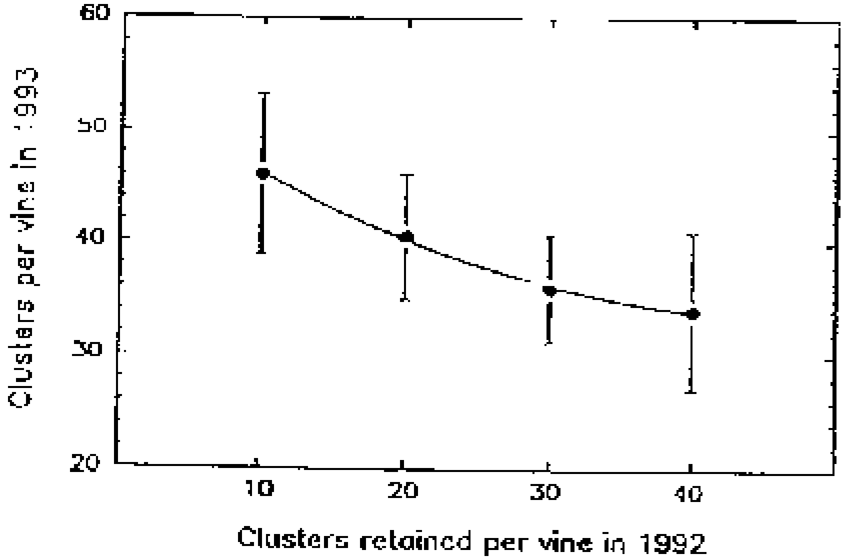


Figure 4. Interaction of crop load x harvest date on the packable yield (upper graph) and cull yield (lower graph) of Redglobe table grapes.

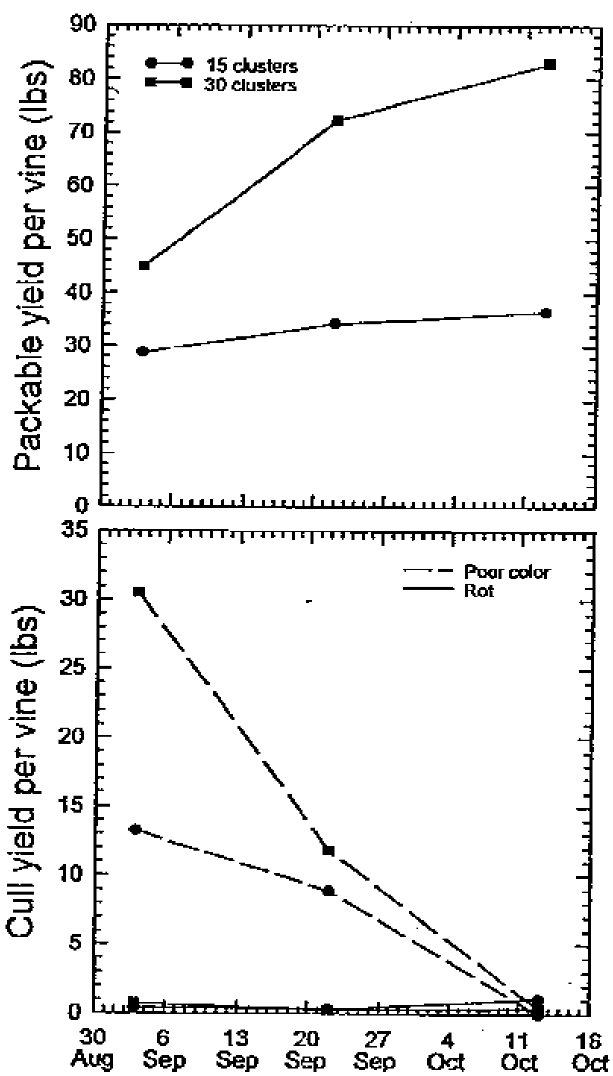


Figure 5. Interaction of crop load x harvest date on the berry weight (upper graph), berry diameter (middle graph), and soluble solids content (lower graph) of Redglobe table grapes.

