Targeted manipulation of vine balance 2.
A whole-vine chamber system for controlling berry sugar accumulation.

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Introduction

Vine balance, from a mechanistic perspective, can be considered as a source-sink relationship, i.e. the relationship between carbohydrate supply (via canopy photosynthesis) and the carbohydrate requirement of the developing fruit. Manipulating vine balance potentially affects the availability of carbohydrates to support berry development. However, when photosynthetic capacity is manipulated through canopy architecture or management practices, bunch exposure can also be affected. Identifying which factor has the greater influence on berry composition is therefore difficult under field conditions. To specifically manipulate whole vine carbohydrate availability, and in turn provide control over the rate of berry sugar accumulation, an experimental approach was developed to reduce photosynthesis by supplying whole vines with air at CO2 concentrations below ambient levels. This poster reports on the design and testing of this system, and the results of the first experiment which examined the impact of low post-veraison carbohydrate supply on berry sugar accumulation and composition.

Whole vine chamber system for Low CO2 mediated reduction of canopy photosynthesis

The experimental system consisted of six acrylic chambers, each with a volume of 1.2 cubic metres, that were built to enclose large pot-grown fruiting grapevines. The acrylic chambers, and plastic base which housed fans, speed controller and air intakes, were built with two halves to allow installation from each side of cordon trained vines. Air scrubbers, with an additional variable speed fan and 27 kg of soda-lime, were used to reduce the CO2 concentration of supply air to three chambers by approximately 200 ppm compared to ambient air supplied to three non-scrubbed control chambers.

The CO2 concentration of incoming and outgoing air was monitored sequentially at 30 second intervals over a period of 5 minutes with a multiplexed infrared gas analyser. All six chambers were measured over a 30 minute cycle, providing a continuous series of CO2 concentration readings (Fig. 1a). Calculations of whole vine photosynthesis, which used the CO2 inlet/outlet differential from these data, air flow rate and leaf area, showed that the photosynthetic capacity of the low CO2 treatment was reduced by approximately 50% compared to control vines (Fig. 1b). Water vapour concentrations (data not shown) and chamber air temperature was also recorded.

Materials and Methods

To determine the response of berry sugar accumulation to low photosynthetic carbohydrate supply during berry ripening, the chambers were installed on six Shiraz grapevines at the onset of veraison in 2015. All chambers were run at Ambient CO2 for 2 days to record initial photosynthesis rates, and then Low CO2 treatment commenced at the beginning of the third day and ran for a period of 27 days before the chambers were returned to Ambient CO2 concentration until harvest. A summary of basic vine and chamber parameters is shown in Table 1 below.

Table 1: Summary of basic vine and chamber parameters during the 27 day low CO2 treatment.

A sample of 50 berries was collected from each chamber on seven dates through the period when both Ambient and Low CO2 treatments were running. Additional samples were collected before and after the low CO2 treatment period, and also at harvest when fruit reached an approximate sugar content of 24 °brix. The berries were weighed and a juice sample collected and frozen at -80°C. Soluble solids were recorded with a digital refractometer, and the concentration of glucose and fructose by HPLC.

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Results and discussion

During the 27 day period when the Low CO2 treatment was running, juice soluble solids in the Ambient CO2 control treatment increased from 11.6 to 19.2 °brix. In the corresponding period, berries in the Low CO2 treatment only reached 15.5 °brix (Fig. 2a). On a per berry basis, the rate of sugar accumulation was reduced from 6.1 to 3.4 mg day-1 in the Low CO2 treatment (Fig. 2b). The reduction in sugar accumulation was therefore proportional to the reduction in photosynthesis. Berry weight loss was not influenced by low CO2, but in both treatments weight loss and continued berry sugar accumulation contributed the increase in sugar concentration in the later part of ripening. By delaying harvest of previously Low CO2 supplied vines an average of 15 days, the same juice sugar values were obtained as for control vines.

Conclusions

Reducing the CO2 concentration of air supplied to whole potted grapevines in transparent chambers caused a proportional reduction in turn a proportional reduction in the rate of berry sugar accumulation. These findings show that CO2 mediated control of vine photosynthesis provides an effective tool for targeted manipulation of the rate of berry sugar accumulation. While vine balance is subjective term and difficult to properly quantify or study, this system provides an opportunity to specifically determine the impact of carbohydrate supply on fruit and wine composition.