A LIMITATION OF PSYCHROMETRIC MEASUREMENTS FOR DETERMINING SOIL-WATER SUCTION

By

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1967

Submitted to the Faculty of the Graduate College
of the Oklahoma State University
in partial fulfillment of the requirements
for the Degree of
MASTER OF SCIENCE
May, 1972

A LIMITATION OF PSYCHROMETRIC MEASUREMENTS

FOR DETERMINING SOIL-WATER SUCTION

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ACKNOWLEDGEMENTS

The author wishes to express his appreciation to Dr. Lawrence G. Morrill, his major adviser, for his help during the course of this study. Appreciation is also extended to Dr. James M. Davidson and Robert D. Morrison for their assistance.

Special appreciation is extended to my wife, Angie, and sons, Trent and Thale, for their sacrifices of time and understanding during the course of this study.

Appreciation is also extended to Mrs. Ann Smith for typing this manuscript.

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CHAPTER I

INTRODUCTION

Tensionmeters have been used extensively to measure soil water potentials[1] under field conditions. Tensionmeters are limited to soil water suctions of less than one bar. Although the neutron probe only measures volumetric soil-water content, it may be used as an indirect measurement of soil-water suction. One disadvantage of the neutron probe for measuring soil-water suction is a soil moisture characteristic curve necessary (for each soil investigated) to establish the relation between volumetric soil-water content and soil-water suction. Since the neutron probe measures volumetric water content to ± 0.5 percent, its use is limited to the lower soil-water suctions.

Thermocouple psychrometers have been used to a limited extent to determine soil-water suction.

Major advantages of thermocouple psychrometers for measuring soil water potential are broad tension ranges in which they are operative, durability, speed of measurement, and the water activity measured is theoretically the same as that encountered by plant roots. The ability to measure activity is one of the primary advantages which makes the thermocouple psychrometer superior to other methods.

Field studies using the thermocouple psychrometers to measure soil

[1] Terminology consistent with International Society of Soil Science, Soil Physics Terminology, Bulletin No. 23, 7 (1963). (Draft report No. 20, 2 (1962).)

moisture suction were instigated at two locations. Technical difficulties concerning the availability of necessary apparatus forced the abandonment of one field study. Field data obtained with the thermocouple psychrometers showed extreme variability. Therefore, laboratory studies using thermocouple psychrometers were initiated. The laboratory studies were made to determine if the variability was due to instrumentation or to field heterogeneity.

CHAPTER II

LITERATURE REVIEW

Numerous articles may be found in the literature describing thermocouple psychrometers. Most of these deal with ascertaining the water potential in plants. The literature cited here will be confined to these theoretical and experimental results that are adaptable to a soil system.

Low and Deming (1952) developed the theory for the relation between soil factors and the chemical activity of water. They give the major factors affecting the activity of water in soils as osmosis, viscosity, Van der Waals forces, gravity, mole fractions, and temperature.

Spanner (1951) was the first to indicate that thermocouple psychrometers were applicable to measuring the activity of water in the range of interest in soils.

Rawlins and Dalton (1967), Rawlins (1966), Richards and Ogata (1958), and Monteith and Owen (1958) present additional thermocouple psychrometer design and procedure theory for measuring the chemical activity of water. Rawlins (1966) gave the most rigorous development (given below) of this theory and indicated that psychrometer geometry of both the thermocouple and the chamber in which it is contained, temperature, water activity, and barometric pressure would affect the voltage response obtained for a given thermocouple psychrometer.

Thermocouple electromotive force, E, is given by the equation:

$$E = a \Delta T \qquad (1)$$

where a is the thermoelectric power of the thermocouple and ΔT is the temperature depression of the thermocouple bulb below the temperature of the reference junction. (See Figure 1 for thermocouple psychrometer construction information.)

The relation between water potential, Ψ, and relative humidity, R. H., is given by:

$$\Psi = \frac{RT}{v} \ln (R.H.) \qquad (2)$$

where:

R = Universal gas constant,

T = Temperature on absolute scale,

v = specific molal volume of water,

and ln = logarithm to the base e.

Solving equations of heat gain and loss within the sample chamber for the temperature depression gives:

$$\Delta T = \frac{\left[4\, r_j r_c \,/\, (r_c - r_j)\right] \; D \; L \; (C_T S) \; \left[1 - \exp\left(\frac{v \Psi}{RT}\right)\right]}{16\, \sigma\, r_j^2\, T^3 + r_w^2\, K_w\, g + (4\, r_j r_c)/(r_c - r_j) \; (K_a + DBL)} \qquad (3)$$

where;

r_j = radius of the wet thermocouple junction,

r_c = radius of the sample chamber,

D = diffusion coefficient for water vapor in air,

L = latent heat of vaporization of water,

$C_T S$ = saturated vapor pressure at temperature T,

σ = Staflan - Boltzman constant (1.36×10^{-12} cal sec^{-1}cm^{-2} $^{o}K^{-4}$),

