Modifying soil potassium content and decreasing plant net carbon assimilation alter the sugar-potassium relationship in the grape berry.

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Introduction

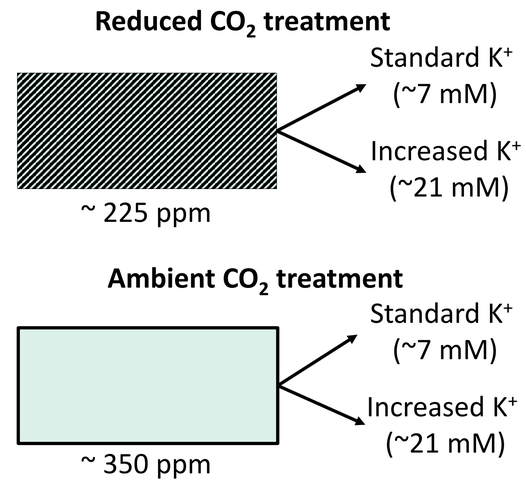
It has been speculated that there is a link between the loading of sugar and potassium (K^+) into the post-véraison grape berry due to similaraties in their accumulation patterns. The existence of this link, which could be either incidental or direct, has not been defined and is mainly based on secondary observations. Potassium fulfils a number of roles in the ripening grape berry such as driving cell expansion and osmoregulation, aside from the possibility of sugar transport functions.

To test whether there is a functional link between the accumulation of these two metabolites, a fully replicated experiment was conducted that (1) lowered the sugar accumulation rate by lowering the photoassimilation rate, and (2) fertilised the plants via the soil with a K^+ enriched solution.

Materials and methods

48 Shiraz vines (clone SA1654) were grown under natural conditions from budburst to the onset of véraison (E-L 34; berry softening), after which the vines were randomly distributed into four environmentally controlled chambers kept at similar climatic conditions. The photosynthesis rate was reduced in two chambers by scrubbing the CO_2 from the atmosphere. Potassium fertilisation was manipulated by fertilising six vines per chamber with a modified Hoagland's solution and the remaining six vines with a similar solution in which the K^+ concentration was increased threefold.

Around 74 days after véraison (E-L 38; harvest), each vine was partitioned into the main vine organs and individually analysed for the carbohydrate content (enzymatically and through high pressure liquid chromatography) and the total K^+ content (flame atomic spectroscopy and ICP-OES).



Results and discussion

A reduction of ~30 % of the atmospheric CO_2 resulted in a decrease of ~35 % in the net photoassimilation rate (Figure 1). Berry fresh mass was lowest in the increased K^+ treatment under ambient CO_2 conditions (Figure 2, A) with the highest berry fresh mass observed in the same K^+ treatment but under low CO_2 conditions. Berry dry mass (biomass) was, however, not altered by either the CO_2 or K^+ treatments (Figure 2, B). Analyses on the berry pericarp (skin and pulp) biomass revealed that there were no differences in the sugar concentration on a dry mass basis between treatments, despite a ~ 35 % lower photosynthetic rate in the low CO_2 treatments (Figure 3). Sugar concentrations on a fresh mass basis were, however, lower in the low CO_2 treatments due to dilution because of a higher water content in the grape berries from these treatments (data not shown). In addition, and opposite to what was expected, the K^+ concentrations in the pericarp biomass for the ambient CO_2 treatments were lower in comparison to the low CO_2 treatments, irrespective of the K^+ treatment (Figure 3). These results indicate that there likely is no tight coupling in the accumulation of sugar and K^+ into the grape berry.

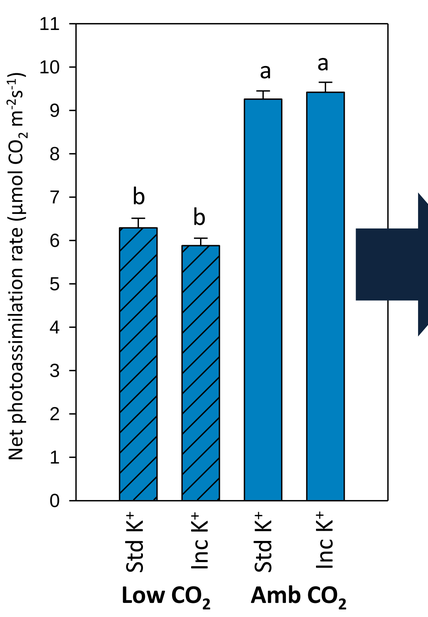


Figure 1: The mean net carbon assimilation rate (n= 36 per treatment combination), as determined by infra-red gas analyses, at ~74 days after véraison.

