range of crop species. Additive genetic variance has been found to be relatively more important than non-additive genetic variance for most characters in a a range of crops including cross-pollinated species, self-pollinated species, and polyploid species.

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Cluster-thinning 'de Chaunac' French Hybrid Grapes Improves Vine Vigor and Fruit Quality in Ontario[1]

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Abstract. **Cluster-thinning of the French hybrid grape cultivar 'de Chaunac' (*Vitis* sp.) resulted in superior fruit quality and an increase in vigor of the vines in comparison to the unthinned vines in a similar pruning and management regime. The higher sugar levels associated with thinning are consistently desirable for wine making under Ontario conditions. The favorable test site used limited the expression of vine decline and winter injury usually associated with over-cropping of this cultivar in the Niagara Peninsula of Ontario.**

Introduction of French direct-producer hybrid grapes to Ontario in the 1950's was part of a program to broaden the base of the wine industry in the province. Bradt (3,4) reported that among the most promising of these was 'de Chaunac' (Seibel 9549), a blue grape of complex genetic background, including *Vitis vinifera* L., *V. labrusca* L., *V. riparia* L. and others (1).

Differences in the response to management practices may be inferred from reports on *V. vinifera* L. and *V. labrusca* L. (8, 9, 10, 11) which might influence the choice of practices to apply to those direct-producer hybrids prone to winter injury (1). The cultivar 'de Chaunac' has a tendency to overbear, weakening the vine and risking winter injury and reduced productivity. Studies on the effect of pruning and cluster-thinning on 'de Chaunac' were begun at the Horticultural Research Institute of Ontario Grape Substation at Beamsville, Ontario. Both techniques have been widely used in grape production in North America (10, 11, 12, 13, 14) and the growth habit of this cultivar suggested a potential response to both.

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Materials and Methods

Variety trials of French hybrid grapes were begun at the HRIO Grape Substation (Beamsville, Ontario, in the Niagara Peninsula) in 1949. These included the cultivar 'de Chaunac'. The soil at the location was Trafalgar silty clay-loam, moderately well drained. The land was tile-drained and of relatively high fertility, with recommended fertilizer[5] and management practices.

In 1955, a pruning experiment was begun on 40 'de Chaunac' vines (3). Each set of treatments comprised 4 vines, one pruned to each of 3 severities of the 6-cane Kniffin pruning system, and one vine spur-pruned. Each complete set of treatments was replicated 10 times.

"Balanced pruning" was done according to a modification of the formula proposed by Partridge (8). In this system, first-year wood was pruned subjectively to one good cane per arm, according to the vigor of the growth. The prunings were weighed and the mean no. of nodes to be left on this cane was then determined by the weight of the cane prunings removed. The buds at these nodes are referred to here as count-buds. The 3 levels of pruning severity selected were 30 + 8, 24 + 4, and 15 + 4. (Level numbers refer to no. of buds left for the first 0.45 kg of prunings + no. of buds retained for each additional 0.45 kg of prunings). In the spur pruning, six 2 node spurs were left per vine; the spur pruned vines were not balanced pruned. In all cases, there were 6 arms, or spurs, to form a 6 cane Kniffin trellis.

In 1957, a cluster-thinning experiment was superimposed on the pruning severity trial. Five of the ten replicate sets were thinned before anthesis to one flower cluster per shoot. The other five replicates were left unthinned.

In 1970 and 1971, 4 sets of fruit samples were taken at 2 week intervals beginning with the end of the first week of August. The first 3 sets were randomly picked from the vine, and the final sample was chosen at random from the harvested clusters of that plant. Fruit was weighed and soluble solids were determined at each sampling date. Data were taken for each pruning system in comparing the thinned and unthinned treatments, and also averaged.

Fresh fruit weight was defined as the weight of all the mature berries in a cluster not including stems. Stem weight included all material in a cluster not included in the berry weight.

Soluble solids content of the fruit was measured with a hand refractometer in degrees Brix. Seed was extracted from a puree made in a low speed blender and measured as fresh and dry weight.

The data for 1970 and 1971 were averaged since there was no indication of heterogeneity or seasonal interactions in any case. For comparison, the long-term yields of the thinned and unthinned vines of the entire experiment are also shown, from the start of the thinning experiment in 1957 through to the season of 1971.