r_w = the radius of thermocouple wires,

K_w = average heat conductivity of the thermocouple wires,

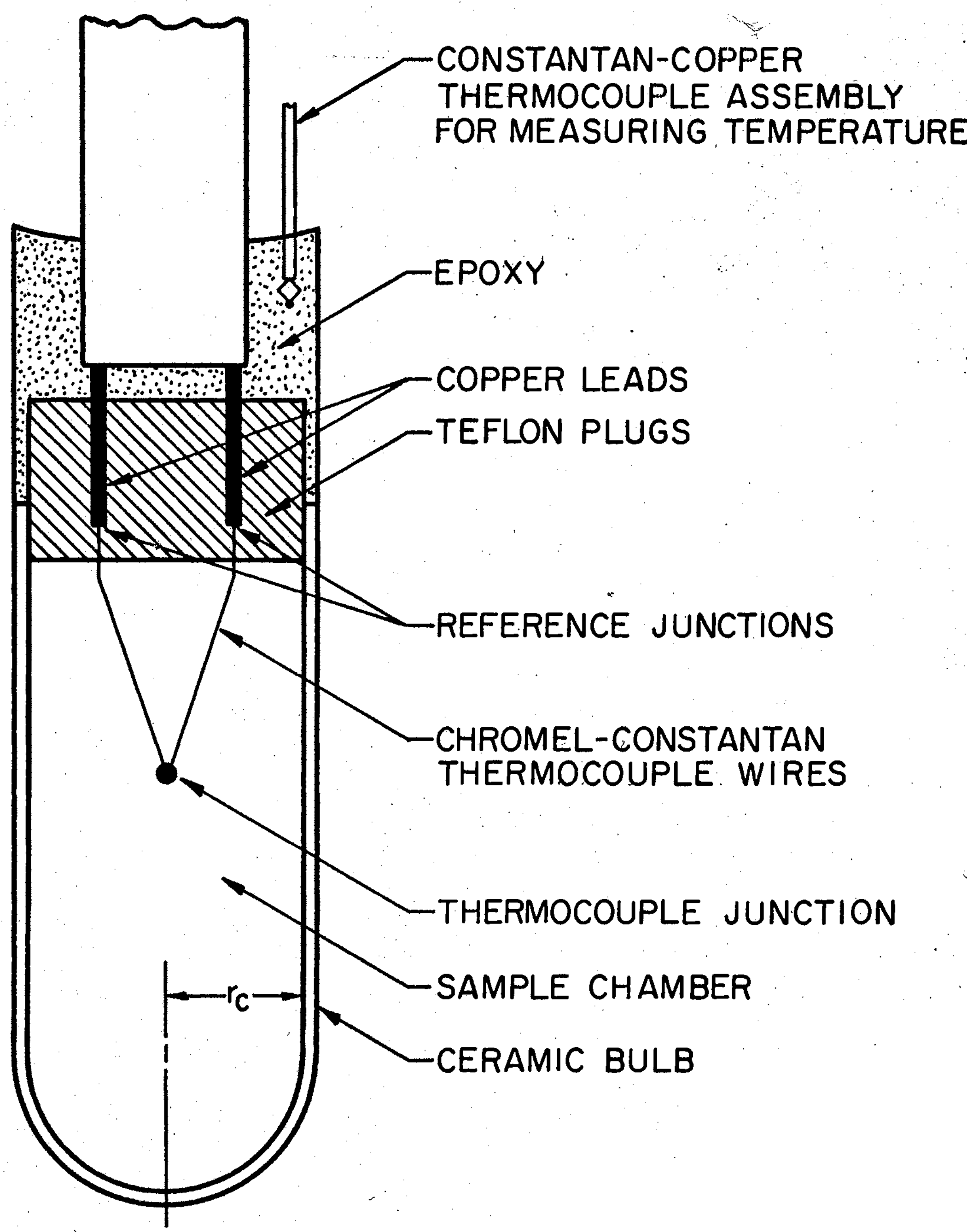

Figure 1. Longitudinal cross sectional view of Peltier effect soil thermocouple psychrometer.

K_a = average heat conductivity of air,

B = slope of the saturated vapor pressure-temperature curve at T,

$$g = 2\left\{\frac{2\pi/\left[\ln(r_c/r_w)\right] + 8\pi r_w \sigma T^3}{r_w^2 K_w}\right\}^{\frac{1}{2}}$$

and the other symbols are defined as before. The references to the thermocouple psychrometer components are depicted in Figure 1.

Substituting this in equation 1 gives:

$$E = \frac{a\left[4 r_j r_c/(r_c - r_j)\right] DL (C_T S)\left[1 - \exp\left(\frac{v\Psi}{RT}\right)\right]}{16\sigma r_j^2 T^3 + r_w^2 K_w g + \left[(4r_j r_c)/(r_c - r_j)\right](K_a + DBL)} \qquad (4)$$

For a given thermocouple psychrometer and barametric pressure this equation can be reduced to:

$$K\frac{E}{T} \cong f(\Psi) \quad \text{where K is a constant.} \qquad (5)$$

Thus for a given temperature the response could be given by:

$$K'E \cong f(\Psi) \text{ where K' is a constant.} \qquad (6)$$

If equation 3 is plotted for a given temperature, psychrometer, and pressure, the result is a straight line up to suections of 100 bars.

The dependency of the equation on the barometric pressure is through the factor D given by:

$$D = D_o(P\,P_o^{-1}) \qquad (7)$$

where D_o is the diffusion coefficient for air at reference pressure P_o and P is the pressure of the sample.

Wiebe et al. (1971) indicates that these same factors were still thought to be the only ones which affect the response of a given psychrometer. Calculations with their data and theoretical equations indicate that maximum error resulting from natural changes in barometric pressure and/or water potential changes from zero to negative ten bars should be less than a few hundredths of one per cent.

A cooling current is required to condense water on the thermocouple junction. Wiebe et al. (1971) reported that any cooling current between 3.5 and 4.0 ma could be used without producing significant errors. However, the duration of time the current was applied is related to the water potential. Current application time of too short a duration result in voltage responses that are too small. However, longer current application time may result in too large a voltage response.

The influence of temperature on thermocouple psychrometer sensitivity is more pronounced than either barometric pressure or water potential. Not only does the temperature influence the thermocouple junction response, but Rawlins (1966) indicates that it affects the diffusivity of water vapor, saturated water vapor pressure, thermoelectric power of the thermocouple, thermal conductivity of the air, and the heat of vaporization for water. Monteith and Owen (1958) and Spanner (1952) show that the response of the thermocouple psychrometer was linear for a specific sample chamber at a given temperature. According to Hoffman and Splinter (1968 a, b), the temperature of the thermocouple junction must be known to the nearest 0.001°C in order to determine water potential to the nearest tenth of a bar. Rawlins and Dalton (1967) calculate that a two percent error was introduced by a one degree error in the measurement of the ambient temperature. Brown (1970) proposed that a temperature gradient across the sample chamber would tend to give rise to one of the largest errors involved in thermocouple psychrometer measurements.

The theoretical range of thermocouple psychrometers is for water activities between 1.00 and 0.95 (0 to approximately 40 bars suction). Experimental results of Spanner (1951) do not extend up to a water activity of one. Richards and Ogata (1958) report data only down to -5.0 bars water potential. They report an error of about 3 percent. Hoffman, Herkelrath, and Austin (1969); Millar, Lang, and Gardner (1970); Rawlins (1966); Brown (1970); and Box (1965) all present data which ranges from high suctions of 10 to 12 bars (-10 to -12 bars water potential) down to 1.5 bars (-1.5 bars water potential).

Monteith and Owen (1958) found that their lower limit of measurement corresponded to a water suction of about 0.4 bars.

