NOTE: A COMPARISON OF THE PRESSURE CHAMBER APPARATUS AND SHARDAKOV METHOD IN DETERMINING LEAF WATER POTENTIAL OF CASSAVA AND SOYBEAN

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ABSTRACT

The efficiency of the Shardakov or dye method in measuring the leaf water potentials of cassava (*Manihot esculenta* Crantz var. Hawaiian 4) and soybean (*Glycine max* [L.] Merr. var. Clark 63) was evaluated and compared with that of the pressure chamber apparatus. These methods were compared by measuring parallel (same plant), fresh leaf samples subjected to varying degrees of soil drying. Pressure chamber measurements were made on whole leaves while Shardakov method measurements were made on leaf discs. A regression analysis showed an agreement between the two methods. Results indicate that the Shardakov or dye method is as useful as the pressure chamber apparatus in measuring the leaf water potentials of cassava and soybean.

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Leaf water potential is the best and appropriate measure of plant water stress (Kaufman, 1968; Ritchie and Hinckley, 1975). Although plant water status represents an integration of the atmospheric demand, soil-water potential, rooting density and distribution, and other plant characteristics (Kramer, 1983), a true measure of plant water deficit or stress is made on the plant and not in the soil or atmosphere (Clark and Hiler, 1973).

Leaf water potential measurements can serve as guide in timing irrigation to overcome plant water stress. It is determined either by the use of a thermocouple psychrometer, pressure chamber apparatus, or by the Shardakov or dye method. However, in many research institutions in the Philippines, sophisticated facilities and accurate apparatus for leaf water potential determination are not available thus, the Shardakov method is widely used. The technique is easy to carry out, less expensive, and applicable in the field.

This study compares the accuracy of the Shardakov method with the pressure chamber apparatus in measuring the leaf water potential of cassava and soybean.

Seeds of soybean (variety Clark 63) and stem cuttings of cassava (variety Hawaiian 4) were planted separately in pots filled with 7.5 kg of air-dried, sifted soil. Thirty plants of each crop were grown at field capacity until they reached full canopy under an improvised plastic cover with a light transmission of 80%. Control of pests and diseases was properly observed throughout the conduct of the experiment.

When the plants attained full canopy (1 month for soybean and 3 months for cassava), they were subjected to soil water stress. This was done by initially watering the plants to field capacity then withholding water in the succeeding days. Leaf water potential was measured every after 3 days to attain the different degrees of soil drying and to obtain leaf tissues of different water potentials. There were 10 sampling days with three replications each. The completely randomized design (CRD) was used.

Leaf water potential was measured by using the pressure chamber apparatus (Ritchie and Hinckley, 1975) and Shardakov method simultaneously. For the pressure chamber measurements, three leaves were randomly selected from different positions on the stem starting from the fully expanded youngest leaf at the top, and downward to the middle portion of the stem leaving one leaf interval. Leaf intervals were sampled for Shardakov measurements. While sampling for the Shardakov method, the leaves to be used for the pressure chamber were placed in a humid plastic bag to minimize water loss.

Sucrose solutions of varying osmotic potentials were prepared for the Shardakov or dye method according to the procedures of Slavik (1974). Fifteen sucrose concentrations were prepared at 20°C (Table 1). General Shardakov procedures used followed the methods described by Knipling (1967) and Knipling and Kramer (1967) with some modifications. Each test series consisted of 15 sucrose solutions (10 mL each) graduated by 1 bar increment and contained in test tubes. Methylene blue dye was used to color the test solutions. Water potentials of leaves were measured using leaf discs (13 mm dia.) which were prepared using a disc puncher. Three leaf discs per plant were immersed in test solutions for 1 hour. Then, the colored test solutions were introduced using droppers into the mid-portion of the corresponding members of a parallel series of uncolored control solutions. The direction of the drops was observed. The measured leaf water po-

Table 1. Osmotic potential (Ψs bar) of sucrose solutions of various molar concentrations (M — moles per liter of the solution) at 20°C (Slavik, 1974).

Sucrose Concentration (M)	Bar Equivalent (Ψs)
0.040	−1.07
0.075	−2.01
0.115	−3.08
0.150	−4.01
0.190	−5.08
0.225	−6.08
0.260	−7.07
0.295	−8.09
0.330	−9.12
0.360	−10.00
0.395	−11.10
0.425	−12.05
0.455	−13.02
0.485	−14.01
0.520	−15.15

tential was taken to be where the colored drop diffused in all directions. In cases where diffusion in all directions was not observed, the measured leaf water potential was taken to be between the solutions in which the colored drops rose or fell.

Results of simultaneous measurements of leaf water potential by the Shardakov method and pressure chamber apparatus are presented in Figures 1, 2, and 3. Curves of regression equations were drawn from the data.

