AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D. C. 20523

**BIBLIOGRAPHIC INPUT SHEET**

*FOR AID USE ONLY*

1. SUBJECT CLASSIFICATION

A. PRIMARY: Agriculture

B. SECONDARY: Cereal Crops

2. TITLE AND SUBTITLE

On the pressure chamber technique for estimating leaf water potential in sorghum

3. AUTHOR(S)

Blum,A.;Sullivan,C.Y. and Eastin,J.D.

4. DOCUMENT DATE: April 1973

5. NUMBER OF PAGES: 2p.

6. ARC NUMBER: ARC 633.174-B658

7. REFERENCE ORGANIZATION NAME AND ADDRESS

University of Nebraska
Department of Agronomy
Lincoln,Nebraska 68503

8. SUPPLEMENTARY NOTES *(Sponsoring Organization, Publishers, Availability)*

Published in Agronomy Journal, Vol.65,April 1973

9. ABSTRACT

The purpose of this work was to re-evaluate the pressure chamber technique for estimating leaf water potential in sorghum [Sorghum bicolor (L.)Moench],with special reference to problems associated with leaf sample crushing under pressure and pressure rate increase inside the chamber. Pressure chamber readings were compared to Spanner--type thermocouple psychrometer readings on leave of five sorghum genotypes at several stages of growth.

A leaf sample holder, constructed from Silicon rubber and accomodated into a brass flange, reduced leaf crushing under pressure. It was found that pressure chamber readings (xylem pressure) cannot be directly used as an estimate of leaf water potential, but should be corrected according to a calibration against a thermocouple psychrometer determinations of leaf water potential. Different rates of pressure increase in the chamber affected the regression between xylem pressure and leaf water potential. The regression improved with a greater pressure rate increase as indicated by smaller error variance estimate. No differences were detected between genotypes in this regression.

This technique is, therefore, useful if worked out according to a calibration curve at a standard rate of pressure increase.

10. CONTROL NUMBER: PN-AAB-075

11. PRICE OF DOCUMENT:

12. DESCRIPTORS

Thermocouple Psychrometer, Xylem Pressure, Sorghum bicolor, Pressure Rate Increase, Genotypes

13. PROJECT NUMBER: 931-17-130-575

14. CONTRACT NUMBER: AID/CM-ta-c-1068

15. TYPE OF DOCUMENT: Research Bulletin

AID 590-1 (4-74)

Reprinted from
AGRONOMY JOURNAL, Volume 65
March-April, 1973, p. 337-338



# ON THE PRESSURE CHAMBER TECHNIQUE FOR ESTIMATING LEAF WATER POTENTIAL IN SORGHUM[1]

A. Blum, C. Y. Sullivan, and J. D. Eastin[2]

## ABSTRACT

The purpose of this work was to re-evaluate the pressure chamber technique for estimating leaf water potential in sorghum [*Sorghum bicolor* (L.) Moench], with special reference to problems associated with leaf sample crushing under pressure and pressure rate increase inside the chamber. Pressure chamber readings were compared to Spanner-type thermocouple psychrometer readings on leave of five sorghum genotypes at several stages of growth.

A leaf sample holder, constructed from Silicon rubber and accomodated into a brass flange, reduced leaf crushing under pressure. It was found that pressure chamber readings (xylem pressure) cannot be directly used as an estimate of leaf water potential, but should be corrected according to a calibration against a thermocouple psychrometer determinations of leaf water potential. Different rates of pressure increase in the chamber affected the regression between xylem pressure and leaf water potential. The regression improved with a greater pressure rate increase as indicated by smaller error variance estimate. No differences were detected between genotypes in this regression.

This technique is, therefore, useful if worked out according to a calibration curve at a standard rate of pressure increase.

*Additional key words:* Thermocouple psychrometer, Xylem pressure, *Sorghum bicolor* L. Moench.

THE pressure chamber has been used for estimating leaf water potential in many plant species (1, 2, 4, 5, 6, 7). De Roo (3) recently investigated its use in sorghum [*Sorghum bicolor* (L.) Moench] variety RS 610. He concluded that xylem pressure was an acceptable direct estimation of sorghum leaf water potential. In principle, the pressure chamber method is based on sealing a leaf inside a pressure chamber with its severed petiole protruding externally. Pressure is increased inside the chamber. When xylem sap menisci appear at the surface of the severed xylem vessels, pressure is then an estimate of the water potential of that leaf.