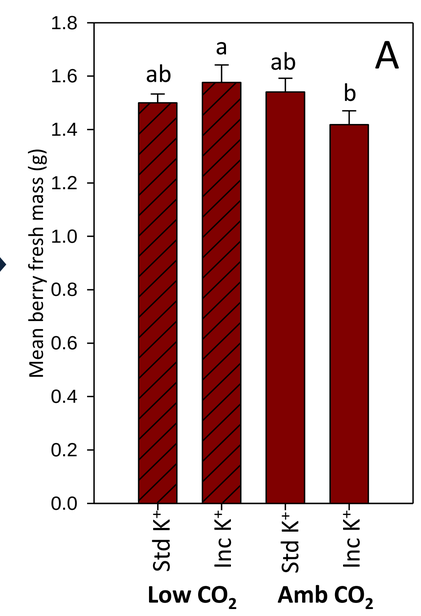


Figure 2: The mean berry fresh mass (**A**) and berry dry mass (**B**) per treatment (n=10 berries per vine, 12 vines per treatment combination) at ~74 days after véraison.

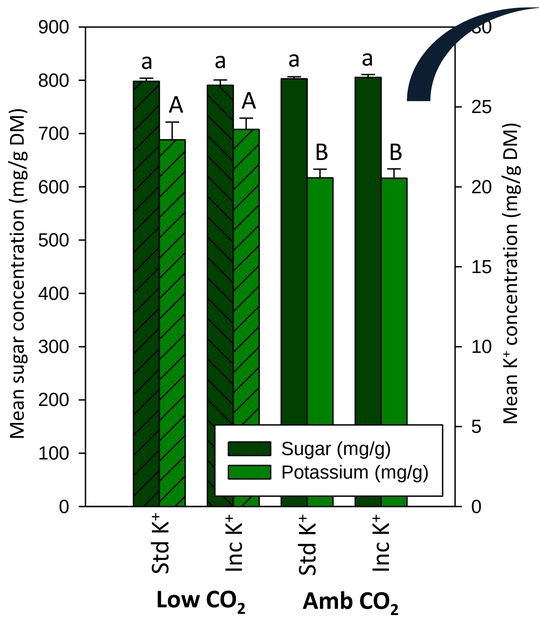


Figure 3: The mean sugar and K^+ concentration of the biomass (n=12 vines per treatment combination) at ~74 days after véraison.

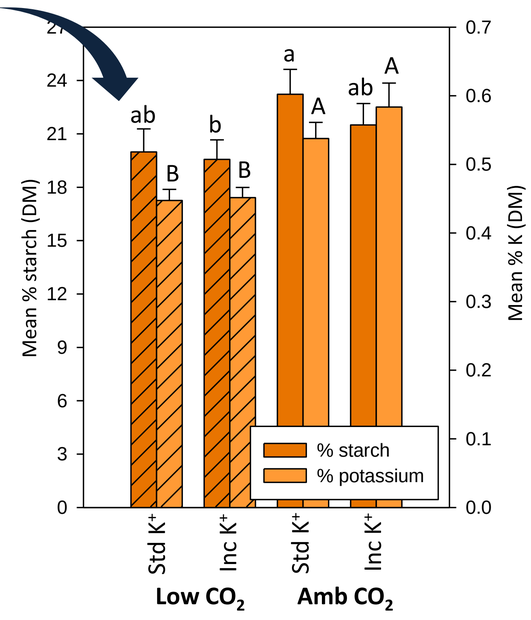


Figure 4: The mean % starch and % K^+ of the root biomass (n=12 vines per treatment combination) at ~74 days after véraison..

The majority of the vine organs had lower starch contents in the low CO_2 treatments in relation to the ambient treatments, but none of these organs indicated differences in the K^+ concentrations for any treatment combination (data not shown). The roots were the only vine organ with a lower K^+ concentration in the low CO_2 treatments, mirroring the increase in the berry K^+ concentration (Figure 4). This decrease in the K^+ concentration within the low CO_2 treatments coincided with a decrease in the starch concentration, particularly in combination with the increased K^+ treatment (Figure 4). The possibility therefore exists that K^+ may facilitate the relocation of carbohydrates from the roots towards the grape berries.

Conclusions

- The accumulation of K^+ and sugar in the grape berry reacted differently towards the atmospheric CO_2 and K^+ fertilisation treatments, indicating plasticity in the loading of these metabolites in the grape berry during ripening.
- In this study it was demonstrated that sugar accumulation within the grape berries was favoured over starch storage in the perennial tissues of the grapevine
- Potassium may play a role in the long distance transport of remobilised carbohydrates from the roots towards the grape berries

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