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HYDRAULIC PRESS MEASUREMENTS OF LEAF WATER POTENTIAL IN GROUNDNUTS†

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SUMMARY

The hydraulic press was compared with the dew point psychrometer and the pressure chamber methods for measuring leaf water potential (Ψ) in groundnuts (*Arachis hypogaea* L.). For measurements on the same leaf, regression analysis revealed that the slopes did not differ significantly from unity. An analysis of functional relations between measurements made by the press and the dew point psychrometer or the press and the pressure chamber showed that the error variance of the press was similar to those of the two other methods. Therefore, we conclude that for groundnuts the performance of the press, the dew point psychrometer and the pressure chamber are similar.

Measurements of leaf water potential (Ψ) are an important requirement in many research programs. Several methods of making these measurements have been developed. Within laboratories, the most accurate method is generally considered to be psychrometry (Klepper and Barrs, 1968). In field studies, the most commonly used method is the pressure chamber technique (Scholander *et al.*, 1964) although an alternative method, the hydraulic press, based on the same principle of applied pressure, has been developed (Campbell and Brewster, 1975).

Each of these methods has advantages and disadvantages for the experimenter. For example, although the psychrometry method has been to some extent automated electronically, the expense of the equipment and lengthy thermal and vapour equilibration period discourage its use, particularly for routine field measurements (Turner, 1981).

The pressure chamber method has also been improved to increase portability and speed of operation and is now well-suited to field use (Ritchie and Hinckley, 1975). Nevertheless, the equipment is still relatively bulky and expensive and the supply of compressed air in sufficient quantities to allow sustained operation can present some difficulties (Jones and Carabaly, 1980). In addition, obtaining the necessary seal around the plant tissue at extreme pressures may present considerable difficulties and so decrease the reliability of the measurements.

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The hydraulic press is inexpensive and rapid to operate without any restraints to movement and place of utilization. However, although on some species the press has been found to be a satisfactory instrument, on others this has not been the case and some difficulty has been experienced in determining the end point (Yegappan and Mainstone, 1981). Radulovich *et al.* (1982) reported that the hydraulic press does not measure small values of leaf Ψ of field-grown cotton as accurately as the pressure chamber does.

This study was conducted to investigate the hydraulic press method as a potential technique for leaf Ψ measurements in groundnuts over the range of Ψ encountered in the field.

MATERIALS AND METHODS

Leaves of groundnut (*Arachis hypogaea* L.) vars TMV-2 and J-11 grown in soil in pots were used. A range of leaf Ψ were achieved by withholding water from the plants.

Hydraulic press measurements of leaf Ψ were made using a J-14 press (Campbell Scientific Inc., Logan, Utah, USA) on one of the two distal leaflets from fully-expanded leaves of various ages. The method involved cutting the leaflets so as to retain the distal 75% of their areas and placing them on a filter paper disc (10 cm^2) in the press. After closing the transparent plate, the pressure was applied. The end point was taken to be that pressure at which the first flush of water was exuded from the entire surface of the cut edge of the leaf lamina and absorbed by the filter paper. For groundnuts, this end point was distinct, repeatable and occurred over the full range of Ψ measured. The Ψ of the remaining leaflets of distal pairs was measured using a thermocouple psychrometer model L-52 sample chamber connected to a HR-33T dew point microvoltmeter (Wescor Inc., Logan, USA). Small circular leaf discs were placed in the sample chamber for 20-30 min for thermal and vapour equilibration before measuring the dew point depression. This 20 min period for equilibration was the time found necessary by experience.

Similar comparisons were also made between leaf Ψ estimated by the hydraulic press and the pressure chamber (PMS Scientific Instruments, Carvallis, Oregon, USA) technique (Scholander *et al.*, 1964).

As each instrument is subject to experimental error, the regression analysis of these comparisons is often unrealistic. Therefore, an analysis of the underlying functional relations (Kendall and Stuart, 1973: Bell and Squire, 1981) has been made for each comparison.

RESULTS AND DISCUSSION

Hydraulic press and the dew point psychrometer

Data for this comparison are shown in Fig. 1. The maximum likelihood estimate of the functional relation between the press and the psychrometer resulted in:

$$\Psi_{press} = 0.975\ \Psi_{psychro} + 0.122\ (-MPa) \qquad \ldots \text{(Eqn 1)}$$

With 95% confidence intervals ranging from 0.911 to 1.044 for the regression coefficient.