Waring and Cleary (7) pointed out two sources of error in pressure chamber measurements: (i) the sample preparation—They stressed that herbaceous tissue might be crushed when placed between two halves of a standard rubber stopper; and (ii) the rate of pressure increase in the chamber.

The work reported here was done in order to evaluate the pressure chamber technique in more than one sorghum genotype taking into account Waring and Cleary's notes and to evaluate whether pressure chamber readings (xylem pressure) can be used directly as an estimate of leaf water potential, or whether the chamber should be calibrated against thermocouple psychrometer readings.

A pressure chamber system as modified from Waring and Cleary's (7) design was built. Pressurized nitrogen gas was supplied from a No. 3 cylinder[3] through a pressure regulator (3-580), No. 96 flexible hose, needle valve (4174-1505), 6″ pressure gauge (63-6213), and released through a valve (3232M4B) connected to the chamber. Leaf segments were cut, ripped off the midvein, and placed between two halves of a No. 6 rubber stopper. It was found that pressure above 12 bars caused severe leaf crushing, sometimes evinced in minute cracks across the leaf sample. In order to overcome this drawback, a different sample holder was designed (Fig. 1). A brass flange accommodated a soft silicon rubber stopper on one side (sliced into two halves), and a brass disc having a narrow (2-mm) slit on the other side to allow the leaf sample to pass through. This disc can be replaced by other discs having a round hole for the accommodation of stalks, roots, etc. The flange and disc were held in place by a threaded steel cover, tightened with a handle. The silicon rubber stopper was formed by pouring the rubber into the flange in excess, so that shoulders were also formed. With this arrangement, only very slight pressure marks on the leaf sample were observed, even at a pressure of 24 bars. Apparently these shoulders relieved some of the pressure on the leaf sample. Field or growth chamber grown sorghum plants from RS 610, Feterita, Hegari, Dwarf White

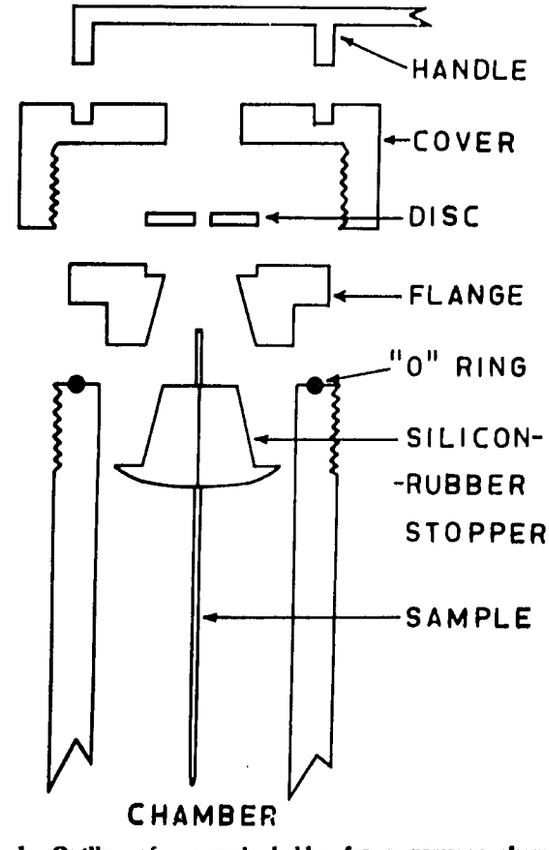


**Fig. 1. Outline of a sample holder for a pressure chamber**

[1] Published with the approval of the Director as Paper No. 3336, Journal Series, Nebraska Agr. Exp. Sta., Lincoln, Neb. This research was supported in part by The Rockefeller Foundation and was carried out under an FAO Research Fellowship to A. Blum. Received May 25, 1972.

[2] Visiting Professor (presently, Research Agronomist, Department of Agronomy, Agricultural Research Organization, The Volcani Center, Bet Dagan, Israel), Department of Agronomy; Associate Professor, Department of Horticulture and Forestry; and Associate Professor, Department of Agronomy, respectively, The University of Nebraska, Lincoln, Neb. 68503.

[3] Parts according to Matheson Catalogue 28, Matheson Gas Products, Joliet, Ill.

Durra and M-35-1 were evaluated at several stages of growth. Samples were taken from the same leaf for xylem pressure and thermocouple psychrometer measurements.