In both species studied, leaf water potential values obtained by the Shardakov method and pressure chamber apparatus were significantly linearly correlated (Cassava, r = 0.98; Soybean, r = 0.94; Both, r = 0.96) at 1% level of significance. Regression analysis showed an agreement between the two methods over the water potential range measured (especially at -1 to -7 bars).

Results of this study agree with the findings of Detling and Klikoff (1971) who compared the efficiency of the Shardakov method with the pressure chamber in estimating the leaf water potentials of two desert halophytes growing in their native habitat. They observed no significant differences between the two methods over a wide range of water potentials in the two halophytes. In each species, the regression equations for the calibration lines were not significantly different from the lines of equal potential. Spomer and Langhans (1972) observed that the Shardakov and pressure chamber methods appeared to provide relatively good estimates of tissue water potential especially at the higher (lower water stress) value. However, they stated that although the Shardakov method can be used to indicate relative tissue water potential between treatments within a single species, a calibration curve based on thermocouple psychrometer measurements is necessary when absolute water stress measurements are desired.

Although slight variations in measurements by the Shardakov method were observed compared with the pressure chamber apparatus, the results obtained (Figs. 1 to 3) could be used as a calibration curve for converting any leaf water potential (cassava and soybean) value measured by Shardakov method into pressure chamber values. Variations could be attributed to contaminations in the sucrose solution, precision and accuracy of dilutions, and amount of dye (methylene blue) added to the solution. Knipling and Kramer (1967) attributed the high dye method potentials (compared