Results

There was no significant difference in the mean annual yield of thinned and unthinned vines of 'de Chaunac' over the entire 15 year period, in spite of the annual removal of a mean of 58 clusters per vine in thinning (Table 1). In both treatments, yield increased slowly with time (Fig. 1).

Thinning increased the vigor of the vines as measured by annual pruning weight per vine, while that of the checks remained relatively constant (Fig. 2). There was a progressive increase with years of the no. of clusters per vine removed by thinning illustrated in Fig. 3. Comparisons of thinning treatments indicated little difference for either yield or pruning weight variances; the coefficients of variability were very close. (Table 1).

Table 1. Response of 'de Chaunac' grapes to cluster-thinning: 1957-71.

Variable	Thinned	Unthinned
Mean yield per vine (kg)	8.64±.92	8.80±.92
Coefficient of variation (%)	41.3	40.5
Regression, yield on years	0.56	0.52
Mean pruning weight per vine (kg)	1.25**±.10	0.78±.06
Coefficient of variation (%)	31.1	30.6
Regression, weight on years	0.59**	0.02
Mean no. of clusters per vine removed by thinning	58.0±6.9	0
Coefficient of variation (%)	44.4	
Regression, clusters on years	4.27**	

**Difference statistically significant at 1% level.

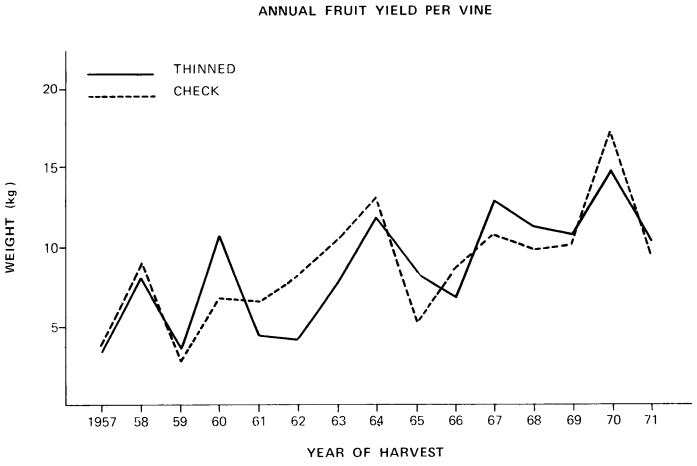

Fig. 1. Annual mean yield of fruit per vine of thinned and unthinned (check) 'de Chaunac' grapes grown at Beamsville, Ont., 1957-1971.

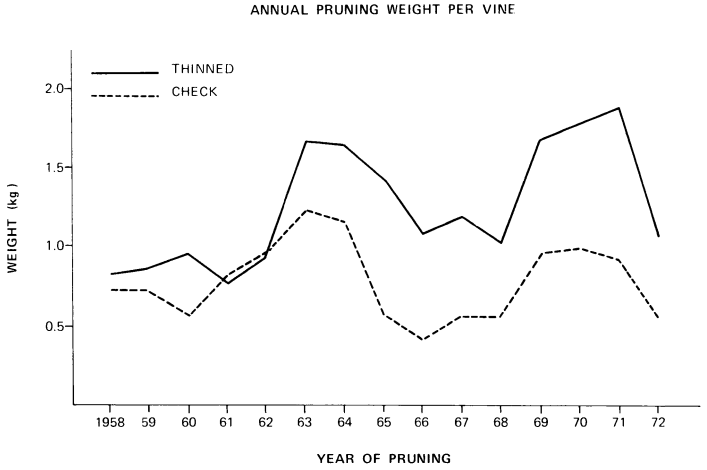

Fig. 2. Annual pruning weight per vine of thinned and unthinned (check) 'de Chaunac' grapes grown at Beamsville, Ont., 1958-1972.

In relation to the pruning system, the thinned vines produced significantly more clusters per vine, as did each pruning system except the 24 + 4 system (Table 2). Likewise, the no. of clusters per count-bud of the vines was significantly greater overall for the thinned vines than for the unthinned, as were those for the 30 + 8 and the spur-pruned systems.