Lang (1968) reported standard errors of ± 1.57 bars for sand and ± 0.75 bars for loam. Kay and Low (1970) developed a new technique which gave a standard error of ± 0.0226 bars by using matched thermocouples and resistance wires instead of a Nanovolt meter. Richards and Ogata (1961) report a standard error of ± 0.5 bars. Klute and Richards (1962) found a standard error of ± 1 bar.

New developments in thermocouple psychrometer technology have been made by several researchers. Miller, Lang, and Gardner (1970) developed systems for determining water potentials in soils which would minimize the effect of a temperature gradient. A new welding technique was proposed by Lopushinsky (1970) which would provide a thermocouple psychrometer that operates more satisfactorily at higher suctions than most of those presently used.

Investigations with respect to the effect of salts in soil on the activity of water were made by Ingvalson et al. (1970). They observed that high salt concentration coupled with high matric suction tended to give too high of a water potential when the two determinations were added up for matric suction and salt content versus the thermocouple psychrometer determination. Using salt free soil, Richards, Low, and Decker (1964) and Kay and Low (1970) established that the pressure membrane and thermocouple psychrometer were measuring the same water potential.

According to Papendick, Cochran, and Woody (1971) gravimetric and pressure plate methods are unsatisfactory for field work at water potentials below -15 bars. They found that, within this potential range, the thermocouple psychrometer was a superior tool and could be used to infer the maximum rooting depth.

From their measurements with plant and soil systems Rawlins, Gardner, and Dalton (1968) concluded that errors caused by temperature gradients were large enough to make their data erratic. Using a temperature compensated thermocouple psychrometer, Hsier and Hungate (1970) found that readings were more easily made. Studies conducted by Campbell and Gardner (1971) showed that changes in soil temperatures do not change the potential of the soil water to any large extent.

According to Zollinger, Campbell, and Taylor (1966) the condensation of water on the thermocouple psychrometer junction, before the measurements are made, produced only a small error in measurements.

CHAPTER III

MATERIALS AND METHODS

Laboratory study: Three laboratory investigations were conducted. These were (1) a calibration check of the thermocouple psychrometers as received from the manufacturer, (2) soil moisture characteristic curves, and (3) determining and recording thermocouple responses to molal solutions (number of moles of solute per 1000 grams solvent).

Calibration: Eighty thermocouple psychrometers were obtained (Wescor model numbers PT51-05 and PT51-10). Ten thermocouple psychrometers were selected and placed in treatments of 1.0, 2.0, 9.3, 22.4, 34.5, 46.4, 59.4, 71.6 bars osmotic suctions. One thermocouple psychrometer was placed in each treatment and an additional one was placed in the 2.0 and 9.3 bar solutions. The osmotic suctions were calculated according to Robinson and Stokes (1955). The solutions containing thermocouple psychrometers were placed in styrofoam containers and allowed to equilibrate at room temperature. The voltage response of the thermocouple psychrometers was then obtained using a Keithley nanovoltmeter (Model number 72133).

Moisture characteristic curves: Three undisturbed core samples were collected from each depth (30 and 60 cm) at six locations within the experimental area used for the field study. For the samples from a given depth, two, selected at random, were assigned to each pressure of 0.1, 0.33, 0.50, 1.0, 2.0, 5.0, and 15.0 bars. The remaining four samples at each depth were used to determine bulk density.

Thermocouple psychrometer response to molal solutions: Molal solutions of osmotic suctions 0.00, 0.49, 0.90, 2.80, 3.68, 4.54, 15.72, 22.44, and 29.28 bars were selected. Since the manufacturer's suggested procedure to calibrate an individual unit was to obtain the response to a solution with osmotic suction of about 22 bars, each thermocouple psychrometer was checked by this procedure. All thermocouple psychrometers gave readings within $\pm$ 5% of the standard curve in (Figure 2) at 22 bars suction. Extreme precautions in washing and handling were taken to insure that these units were free from salt contamination in all phases of the investigation.

Thermocouple psychrometric responses to these solutions were recorded with a Sargent recorder (Serial Number 345). Determinations were made after a standard cooling time of 10 sec. Two or more recordings for each tension were made. The readings were made in a constant temperature room with air temperature at 25 $\pm 2.7^{\circ}C$. There was no detectable variation in the temperature of the solutions. Response readings were also taken with a Keithly nanovoltmeter.

Field Study: Field studies were made in a good uniform stand of alfalfa at Tipton, Oklahoma. Twenty-four plots were enclosed by a levy and flood irrigated. Approximately 12.5 cm of water were applied every two weeks. Two psychrometers were located at soil depths of 30 cm and 60 cm. Thermocouple psychrometer readings, soil temperature readings, and gravimetric soil samples (in the immediate vicinity of the sensors) were taken every two days.

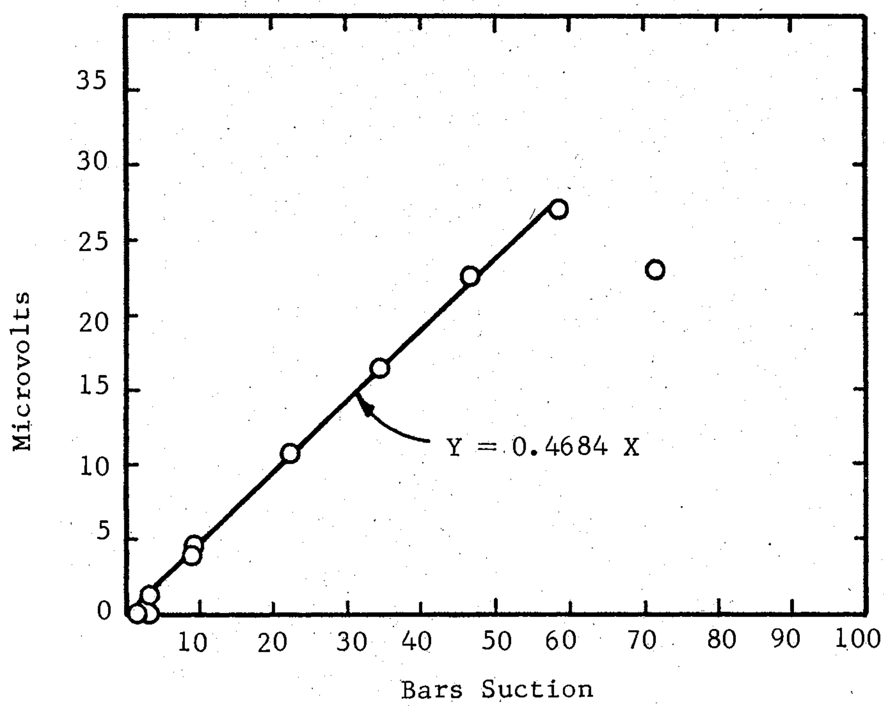

Figure 2. Microvoltage response as a function of molal suction.