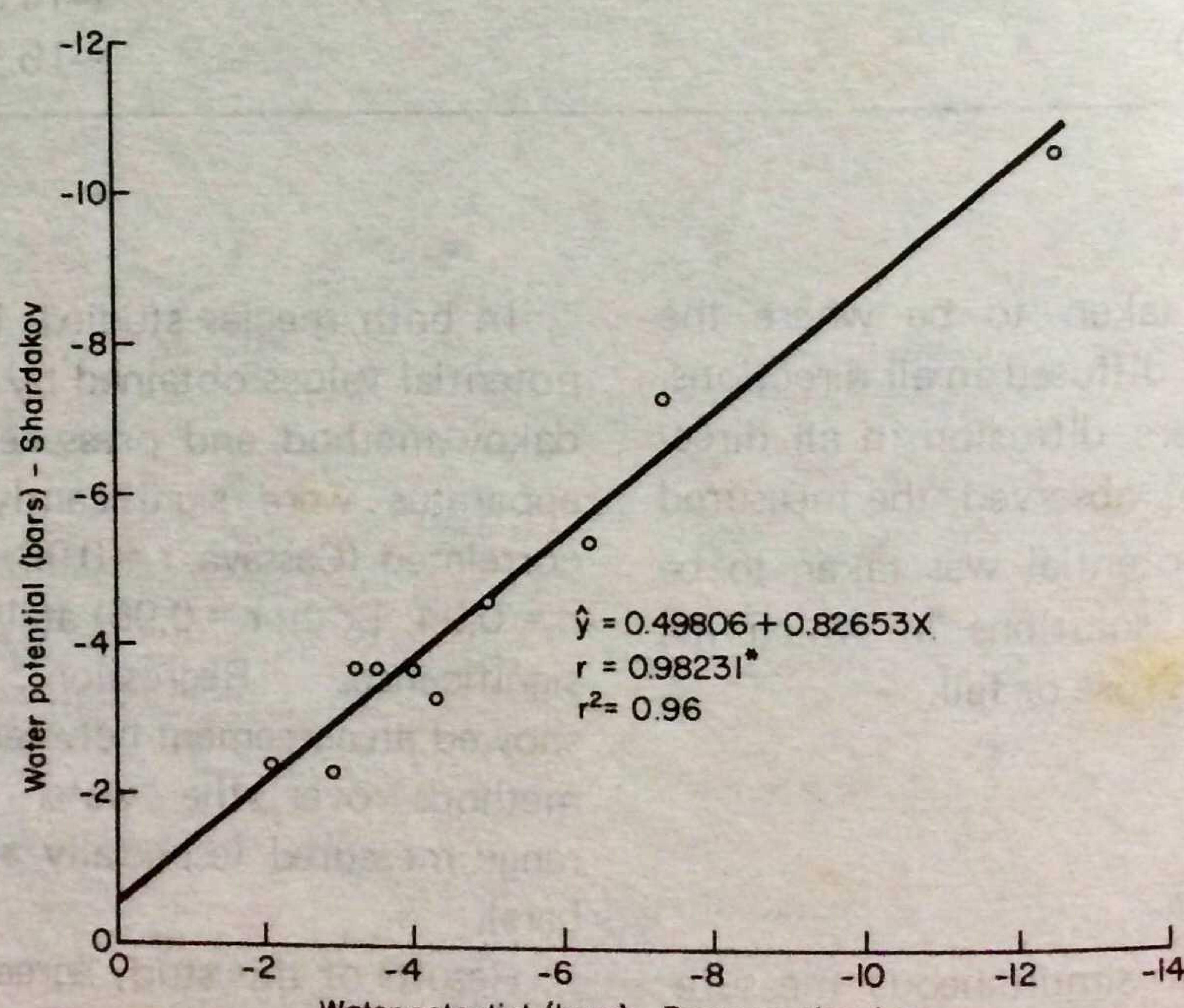

Figure 1. Cassava leaf water potential measured by the pressure chamber apparatus (x) and Shardakov method (y).

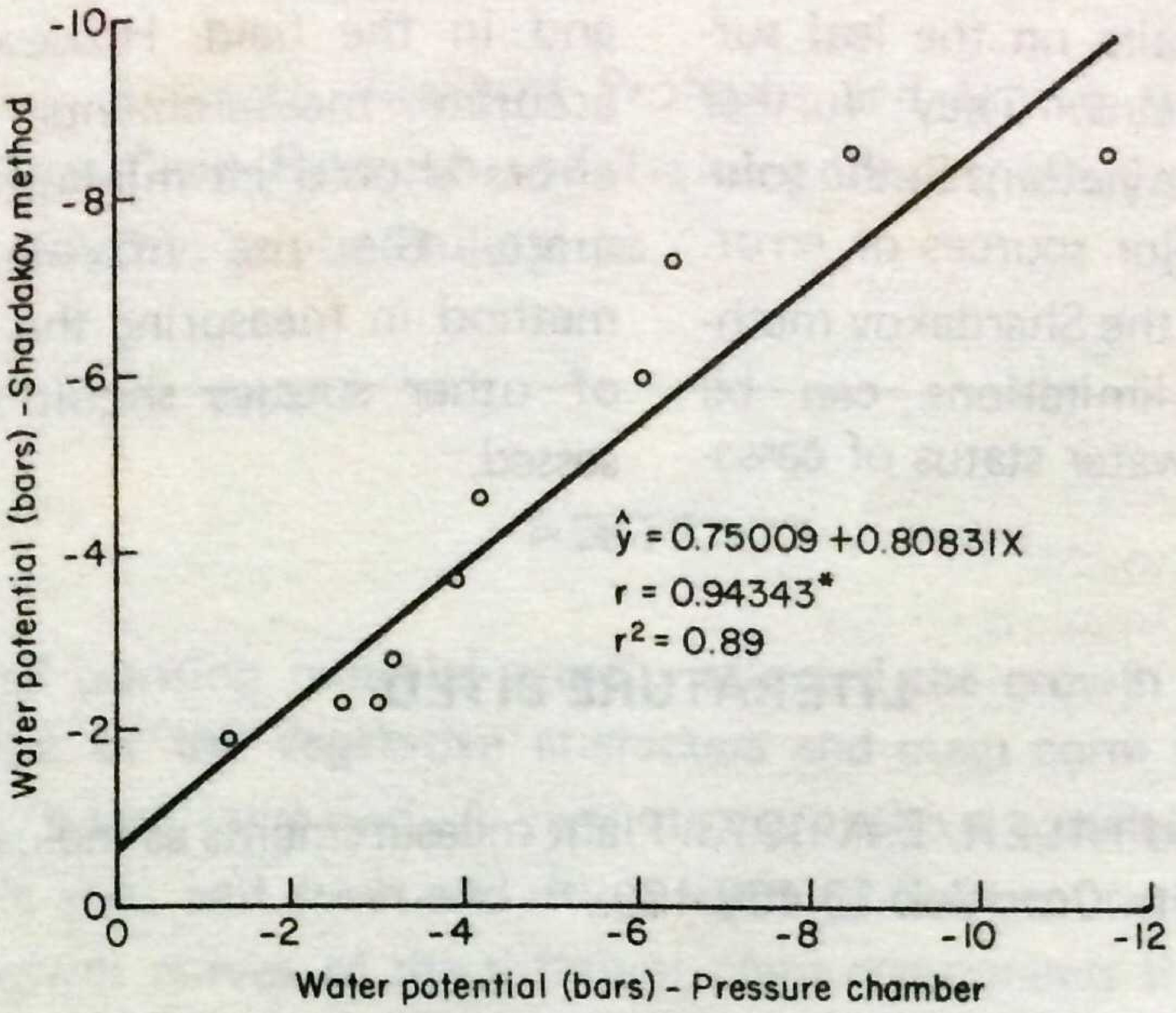

Figure 2. Soybean leaf water potential measured by the pressure chamber apparatus (x) and Shardakov method (y).

