Comparisons of Growth and Gas Exchange of Conventionally- and Minimally-Pruned 'Concord' Grapevines

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Abstract

Growth and leaf and canopy net CO_2 exchange in the light and in the dark were compared in 'Concord' grapevines conventionally-pruned (about 90 shoots per vine) and minimally-pruned vines (over 500 shoots). Leaf area developed more quickly on the minimally-pruned vines, but the total leaf area per vine was similar in both pruning regimes at full canopy although the minimally-pruned vines had about 20% larger crops and lower juice brix. Leaf photosynthesis rates were essentially the same. Canopy net CO_2 uptake in the light of the minimally-pruned vines was higher early in the season, then comparable for the rest of the season compared to the conventionally-pruned vines. Similarly, the net CO_2 evolution in the dark was greater early, then comparable, for the minimally-pruned vines.

Introduction

Increasing economic pressures for high yields and production efficiency has led to increasing use of the method of minimal pruning of juice grapes in the Northeast US due to its reduced inputs and higher yields. Since this production method changes many of the basic growth and development patterns we have studied over decades with conventionally pruned vines, we need to understand the bases of these differences in a systematic way in order to optimize management.

Initial studies on the physiology of minimally pruned vines date back to A.J. Winkler's classic studies of unpruned vines that concluded that unpruned vines have the highest productivity, but require thinning to optimize crop quality (Winkler et al., 1974). More recent research in Australia by Clingeleffer and colleagues on *Vitis vinifera* (Clingeleffer, 1988; Clingeleffer et al., 1992; Ruhl et al., 1993) and by Pool in New York on American and hybrid cultivars (Pool et al., 1989; Pool et al., 1993) have show that compared to conventionally pruned vines, minimally pruned vines typically: have 3-8 times the shoot number; develop leaf area sooner in the spring but stop canopy development sooner; have shorter shoots, and smaller leaves; have smaller clusters with fewer and smaller berries, generally larger yields with lower Brix juice.

Although measurements of leaf area, light interception or single leaf photosynthesis are useful by themselves, measurements of the behavior of the net CO_2 exchange of the whole canopy are needed to better understand the relative performance of conventionally and minimally pruned grapevines. One particular concern was that the canopy photosynthesis may decline more rapidly in the late season for the minimally-pruned vines due to an "older" canopy. The objectives of this research were to compare conventionally-pruned versus minimally-pruned 'Concord' (*Vitis labruscana*) grapevines over the season for leaf area development, single leaf and whole canopy gas exchange (a full report will be published later). This report emphasizes the canopy gas exchange comparisons.

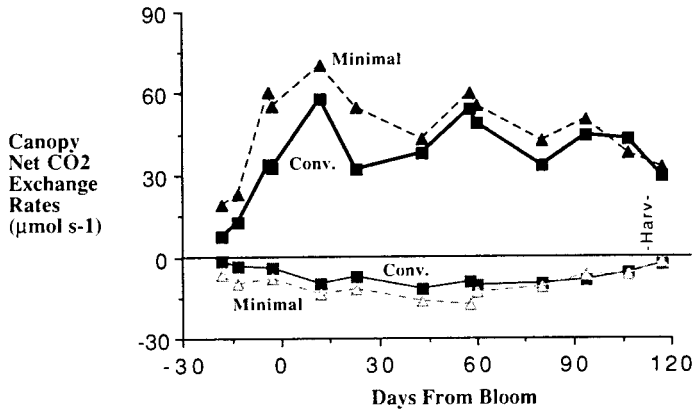

Figure 1. Seasonal pattern of whole canopy photosynthesis (positive values) and respiration (negative values) of conventionally- and minimally-pruned 'Concord' grapevines under sunny conditions. After several readings in the light, the vines were covered for respiration readings in the dark in the afternoon.

Materials and methods

Own-rooted 5-year-old 'Concord' vines were selected in an experimental vineyard at the Experiment Station at Geneva with both minimal pruning and conventional pruning plots. Conventional pruning left 33 nodes/meter of canopy (80 nodes/vine). On the minimal pruned vines crop loads were allowed to develop naturally. The minimal pruned vines were in their second year of minimal pruning. In 1994, the first year of conversion, crop loads were adjusted by hand to avoid the alternate bearing that can occur if unthinned. The vines in 1995 visually had shoot numbers, development and clusters similar to other long-term minimal pruning trials in NY.