CHAPTER IV

RESULTS AND DISCUSSION

The results of the calibration check are depicted in Figure 2. Voltage responses were obtained by setting the nanovolt meter on zero, depressing the cooling switch for 2-5 seconds for solutions less than ten bars suction, and for ten seconds for solutions greater than ten bars suction. The resultant initial voltage surge was taken as the reading. This reading procedure will be referred to in Table I in the appendix as method "A".

The properties of the field soil are given in Table II. The soil is classified as a Tipton loam. The soil is not characterized by an excessively high free salt content. If the salt content is dilute enough to obey the Debey-Huckel equation, the suctions due to salt at 25° C and 1 atm barometric pressure should be 1.17, 1.72, 2.03, 2.15, and 2.21 bars at a matric suction of 0.10, 0.33, 0.50, 1.00, and 15.0 bars respectively at the 30 cm depth using the moisture characteristic curve shown in Figure 3. Similarly for the 60 cm depth, the suctions for the same conditions would be 1.17, 1.63, 1.75, 2.12, and 2.17 bars at a matric suction of 0.10, 0.33, 0.50, 1.00, and 15.0 bars respectively using the moisture characteristic curve shown in Figure 4.

This calculation assumes no interaction between the soil particles and ions that exist in solution. The soil particles per se do not contribute significantly to the molal suction of the soil solution.

TABLE II

CHEMICAL AND PHYSICAL PROPERTIES OF TIPTON LOAM

Property	30 cm depth	60 cm depth
% Sand	46.05	47.93
% Silt	38.20	35.82
% Clay	15.75	16.25
Bulk Density (g/cm^3)	1.48	1.31
Soil pH	7.1	7.2
Soil Extract pH	8.4	8.5
Extractable Calcium (ppm)	10.0	10.0
Extractable Magnesium (ppm)	0.2	2.0
Extractable Sodium (ppm)	84.0	68.0
Extractable Chloride (ppm)	36.0	36.0
Extractable Sulfate (ppm)	36.0	5.0
Extractable Carbonate (ppm)	0.0	0.0
Extractable Bicarbonate (ppm)	128.0	165.0

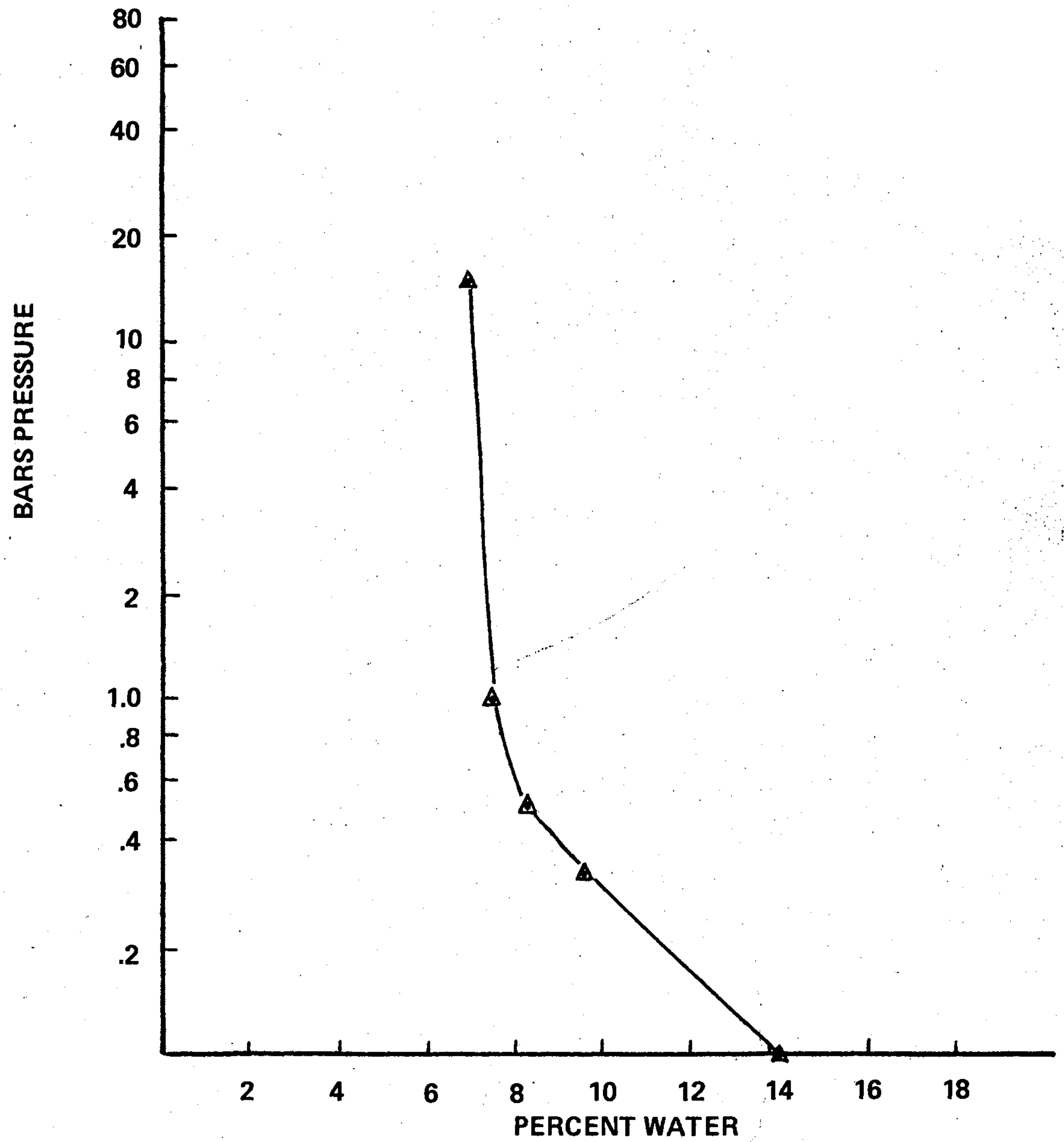

Figure 3. Tipton loam moisture characteristic curve for 30 cm depth.