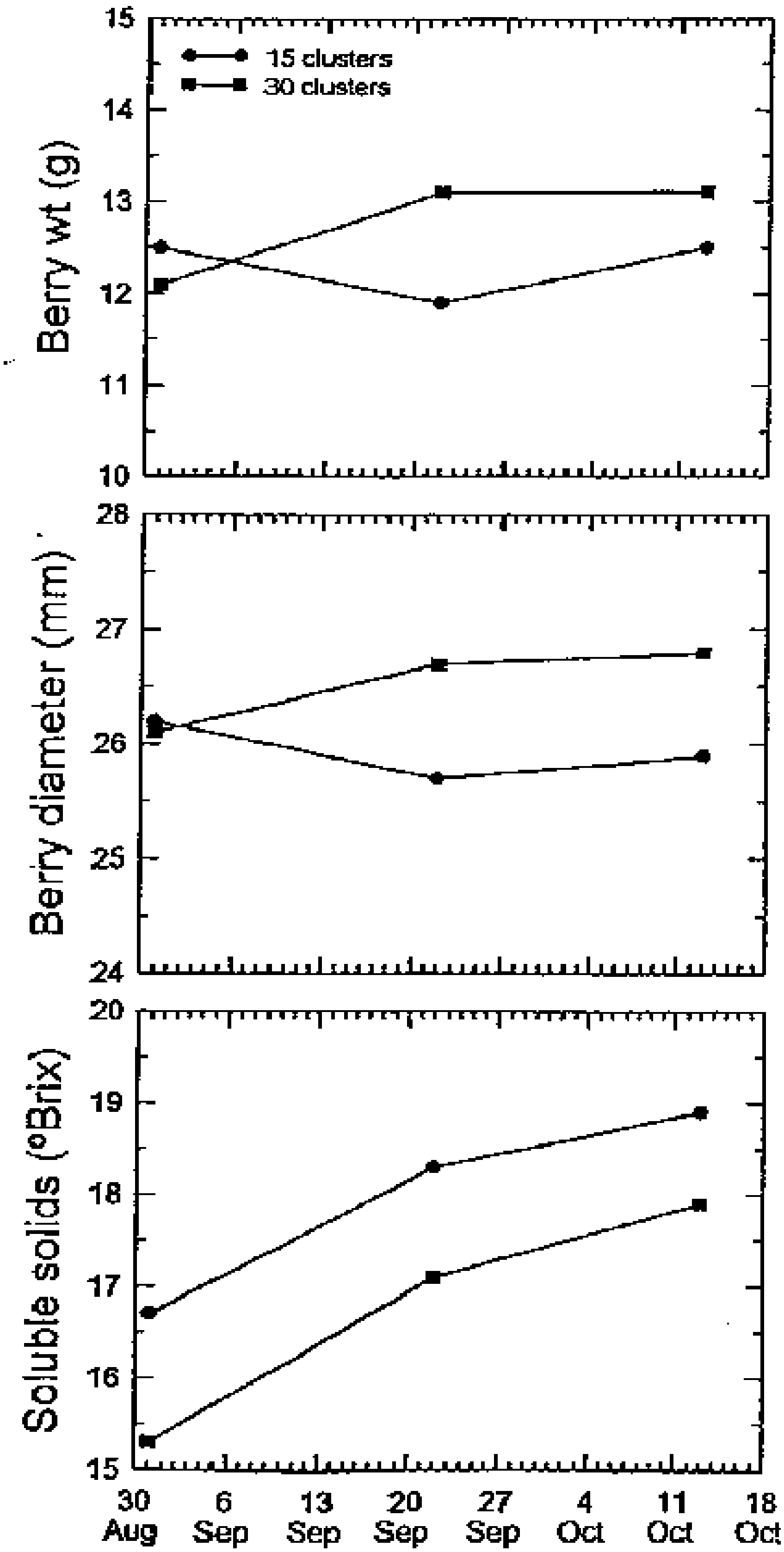


Figure 6. Influence of berry number per centimeter shoulder length on the berry weight (upper graph), berry diameter (middle graph), and soluble solids content (lower graph) of Redglobe table grapes.