Two rates of pressure increase, 0.33 and 0.38 bars $sec^{-1}$, were tried. In both cases (Fig. 2 a and b) the relation between xylem pressure and leaf water potential was linear, but did not fit the line of equivalency. Pressure chamber readings cannot, therefore, be used directly as an estimate of leaf water potential, and the correct leaf water potential should be read off the regression curve. As indicated from the ratio between error variance estimates for the two pressure increase rates ($\sigma^2$ 0.38/$\sigma^2$ 0.33 = 0.52) a better estimate of leaf water potential from the regression line would be obtained in this case under the higher rate of pressure increase. No differences between genotypes were detected in the regression between xylem pressure and leaf water potential.

Various investigators were concerned with osmotic potential of the xylem sap and indicated that pressure chamber readings would yield a direct estimate of leaf water potential only if the osmotic potential was negligible (1, 2, 3). Osmotic potential in sorghum was found to be negligible (3), but still it can be seen from the results presented here that pressure chamber readings can not be used directly as an estimate of leaf water potential, and are dependent on the rate of pressure increase in the chamber.

The pressure chamber is a worthwhile method for estimating leaf water potential in sorghum, provided care is taken not to crush the leaf sample and leaf water potential values are read of a calibration curve prepared at an appropriate pressure rate increase for the pressure chamber used.

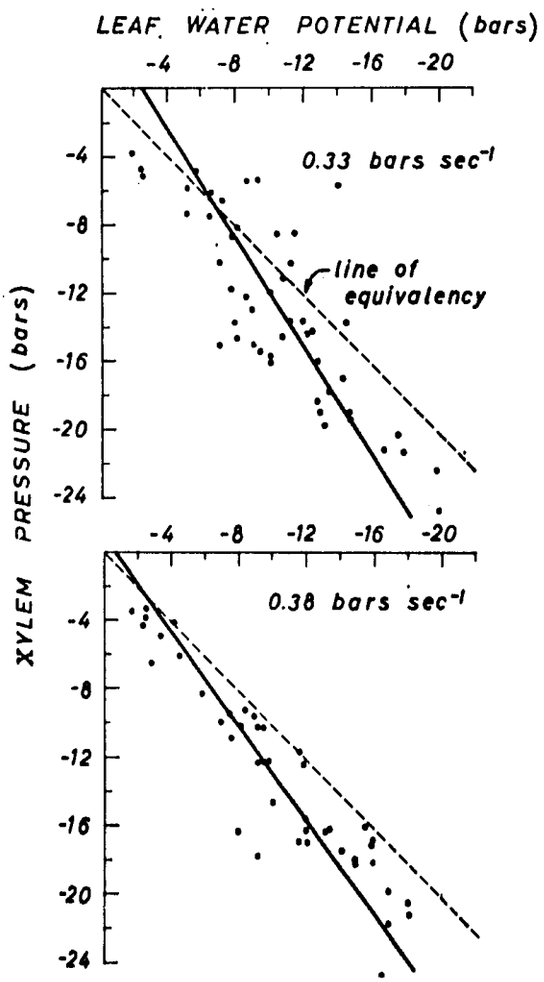


**Fig. 2, a. and b. Xylem sap pressure and leaf water potential values for five sorghum varieties at several stages of growth; at (a) 0.33 bars $sec^{-1}$ and (b) 0.38 bars $sec^{-1}$ pressure increase rate in the chamber.**

## LITERATURE CITED

1. Barrs, H. D., B. Freeman, J. Blackwell, and R. D. Ceccato. 1970. Comparisons of leaf water potential and xylem water potential in tomato plants. Aust. J. Biol. Sci. 23:485-487.
2. Boyer, J. S. 1967. Leaf water potentials measured with a pressure chamber. Plant Physiol. 42:133-137.
3. De Roo, H. C. 1969. Leaf water potentials of sorghum and sorn, estimated with the pressure chamber. Agron. J. 61:969-970.
4. Kaufman, M. R. 1968. Evaluation of the pressure chamber technique for estimating plant water potential of forest tree species. Forest Sci. 14:369-374.
5. Scholander, P. F., H. T. Hammel, E. A. Hemmingsen, and E. D. Bradstreet. 1964. Hydrostatic pressure and osmotic potential in leaves of mangroves and some other plants. Proc. Natl. Acad. Sci. 52:119-125.
6. ———, ———, E. D. Bradstreet, and E. A. Hemmingsen. 1965. Sap pressure in vascular plants. Science 148:339-346.
7. Waring, R. H., and B. D. Cleary. 1967. Plant moisture stress: evaluation by pressure bomb. Science 155:1248-1254.