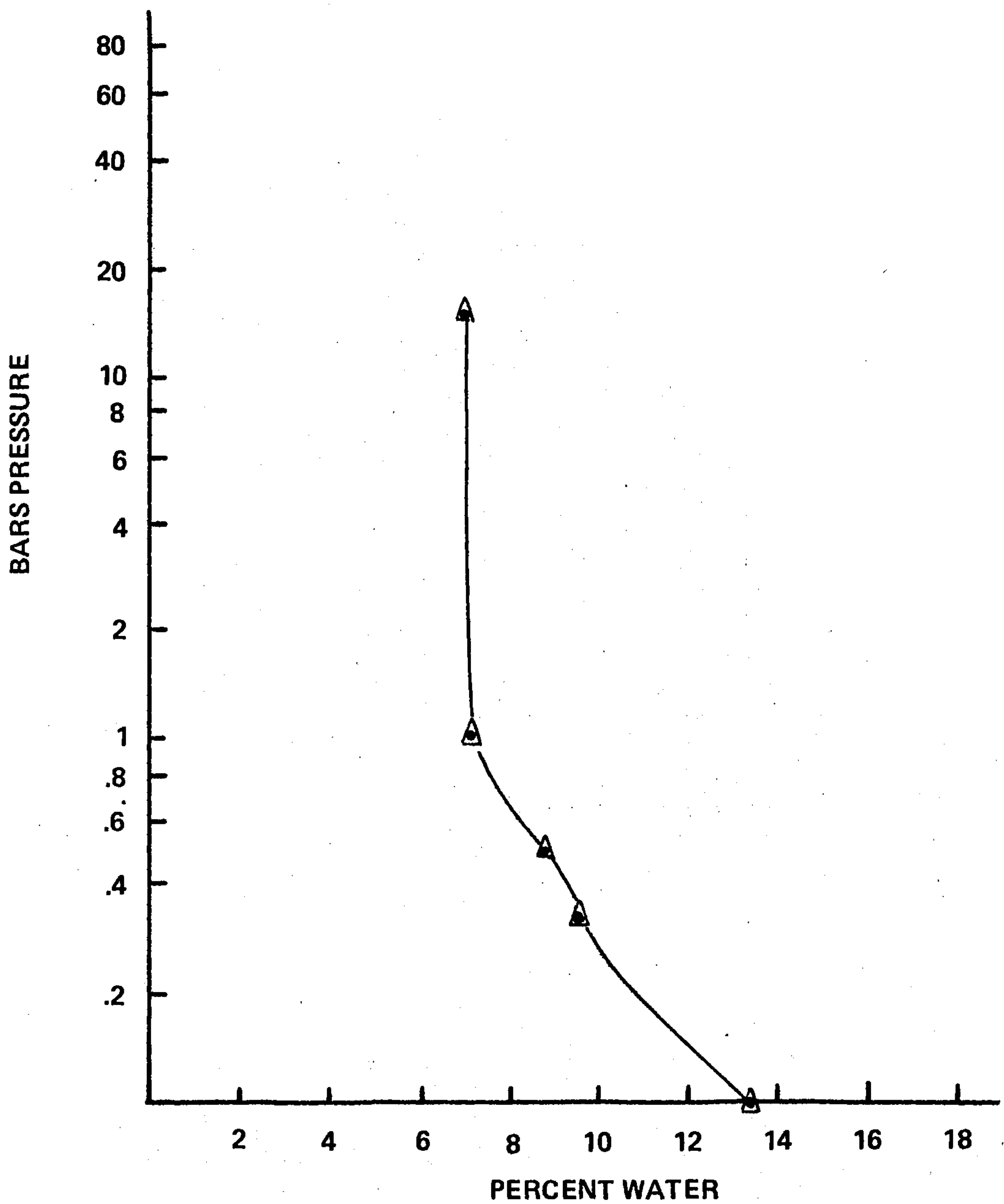

Figure 4. Tipton loam moisture characteristic curve for 60 cm depth.

However, the ions are not free and according to Richards et al. (1964) and Kay and Low (1970) the suctions should be the same as those developed by the pressure membrane. Calculations indicate that the results in Table I (Appendix) are erroneous. Immediately following an irrigation the maximum suction owing to osmotic sources would be less than that shown in Table I. Therefore, the procedure for obtaining readings was thought to be erroneous when one considers the water suctions that normally exist in the soil following an irrigation.

Thermocouple psychrometer responses to various osmotic solutions are depicted in Figures 5 through 13. The microvoltage response curve is flat for the first ten seconds in each case. The flat portion of the response curves is obtained during the cool time, i.e. time that a current is being passed through the thermocouple junction to condense water vapor on it. The cooling time is followed by a surge in voltage from which the initial maximum is taken for the thermocouple psychrometer response reading. It is interesting to note the general shape of each curve and the initial voltage surge.

The thermocouple psychrometer response to a molal solution of 0.0 bars is shown in Figure 5. Of special interest in Figure 5 is the immediate change when the cooling current was applied. The voltage recorded did not remain zero as for the other response curves in Figures 5 through 13.

The thermocouple psychrometer response shown in Figure 6 is more characteristic of those obtained by thermocouple psychrometers used for higher suctions. There does not seem to be any appreciable zero drift with this thermocouple psychrometer.