Relative differences between thinning treatments were greater for the spur-pruned system, both in terms of total no. of clusters per count-bud and per vine.

Table 2. Production of clusters of 'de Chaunac' grapes as affected by the pruning system and cluster-thinning, 1970-71 means.

Variable	Treatment	Pruning system 30+8	24+4	15+4	Spur	Mean
Total no. of clusters produced per vine	Thinned	214.9**	173.5	177.3*	167.6**	183.3**
	Unthinned	122.7	149.5	120.6	71.4	116.0
No. of clusters produced per count-bud per vine	Thinned	4.44**	5.18	6.54	13.96**	7.53**
	Unthinned	3.53	5.00	5.68	5.95	5.04

* and ** indicate significance between thinned and unthinned vines at 5% and 1% levels respectively. All comparisons are made only within the same pruning system and variable, and the corresponding mean.

On each sampling date, the mean wt of the sample cluster was significantly greater for the thinned treatment than for the unthinned treatment (Table 3). This was also true for berry wt, except on the last sampling date.

The no. of berries per cluster was significantly greater in the thinned treatment than in the unthinned treatment at all dates of the sampling and the mean wt of the fresh fruit per cluster was also significantly greater in the thinned treatment at each sampling date. Fig. 4 shows typical clusters from thinned and unthinned vines.

The ratio of stem wt to cluster weight decreased progressively as the season advanced through August to mid-Sept. Differences between thinning treatments for this ratio appear to be entirely random. Both % dry matter in the fruit and soluble solids content of the fruit samples increased steadily over the 6 weeks of the sampling period and had a highly significant advantage for the thinned treatment at final harvest.

Seed characteristics of berries from the thinned and unthinned vines differed less among treatments than did the berries (Table 4). Both fresh and dry seed wt reached their maximum by August 20; there were no differences between treatments.

The ratio of seed to fruit wt on both fresh and dry wt bases showed differences associated with thinning treatments at the earlier sampling dates, but not at the final harvest date.

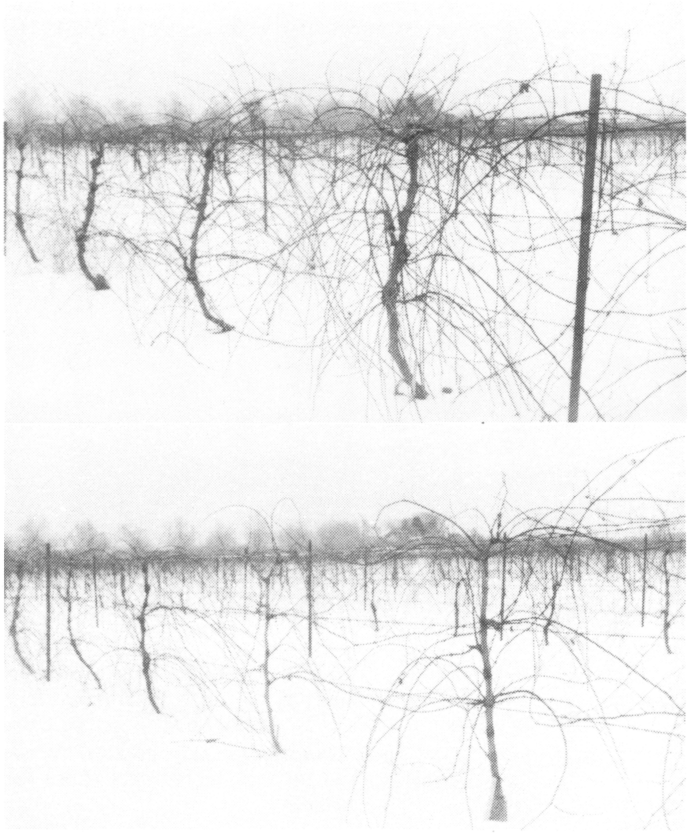

Fig. 3. Growth of 'de Chaunac' grapevines associated with cluster-thinning (Jan. 1972). Spur-pruned vines after 15 years of (top) cluster-thinning and (bottom) no cluster-thinning (note less wood).

Table 3. Cluster and berry characteristics of 'de Chaunac' grapes as related to cluster-thinning: 1970-71 means.

