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PLANT WATER STATUS OF APPLE TREES AND ITS MEASUREMENT IN THE FIELD. 2. COMPARISON OF THE DYE TECHNIQUE AND THE VAPOUR EQUILIBRATION TECHNIQUE FOR THE MEASUREMENT OF LEAF WATER POTENTIAL

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SUMMARY

The dye technique, developed after Shardakov's method, for the measurement of leaf water potentials may be subject to contamination errors or errors arising from solute uptake by leaf discs. A measure of this total error arising from these sources was made by a comparison of the dye method with Slatyer's vapour equilibration technique.

Differences in leaf water potentials measured with the two techniques were small and limits were not in excess of ±1 atm for the three apple varieties tested.

The accuracy, speed and portability of the dye method should make this method quite suitable for field measurements of plant water stress in apple trees.

I. INTRODUCTION

The dye method described in Part 1 (Chapman 1970) is subject to errors not encountered with vapour equilibration techniques. To assess these errors, which may arise from the contamination of solutions (Brix 1966; Knipling and Kramer 1967), or from uptake of solutes by leaf tissue (Goode and Hegarty 1965), a comparison is made between the dye method and the vapour equilibration technique described by Slatyer (1958).

The direction of contamination error depends on the density of contaminants relative to the density of the solution having a potential equal to that of the leaf. However, the final size of the contamination error will depend on the extent which osmotic water gain by or loss from the leaf tissue compensates for the contamination density changes during complete equilibration (Knipling 1967). Since this error may be larger for woody species such as the apple, which undergo smaller changes in water content per unit change in water potential, it was pertinent to investigate this problem in the present study.

II. MATERIALS AND METHODS

On a number of different occasions water potential was determined simultaneously by the dye and vapour equilibration techniques.

The dye method has already been described (Chapman 1970), while the vapour equilibration technique used was similar to that described by Slatyer (1958). Predetermined equilibration times were 4 hr and 24 hr for the dye and vapour equilibration methods respectively.

To make the comparisons, four field replicates with three tree plots were used, with all work being performed on the three apple varieties, Delicious, Jonathan and Granny Smith. An attempt was made to obtain measurements of stress at approximately 2 atm intervals from 0 to 20 atm. To achieve this range of water potentials leaves were in some instances brought to full turgor and on other occasions left to dry out in the laboratory.

Fourteen fully expanded, exposed terminal spur leaves per replicate were sampled from trees at a fixed height of 5 ft above ground level. Eight 16 mm discs were cut from each leaf with a very sharp cork borer, avoiding main veins and discarding discs with main veins present. Four discs were placed in each of the seven solutions used with both methods. Water potentials with the vapour method were determined by a plot of final weight/original weight against osmotic pressures of the solutions used.

III. RESULTS

Figures 1–3 show the results for the three varieties. In all cases regression coefficients were highly significant and regression equations are shown on the figures together with standard errors for b values. Fiducial limits are presented for $P = 0{\cdot}05$, indicating the limits within which the true relationship is likely to lie. No differences were present between slope or position of the regression lines of each of the three varieties. In no instance did the limits vary by more than $\pm$ 1 atm for any variety under any stress condition.

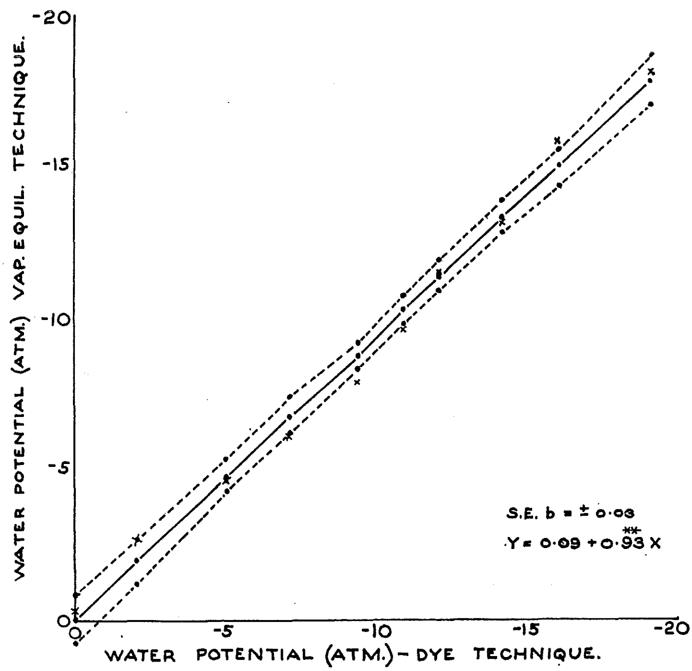

Fig. 1.—Relationship between water potential measured by the vapour equilibration technique and the dye technique for Delicious.

