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The use of ultrasonic detectors for water stress determination in fruit trees

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Introduction

In drought, the hydraulic conductance in tree stems can be reduced by embolisms that occur within xylem vessels and tracheids. There is good circumstantial evidence that these cavitation events can be detected acoustically, either at low frequency, *i.e.*, 0.2–2 kHz (Milburn and Johnson, 1966) or high frequency, *i.e.*, 0.1–1.0 MHz (Tyree and Dixon, 1983) It is important to know at what stage cavitations occur and whether there are inherent differences between varieties or species. As a tool to investigate cavitation events, we have used ultrasound detectors, since they are able to operate in a noisy environment or in field conditions without background interference.

Materials and Methods

Using a circuit design based on that by Sandford and Grace (1984), acoustic emissions (AE) were converted into 5 V pulses and recorded on a counter or logger. AE production of 3 apple cultivars (*Cox's Orange Pippin, Golden Delicious* and *A120/3*) on 2 rootstocks (M.9 and M.25) were compared in a glasshouse drought experiment from 8–10 October 1987. 24 potted trees were transferred from a sandbed on 4 October and water was withheld from 2 of each rootstock/cultivar combination. Three days later, water was withheld from one more tree from each combination, the remainder of the trees being retained as well-watered controls. Two ultrasound transducers were attached to stems of pairs of trees to record counts over 5 min periods. Each transducer was mounted onto the xylem tissue of the rootstock stem (covered with petroleum jelly) about 10 cm below the graft union. Leaf water potential (ψ_l, down to –4 MPa) and conductance to water vapor (g_l) were monitored concurrently with AE.

Results

Results are presented for the 3 cultivars separately in Fig. 1. There was a clear rootstock effect with the count rate for M.9 being up to 6 times that for M.25, depending upon ψ_l. The threshold of ψ_l at

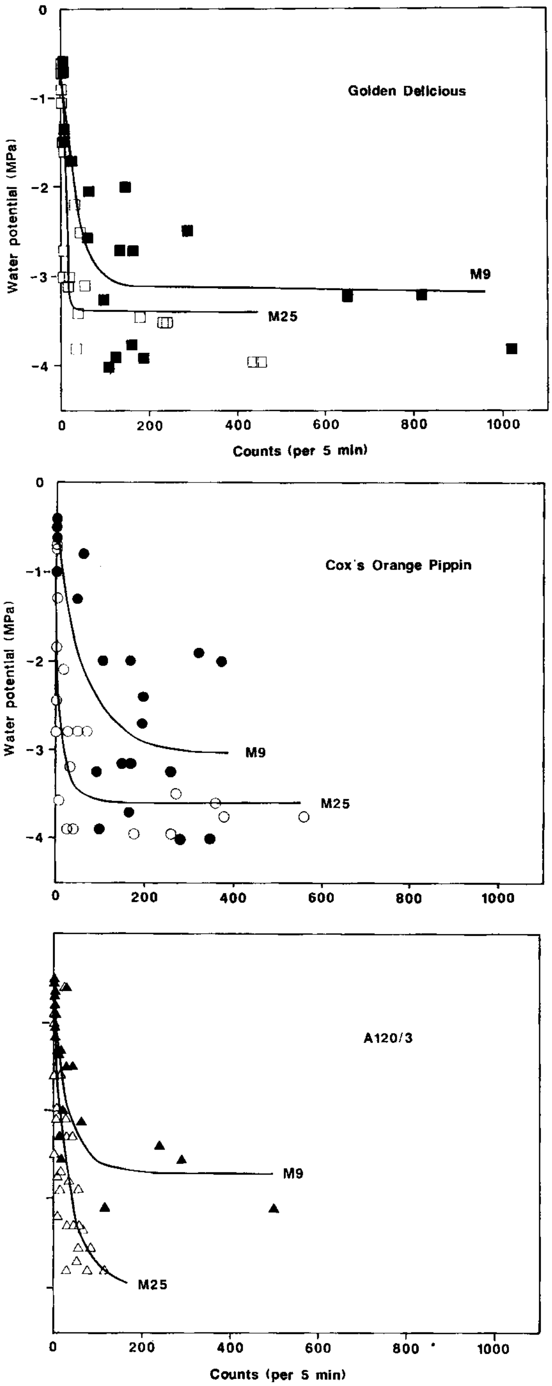

Fig. 1. AE from dwarfing (M.9) and vigorous (M.25) rootstocks for three apple cultivars during a drought course.

Table I. Threshold values of ψ_l (MPa), above which few AE were observed.

	Cox	*Golden Delicious*	*A120/3*
M.9	–0.6	–0.7	–0.6
M.25	–1.7	–1.2	–1.0

which AEs started was different for the various rootstock/cultivar combinations (Table I).

The cultivar effect was not so marked, although there was a tendency for fewer AE to be produced at any ψ_l for *A120/3* on M.25 when compared with the other cultivars on the same rootstock. On no occasion did AE for well-watered controls exceed 2 per 5 min and were usually zero. There was some evidence with individual plants that AE decreased after prolonged stress.

In a separate experiment, AE were monitored diurnally (along with radiation) using a data logger recording at 30 min intervals. Two trees were used: *A120/3* on M.25 and *Cox* on M.9. The pattern of ψ_l *vs* AE was similar to that in the previous experiment. It was evident from the time courses that a marked diurnal pattern existed where AE followed radiation (PAR) levels approximately, except in some instances when AE increased, or continued, during the night (Fig. 2).

Discussion and Conclusion

These results indicate that the response to applied drought in apple trees produced more AE in a dwarfing rootstock (M.9) than in a vigorous one (M.25) for a given ψ_l. Also there was a threshold of ψ_l, below which AE start to occur. This was different for the 2 rootstocks. Other evidence suggests that embolised vessels are not easily refilled (Milburn, 1979;

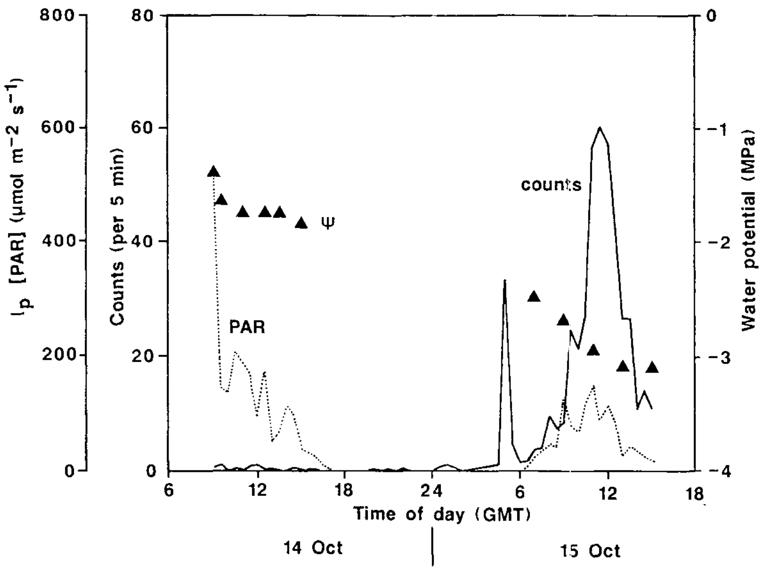

Fig. 2. Diurnal course of AE for *A120/3* on M.25 rootstock.

Jones and Peña, 1986) and so a cumulative reduction in hydraulic conductivity could occur. Work is continuing in order to evaluate the technique for assessing plant responses to drought in the field and as a means of measuring physiological water stress.

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