Variable	Treatment	Mean sampling date Aug. 6	Aug. 20	Sept. 2	Sept. 20
Mean wt of sample clusters(g)	Thinned	96.56**	129.45*	214.78**	250.80**
	Unthinned	75.44	95.20	135.24	183.50
Mean wt per berry (g)	Thinned	0.78*	1.06*	1.37*	1.56
	Unthinned	0.73	0.94	1.24	1.55
Mean no. of berries per cluster	Thinned	114.4**	118.0**	145.2**	153.2**
	Unthinned	96.0	95.5	103.4	112.2
Mean wt of fresh fruit per cluster (g)	Thinned	89.30**	121.54*	203.54**	238.22**
	Unthinned	69.07	88.98	126.26	172.84
Ratio of stem wt to cluster wt (%)	Thinned	7.50	5.92	4.86	4.40
	Unthinned	7.46	5.72	5.26	4.40
% dry matter in fruit	Thinned	10.24	13.41	15.92**	14.29**
	Unthinned	10.72	13.32	15.00	13.14
Soluble solids of fruit samples	Thinned	4.18[z]	8.13**	13.62*	17.33**
	Unthinned	4.22[z]	7.29	12.65	15.64

* and ** indicate significance at 5% and 1% levels respectively. All comparisons are made within the same sampling date and variable, between thinned and unthinned.

[z]1971 reading only.

Fig. 4. Samples of 'de Chaunac' grapes on September 15, 1971. Fruit from (left) thinned vines with heavy compact clusters and (right) non-thinned vines with thin, open clusters.

Table 4. Seed characteristics of 'de Chaunac' grapes as related to cluster-thinning: 1970-71 means.

Variable	Treatment	Mean sampling date			
		Aug. 6	Aug. 20	Sept. 2	Sept. 20
Ratio of seed wt to fruit wt as fresh wt (%)	Thinned	7.87	7.11*	5.36*	4.75
	Unthinned	8.08	8.19	6.30	4.71
Fresh seed wt per berry (g)	Thinned	0.032	0.038	0.036	0.038
	Unthinned	0.030	0.038	0.036	0.036
Ratio of seed wt to fruit wt as dry wt (%)	Thinned	43.24*	38.54**	26.28*	27.43
	Unthinned	46.88	43.84	30.82	28.89
Dry seed wt per berry (g)	Thinned	0.018	0.026	0.028	0.030
	Unthinned	0.018	0.026	0.028	0.028
Dry matter in seeds (%)	Thinned	57.59**	71.32	75.66	79.08
	Unthinned	63.58	71.27	74.80	78.26

* and ** indicate significance at 5% and 1% levels respectively. All comparisons are made within the same sampling date and variable, between thinned and unthinned.

Discussion

Cluster-thinning results in many changes in the translocation of photosynthates to the advantage of the fruit or plant reserves, depending on the timing of the operation and the proportion of clusters removed (5, 6, 7). This is borne out in our work where fruit soluble solids content was improved by cluster-thinning before anthesis. Pruning alone is apparently not an adequate control of overbearing and results in delayed fruit maturity in 'de Chaunac', as shown here, and in similar cultivars (2).

The results suggest that in future studies, the sampling method needs to be adjusted to allow for the increase in no. of berries per cluster with time. The preharvest sampling had been undertaken to check the possibility that fruit on thinned vines matured earlier, and allowed sugars to be translocated to other parts of the vine. Apparently this did not happen, since the differences in °Brix became greater with time.

Seed wt data do not appear to justify any reliable conclusions. While fruit quality is more than soluble solids, °Brix continues to be the most useful criterion with regard to grape research in Ontario.

Thinning introduces an extra operation into the sequence of grape production with the attendant increase in labor costs; but our results suggest that it does improve fruit quality, while maintaining better vine vigor. In commercial plantings, unthinned 'de Chaunac' has often suffered from low vigor and winter injury, although under the management conditions of this experiment, there appeared to be no loss in vigor in the unthinned vines. However, the continued increase in pruning wt of the thinned vines suggests that the thinned vines were constantly increasing their vegetative reserve throughout the entire 15 years of the experiment.

Under less favorable conditions of soil fertility and management than ours, the unthinned vines could well suffer winter injury and decline in vigor and productivity (1, 10).

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