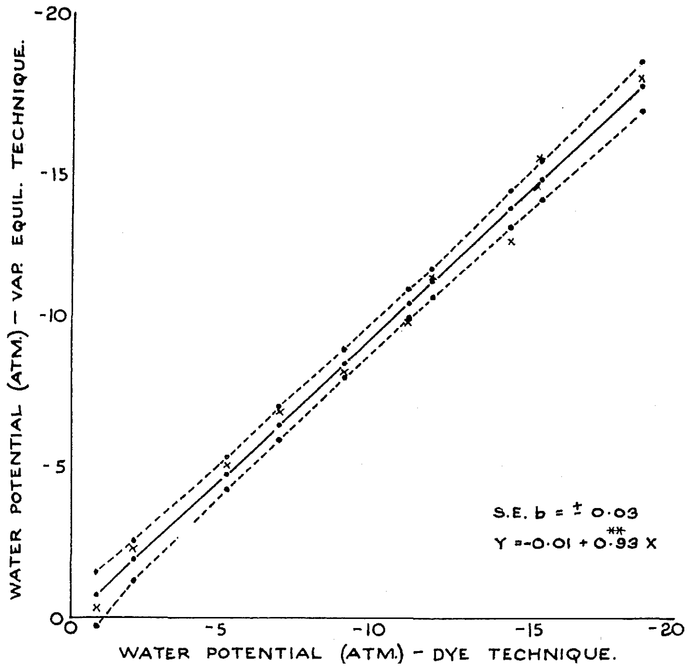

Fig. 2.—Relationship between water potential measured by the vapour equilibration technique and the dye technique for Jonathan.

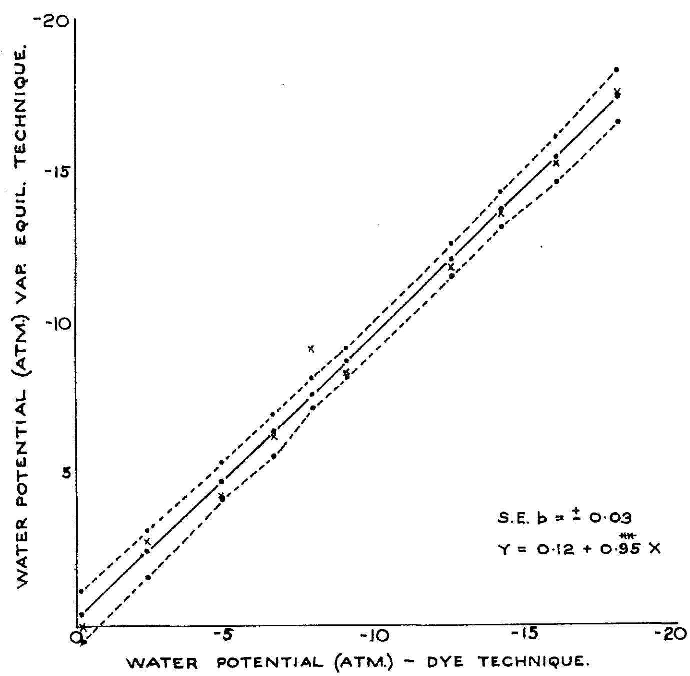

Fig. 3.—Relationship between water potential measured by the vapour equilibration technique and the dye technique for Granny Smith.

IV. DISCUSSION

It is apparent that, with the apple varieties tested, the values for water potential determined by the dye method agree closely with true leaf potentials determined by the vapour equilibration technique. However, values obtained may differ by as much as 5-8 atm for some species when the dye method and a vapour technique are compared (Kramer and Brix 1965; Knipling and Kramer 1967.).

With these apple varieties contamination errors and errors arising from the uptake of solutes appear to have been small in magnitude.

In view of the speed, simplicity and accuracy of the dye method, it should be quite useful for field studies involving plant water stress measurements with apple trees.

V. ACKNOWLEDGEMENTS

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