Hydraulic press and the pressure chamber

Figure 2 shows the comparison of the two estimates of leaf Ψ measured using the press and the pressure chamber. The maximum likelihood estimate of the functional relation of this comparison resulted in:

$$\Psi_{press} = 0.953\ \Psi_{chamber} + 0.052\ (-MPa) \qquad \ldots \text{(Eqn 2)}$$

With 95% confidence intervals of 0.899 to 1.009 for the regression coefficient.

Results showed that the variances of estimates obtained using the press, the pressure chamber and the psychrometer are homogenous since the observed values of variance ratios are smaller than the tabulated F-value at P = 0.05 (Table 1).

Therefore, despite the hydraulic press being unsuitable for other species (Yegappan and Mainstone, 1981; Radulovich *et al.*, 1982), it can be used with confidence to determine leaf Ψ in groundnuts.

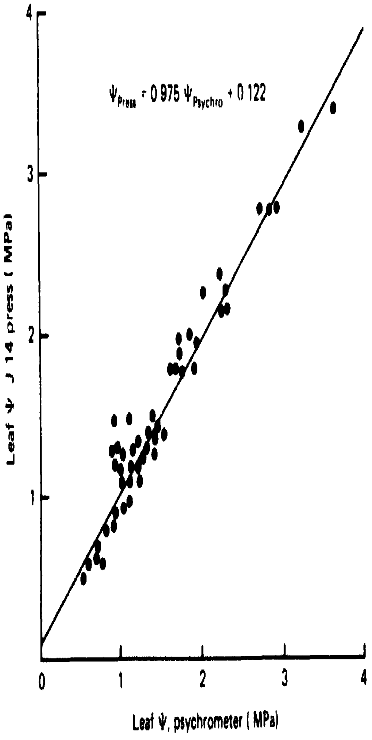

Fig. 1. Relation between the water potential (Ψ) of the same leaf measured by hydraulic press and psychrometer. The solid line shows the maximum likelihood estimate of functional relation of the two instruments.

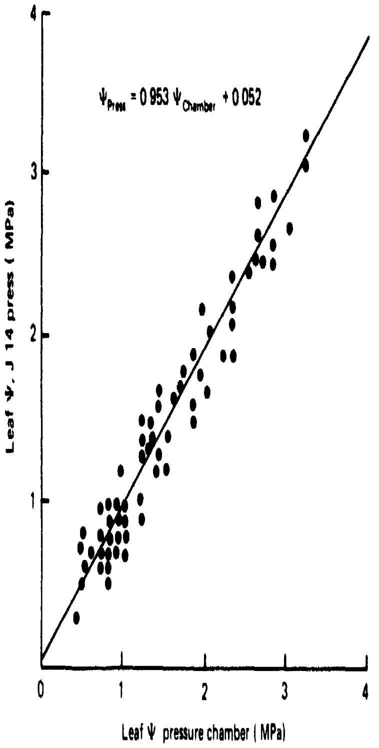

Fig. 2. Relation between the water potential (Ψ) of the same leaf measured by hydraulic press and pressure chamber. The solid line shows the maximum likelihood estimate of functional relation of the two instruments.

Table 1. *Sample means, variances and numbers of observations in two sets of comparisons for the water potentials of groundnut leaflets measured by J-14 hydraulic press, dew point psychrometer and pressure chamber*

Comparison	Instrument	Sample means ($\bar{x}$)	Variances (s^2)	No. of observations (n)
1	J-14 press	1.556 ($\bar{x}_1$)	0.475 (s_1^2)	50 (n_1)
	Psychrometer	1.471 ($\bar{x}_2$)	0.499 (s_2^2)	50 (n_2)
2	J-14 press	1.472 ($\bar{x}_3$)	0.511 (s_3^2)	70 (n_3)
	Pressure chamber	1.491 ($\bar{x}_4$)	0.561 (s_4^2)	70 (n_4)

F-ratios.

$s_3^2/s_1^2 = 0.511/0.475 = 1.076^a$.

$$\text{Then pooled } s^2_{1,3} = \frac{s_1^2 \times (n_1-1) + s_3^2 \times (n_3-1)}{(n_1-1)+(n_3-1)} = 0.496.$$

$s_2^2/s^2_{1,3} = 0.499/0.496 = 1.006^a$

$s_4^2/s^2_{1,3} = 0.561/0.496 = 1.131^a$

[a] Not significant at P = 0.05.

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