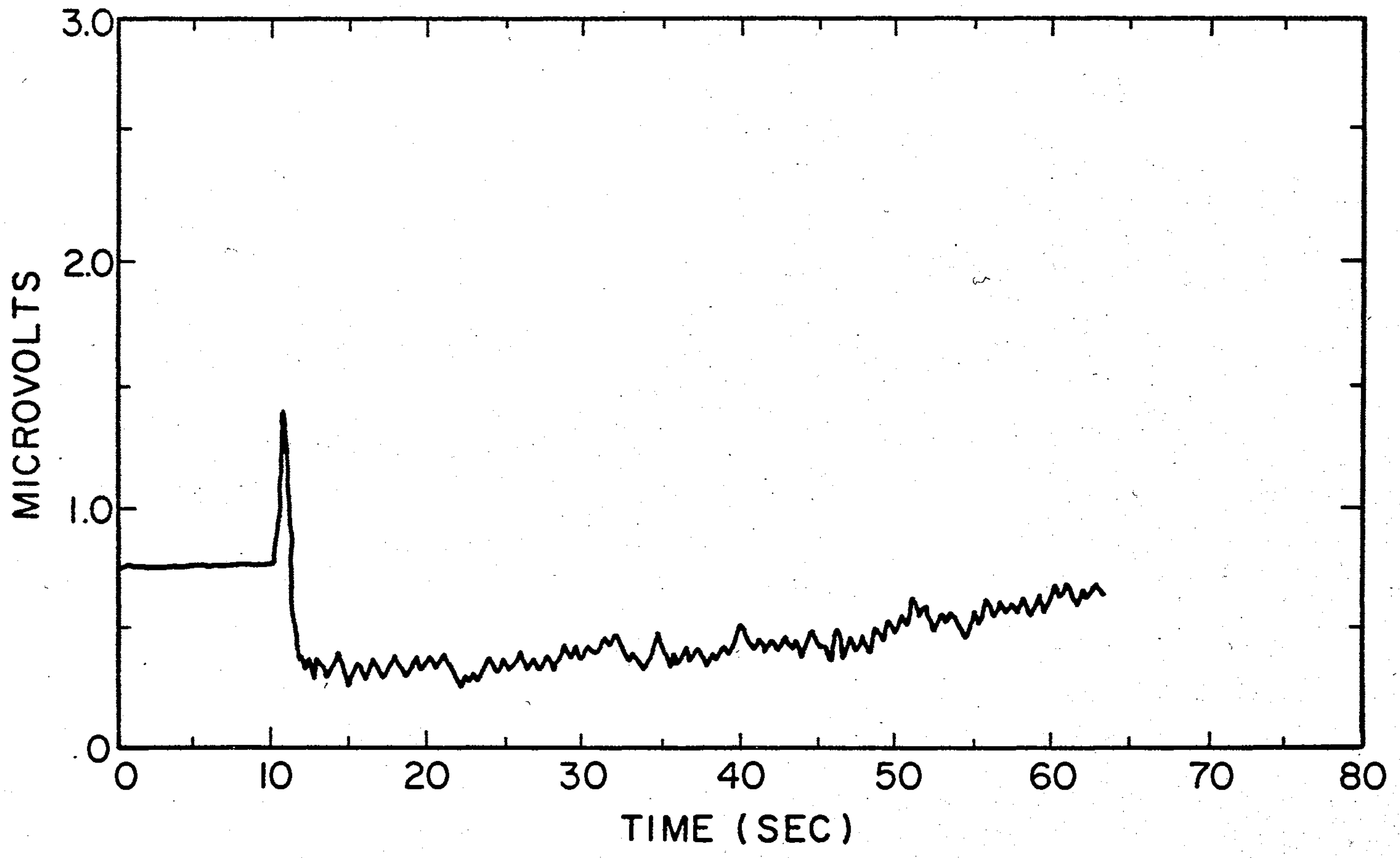

Figure 5. Microvolt response to a molal suction of 0.0 bars as a function of time.

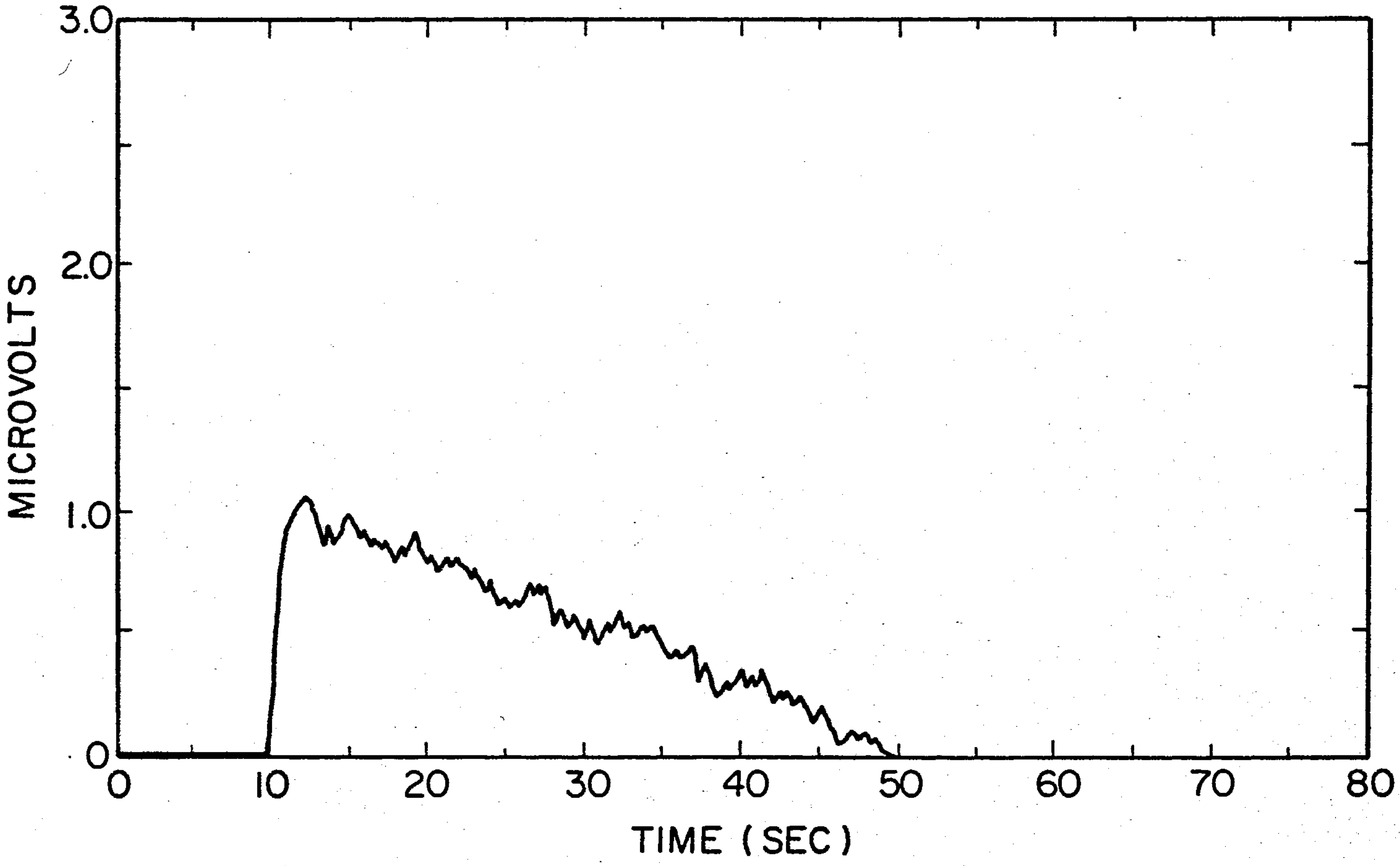

Figure 6. Microvolt response to a molal suction of 0.49 bars.