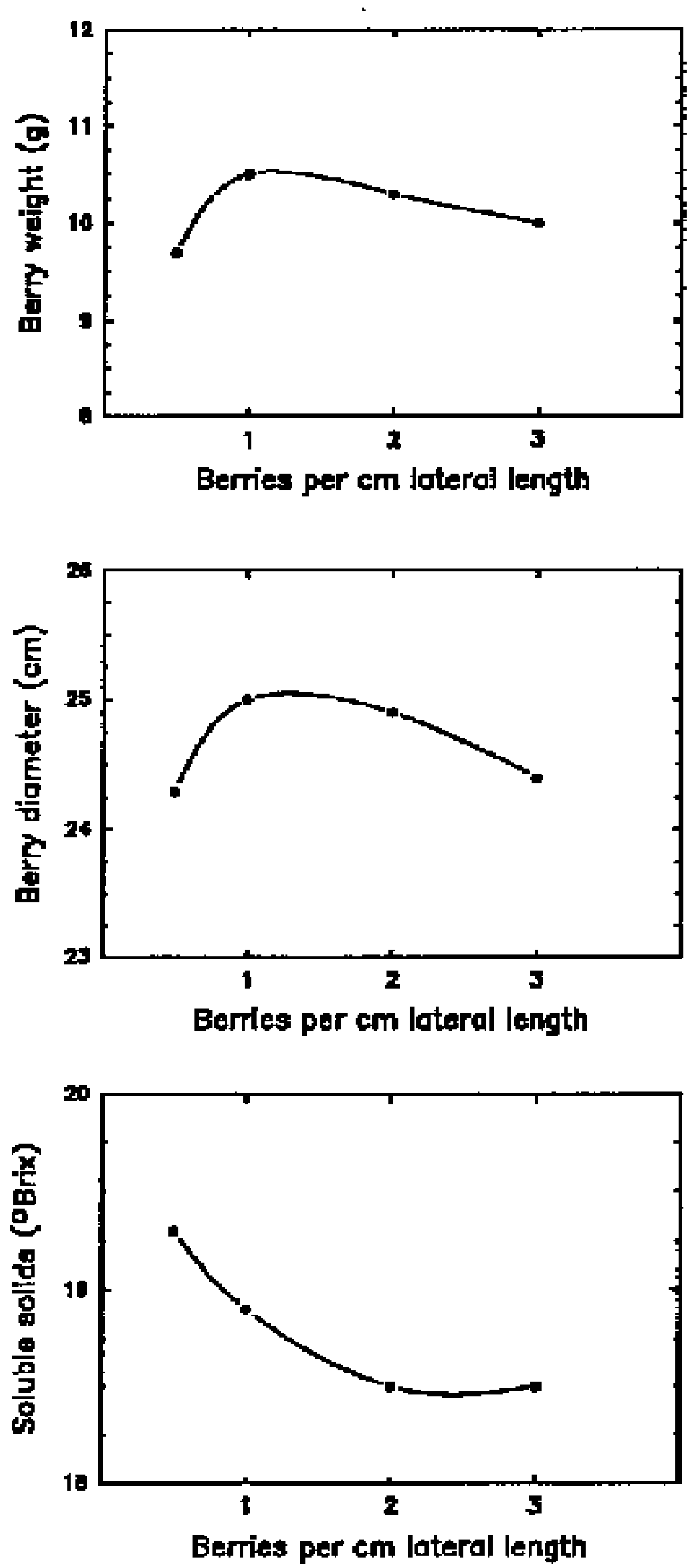


Figure 7. Influence of the number of berries retained per cluster on the berry weight (upper graph) and soluble solids content (lower graph) of Redglobe table grapes.

