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COMPARISONS OF LEAF WATER POTENTIAL AND XYLEM WATER POTENTIAL IN TOMATO PLANTS*

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The rapidity and convenience of the pressure chamber technique for estimating leaf water potentials, especially under field conditions, has been remarked (Boyer 1967; Kaufmann 1968*a*, 1968*b*) and demonstrated (Klepper and Ceccato 1969). However, Kaufmann (1968*a*) showed that it is necessary to exercise caution in using measurements made with the pressure chamber as direct estimates of leaf water potential. Instead, he recommended that calibration curves should be drawn up for each species, relating measurements of xylem pressure potential obtained with this technique to corresponding known leaf water potentials. The present communication reports such a relation for tomato leaves, which have not previously been studied in this way. Plant age is shown to affect the relation.

Recently fully expanded leaves of well-watered tomato plants (*Lycopersicon esculentum* Mill cv. Gros Lis), sown on January 21, 1969, were brought from the field to the laboratory in polythene bags in a thermally insulated container. Xylem pressure potential was measured with the pressure chamber; this was followed by a measurement of leaf water potential with a Peltier-cooled thermocouple psychrometer, using a subsample of tissue from the same leaf. Full experimental details of these techniques were given by Klepper and Ceccato (1969). Some leaves were allowed to dry in the laboratory for up to an hour before sampling in order to obtain a range of water potentials.

Figure 1 shows results of this procedure, carried out on two separate occasions. On both occasions leaf water potential and xylem pressure potential were linearly related ($r^2 = 0\cdot8628$ for March 23 and $0\cdot9884$ for May 23, 1969, respectively). Similar linear relations have been obtained by Kaufmann (1968*b*) for leaves of Valencia and Washington Navel oranges. At least approximately linear relations between these two potentials have also been obtained by Klepper and Ceccato (1969) for leaves of pears, apricots, and Washington Navel oranges, and by Boyer (1967) for leaves of sunflower, rhododendron, and yew. However, considerable departures from linearity can occur, as Kaufmann (1968*a*) showed for leaves of northern red oak and white oak.

Figure 1 also shows that the slopes of the regression lines differed between the two occasions, the slope ($0\cdot59$) for leaves from the younger plants being less than that ($0\cdot93$) for leaves from plants a month older. This difference in slope was shown to be significant at the $0\cdot05$ level by Student's *t*-test. The two sets of data therefore

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cannot be pooled and it follows that the relationship between the two potentials shifts with plant age. It is therefore necessary to check the relation from time to time. Possibly once a month would be adequate, since the *t*-test was only just significant at the 0·05 level. A somewhat similar situation was reported by Kaufmann (1968*b*) for leaves of citrus although he was primarily concerned with the effect of leaf age rather than plant age. In both Washington Navel and Valencia orange leaves he found the slope of the line for leaves nearly a year old was higher than that for young leaves which had not quite reached mature size. Such data alone do not offer an explanation of the increase in slope with time. However, Kaufmann's results may be explicable in terms of change in the strength of the cell wall and in the permeability of cell membranes to water which may occur as leaves age (Knipling 1967). Our results, on the other hand, could be due rather to the increase in dry weight of leaves of the same physiological age that occurs as a crop ages (Weatherley 1950).

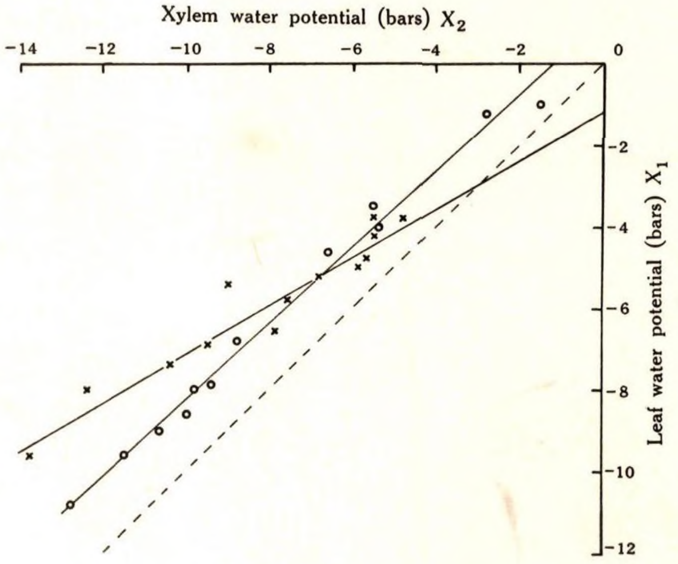

Fig. 1.—Two comparisons of psychrometer measurements of leaf water potential (X_1) with pressure chamber measurements of xylem pressure potential (X_2) for tomato leaves, made 2 months apart. × Readings for March 23, 1969. Regression equation: $X_1 = -1{\cdot}21+0{\cdot}59X_2$; $r^2 = 0{\cdot}8628$. o Readings for May 23, 1969. Regression equation: $X_1 = -1{\cdot}10+0{\cdot}93X_2$; $r^2 = 0{\cdot}9884$.

Two points arise from the observation (Fig. 1) that all experimental xylem pressure potential values were more negative than the corresponding leaf water potentials. Firstly, it would seem profitless to convert pressure potentials to total potentials before comparing them with leaf water potentials, by including the osmotic potential of the xylem sap, as did Boyer (1967), since this would only increase the difference between the two sets of potentials. Kaufmann (1968*a*, 1968*b*) observed a similar tendency in his data and reached the same conclusion. Secondly, the fact that pressure potentials were considerably lower than water potentials, suggests that either the psychrometers were reading spuriously high or the pressure chamber was reading spuriously low. Factors which may cause psychrometric measurements of leaf water potential to be spuriously high include effects due to heat liberated by the respiring tissue (Barrs 1964) and leaf resistance to water vapour transfer (Boyer and Knipling 1965). A correction for the former effect was made (Barrs 1965) and the latter appears unlikely to be important in practice, especially with Peltier-cooled psychrometers (Barrs 1968). Klepper and Ceccato (1969) reported water potentials of relatively turgid leaves of grape and pear to be lower than corresponding pressure potentials. They suggested this was due to secretion of salt onto the surfaces of the leaves during equilibration in the psychrometer chambers, which has been shown to occur with cotton leaves (Klepper and Barrs 1968). This appears to be an unlikely source of error in the present measurements, since, as already noted, leaf water potentials were higher than corresponding pressure potentials. Furthermore, the tomato leaf water potentials were observed to remain constant over a considerable period (14 hr). Had there been any salt secretion, leaf water potentials would likely have drifted downward with time.

It seems reasonable to infer that the leaf water potentials were accurate and may be used as a standard with which to compare the pressure potentials. In other words, the pressure potentials were probably spuriously low (too negative). This general conclusion was also reached by Boyer (1967) and Kaufmann (1968*a*, 1968*b*). These workers suggested the effect was due to resistance to movement of water through the xylem toward the cut surface, as a result of compression of the vascular tissue, which would cause the application of greater pressure than required.

In summary, tomato leaf water potentials may readily be estimated from pressure potentials, especially since the two are linearly related. However, calibration of pressure potential against leaf water potential is necessary because pressure potential values are spuriously low. Plant age affects the calibration, hence calibration needs to be repeated from time to time.

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