Does Dye Infusion Indicate Xylem Functionality in Kiwifruit?

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Abstract

This study was undertaken to establish whether the rate of uptake of an aqueous solution by the fruitstalks of detached *Actinidia deliciosa* fruits ('Hayward') correlates with fruit xylem functionality assessed by dye infusion. Fruits were collected from the orchard, pre-dawn and 65 days after bloom. In the laboratory the fruitstalks were re-cut under water and their outsides lightly smeared with Vaseline before placing their cut ends in small, pre-weighed (W_1) (mg) vials of dye solution. Fruits were allowed to take up dye solution for ~100 min (T) under uniform aerial conditions. Fruits were then sliced 1/5 way up from the stalk end and the fraction (F) (%) of stained bundles was determined. The residual dye solution was weighed (W_2) (mg) and the solution uptake rate (U) (mg/min) determined per unit of fruit surface area (S) as $U=(W_1-W_2)/(S\times T)$. Analysis reveals that F is linearly related to U (R^2 = 0.81). The suitability of the stain infusion technique for assessing xylem functionality is discussed.

INTRODUCTION

Quality is always highly variable between individual fruits from the same tree/vine. Many fruit traits contributing to quality also show very high variability between fruit. The numbers, diameters and functional status of the xylem conduits serving a fruit and the driving force for xylem sap flow (transpiration) are all likely to influence the delivery of xylem-borne minerals to a developing fruit and especially that of calcium (Ca) (Montanaro et al., 2006). Qualitative assessments of fruit xylem functionality have been made by infusing dye solutions into the stalks of detached fruit (Dichio et al., 2003) but quantitative assessments of fruit xylem functionality have not been explored as thoroughly. Therefore, this study makes a combined quantitative+qualitative assessment of fruit xylem functionality in kiwifruit by measuring the uptake rate of dye solution (quantitative) to establish whether this correlates with the pattern of dye distribution (qualitative).

MATERIALS AND METHODS

Closely similar fruits (×28) of *Actinidia deliciosa* 'Hayward' were selected pre-dawn on day 65 after bloom. For dye infusion, fruitstalks were prepared as in Dichio et al., 2003). Briefly, fruitstalks were re-cut under water and their outsides smeared with Vaseline, then their cut ends were placed in pre-weighed (W_1) (mg) vials of dye solution (0.5% aqueous toluidine blue).

Fruits were supported on a wooden frame and allowed to take up dye solution for ~100 min (T) under uniform laboratory conditions (air-flow 0.8 m s^{-1}, 25°C, 55% RH) at the Pantanello Regional Agriculture Research Station. Afterwards, fruits were sliced 1/5 way up from the stalk-end and the fraction (F) (%) of stained (functional) bundles was determined. Fruit surface area was estimated according to Montanaro et al. (2006). Vials were reweighed (W_2) (mg) and solution uptake rates (U) (mg cm^{-2} h^{-1}), standardized per unit of fruit surface area (S) (cm^2), and were determined as:

$$U=(W_1-W_2)/(S\times T) \quad (1)$$

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RESULTS AND DISCUSSION

Dye solution uptake rates *U* ranged about 3-fold (1.4 to 3.9 mg cm^{-2} h^{-1}) and the fraction of stained bundles *F* ranged about 15-fold (5.5 to 93%) (Fig. 1). Regression revealed that *U* correlates linearly with *F* with a high coefficient of determination (R^2 = 0.81). Correlation between bundle staining and solution uptake plausibly suggests a direct causal association between these two, largely-independent measures of fruit xylem functionality. The high fruit: fruit variability was not related to fruit size as fruit were carefully selected to be closely uniform in size. Mean *S* (± SE) was 81.8 cm^2 (± 1.2).

High variability of xylem functionality between fruit is a widespread phenomenon observed also in other species including apples and grapes (Dražeta et al., 2004). Also, the Ca concentration of kiwifruit flesh ranges by as much as 14-fold (from min ~7 to max ~110 mg Ca/100g FW) (Lang, unpublished) and, moreover, Ferguson et al. (2003) have reported high variability in fruit Ca from vine-to-vine and from orchard-to-orchard.

CONCLUSIONS

These preliminary results lead strong force to the argument that this simple laboratory technique (dye infusion) offers a valid perspective on fruit vascular functionality and contributes valuable insights into the mechanisms underlying the development of fruit quality. To better understand the causes of high fruit: fruit variability further study is required including consideration of other mechanisms affecting xylem and phloem sap flows (e.g. fruit transpiration, phloem unloading, spatial distribution of in-fruit hydraulic resistance).

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Figures

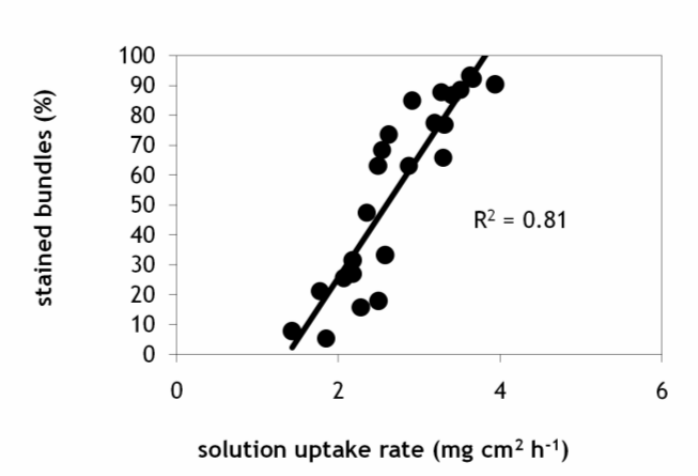

Fig. 1. Stained bundles (*F*) vs solution uptake rate (*U*).