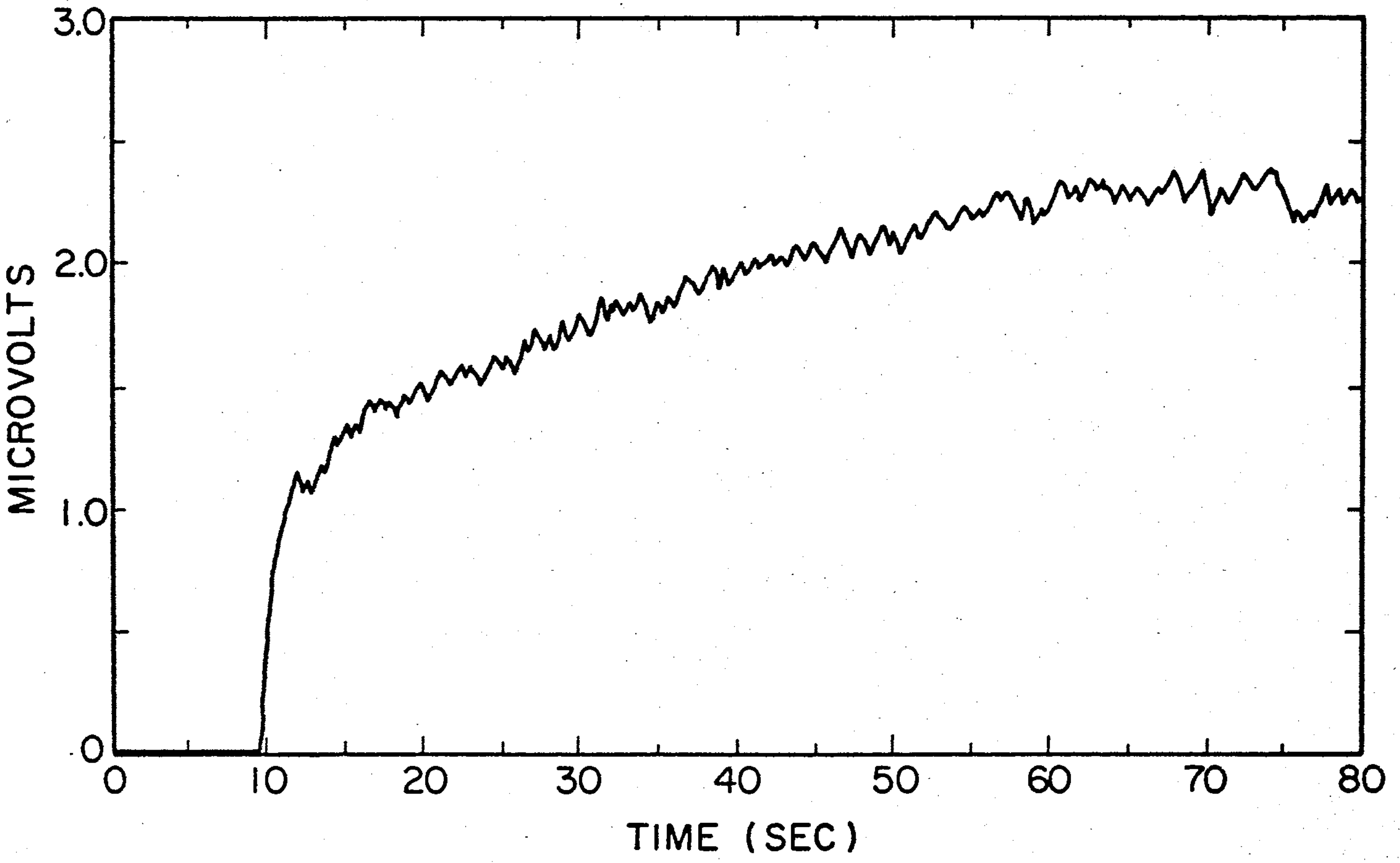

Figure 7. Microvolt response to a molal suction of 0.90 bars as a function of time.