In four plots two vines of each pruning regime were monitored over the season for shoot development, leaf area, and single leaf photosynthesis. Shoot development patterns were estimated by measuring at weekly intervals the lengths of 40 shoots per pruning regime (five shoots on eight vines/treatment). Final leaf areas per vine were estimated from shoot length measurements and leaf area-shoot length regressions.

Canopy gas exchange was measured at intervals over the season by enclosing halves of vine canopies in clear Mylar® plastic flow-through gas exchange chambers modified from the basic design of Corelli Grappadelli and Magnanini (1993). Three half-vine canopies per pruning regime were enclosed and monitored for periods of 3-6 hours mid-day during sunny days over the season

starting when the shoots were about 5 cm in length. Immediately after several gas exchange measurements in full sun, the vines were covered to darken them , allowed to equilibrate for at least 30 minutes, and the net respiration in the dark measured. Final yields, cluster counts and fruit sugars were determined at harvest.

Results and discussion

Shoot development stopped at about bloom for the minimally pruned vines, but continued for about 3 weeks more in the conventionally pruned vines. At full canopy compared to the conventionally pruned vines, the minimally pruned vines had: more than three times the number of shoots, much shorter shoots but similar total leaf area per vine (Table 1). The final yields and yield components of the two pruning regimes indicated that the vines were representative of their pruning types. The minimally pruned vines had about 3 times the cluster numbers, but much smaller clusters with fewer and smaller berries, but higher yields and lower Brix (Table 1).

The photosynthesis rates of representative exposed leaves on the upper shoulder of the canopy in each pruning regime showed no significant differences over the season between conventional and minimal pruning regimes (data not shown). This agrees with the report by Downton and Grant (1992), and we have seen this in comparisons in other experiments as well. There was a slight trend toward lower leaf photosynthesis rates around bloom for the minimally-pruned, but early leaf aging and late-season declines in leaf function was not seen. An interesting observation was that although the conventionally pruned vines had longer shoots that produced leaves later into the season, the pendant habit meant that these younger leaves were generally near the ground. So, the leaves on the upper shoulders of the canopy that capture the sunlight were mostly more basal leaves, similar in age to the leaves on the minimal pruning regime.

Although the single leaf photosynthesis did not differ, the whole canopy is the sum of leaf photosynthesis, leaf area and respiratory losses needed to build vine components. Since the leaf area develops so much faster in the spring, the minimally-pruned vines had higher whole canopy photosynthesis readings pre-bloom, although the difference was seen up to about 20 days after bloom (Fig. 1). The greater number of growing shoots also had a cost, however, in that minimally-pruned vines had clearly higher respiration rates during that same period. The total balance of the photosynthesis versus the respiration over 24 hours could not be determined from these measurements, but these results suggest that early season photosynthesis is higher in the minimally pruned vines, and that the canopy of the minimally-pruned vines does not decline markedly in late season.

As expected, the greater shoot numbers on the minimally pruned vines led to earlier canopy development and termination, earlier light interception, and higher early season whole canopy photosynthesis and respiration. The final leaf areas per vine were very similar. Leaf photosynthesis did not decline below the leaves on the conventionally pruned vines as was suspected. Similarly, the whole canopy photosynthesis did not appear to decline below that of the conventionally pruned vines late in the season. Overall, it appears that total vine productivity should be somewhat higher in the minimally pruned vines, although a more comprehensive monitoring of 24-hour gas exchange would be needed to measure this.

Table 1. Growth and production summary of conventionally- versus minimally-pruned 'Concord' vines. Asterisks indicate significant differences between pruning regimes at the 5% level.

Parameter	Pruning Regime		
	Conventional	Minimal	
Shoots/vine	90	297	*
Mean Shoot Length (cm)	41	97	*
Leaf Area/vine (m^2)	13.3	14.4	nsd
Clusters/vine	147	514	*
Weight/Cluster (g)	101	40	*
Weight/Berry (g)	2.9	2.2	*
Juice Brix	15.4	14.1	*
Yield equivalent (t/ha)	22.7	27.9	*

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