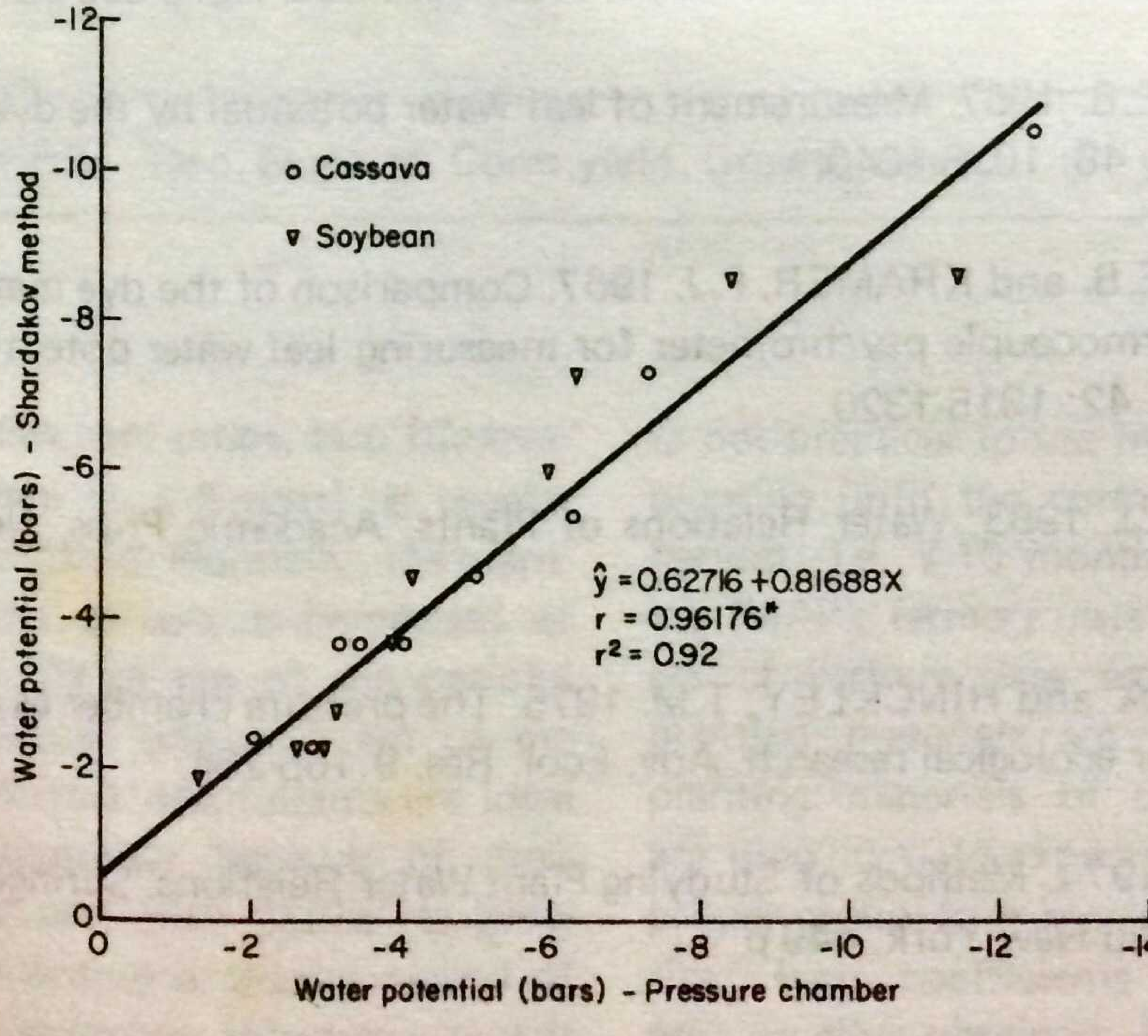

Figure 3. Leaf water potentials of cassava and soybean measured by the pressure chamber apparatus (x) and Shardakov method (y).

with thermocouple psychrometer) of species studied to the low density contaminations secreted into the solutions from glandular hairs on the leaf surfaces and midveins. They further stated that contaminations in the solutions are the major sources of error.

In conclusion, the Shardakov method despite its limitations can be used to measure water status of cassava and soybean. Moreover, the method is simple, easy to learn, less expensive, and applicable both in the laboratory and in the field. However for more accurate measurements, sources of errors should be minimized. Furthermore, the use of the Shardakov method in measuring the water status of other species should also be assessed.

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