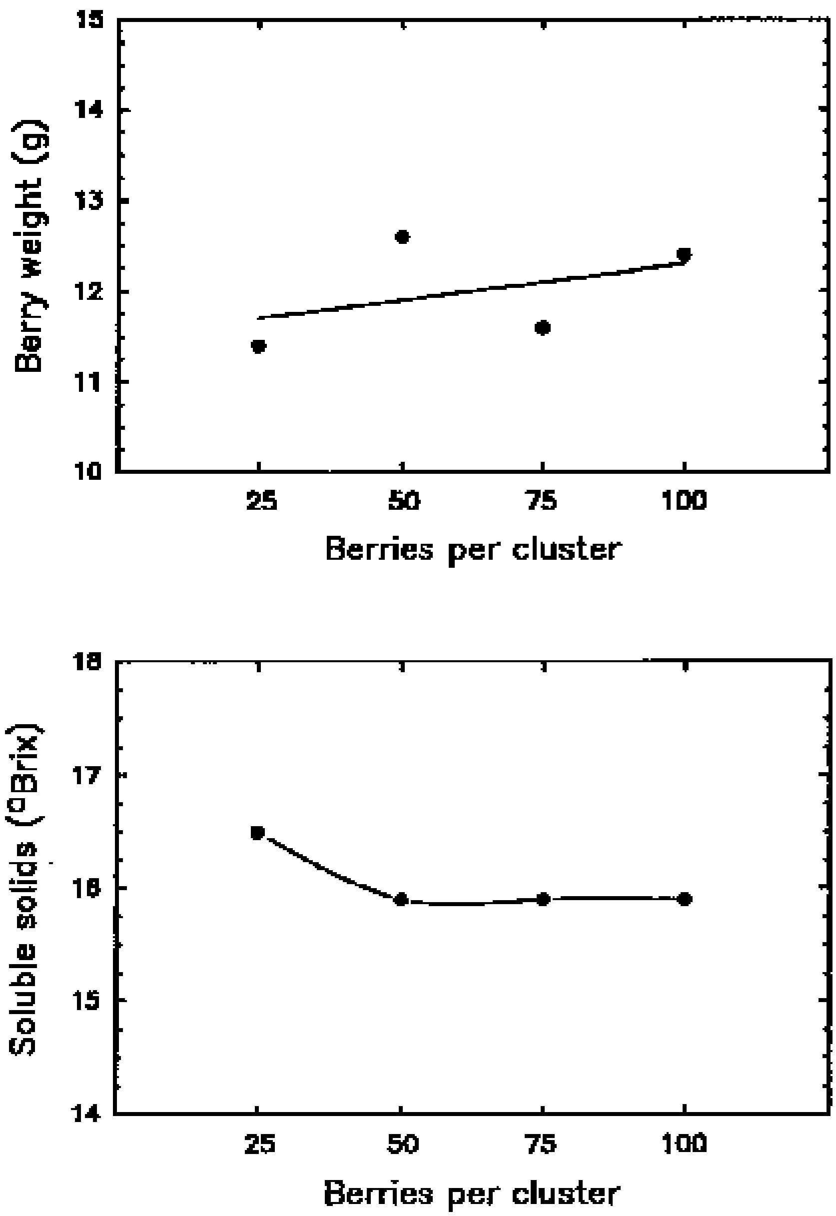
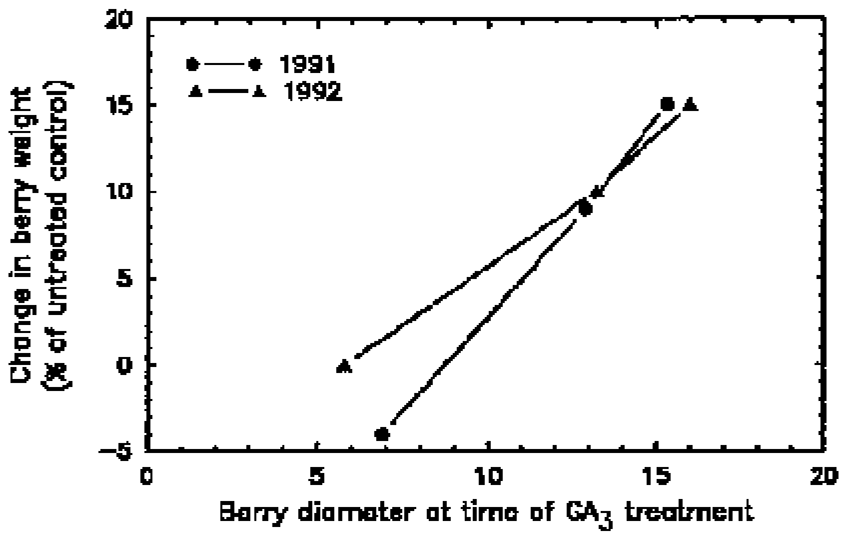


Figure 8. Influence of gibberellic acid (GA_3) on the berry fresh weight (upper graph), the relationship between berry fresh weight x seed number (middle graph), and the increase in berry fresh weight as a percentage of the untreated control (lower graph) of Redglobe table grapes.



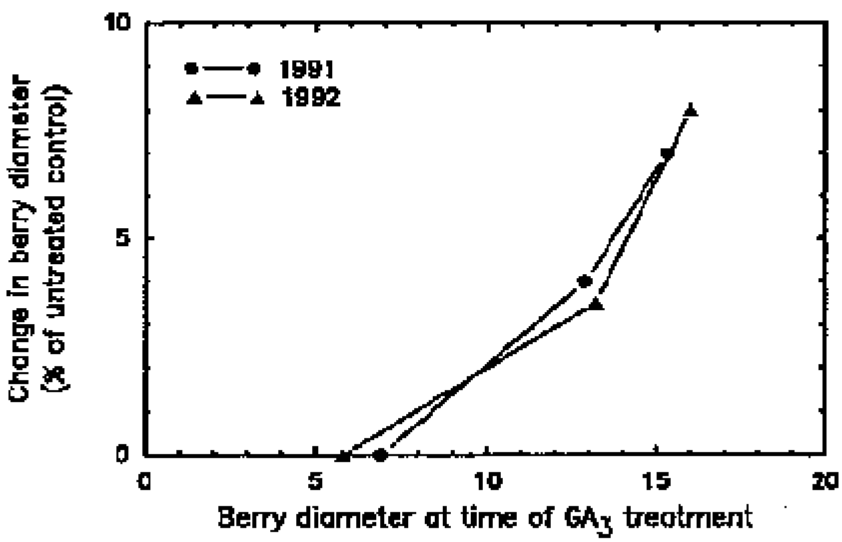


Figure 9. Influence of gibberellic acid (GA_3) application timing on the berry fresh weight (upper graph) and berry diameter (lower graph) of Redglobe table grapes.