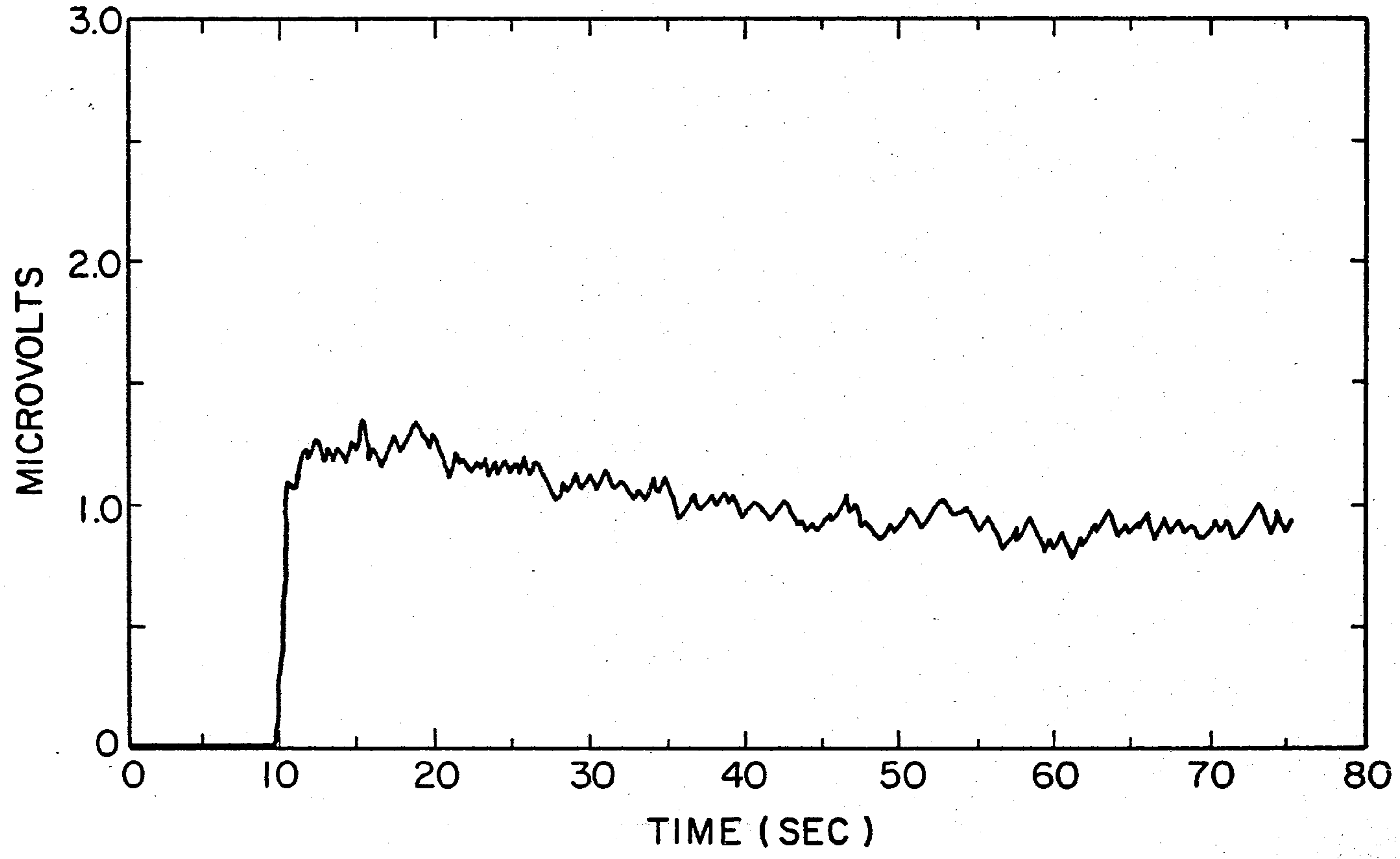

Figure 8. Microvolt response to a molal suction of 2.80 bars as a function of time.

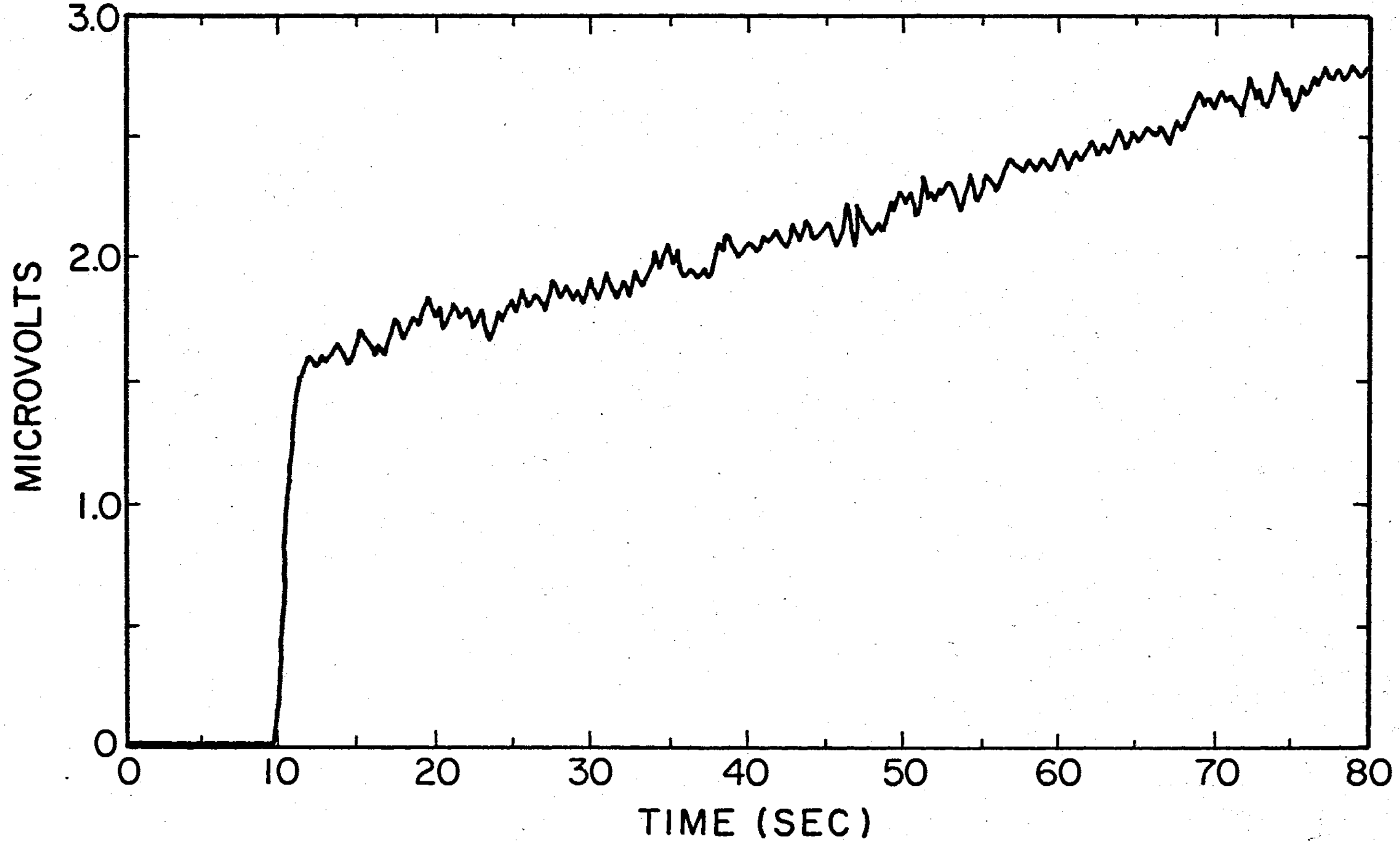

Figure 9. Microvolt response to a molal suction of 3.68 bars as a function of time.

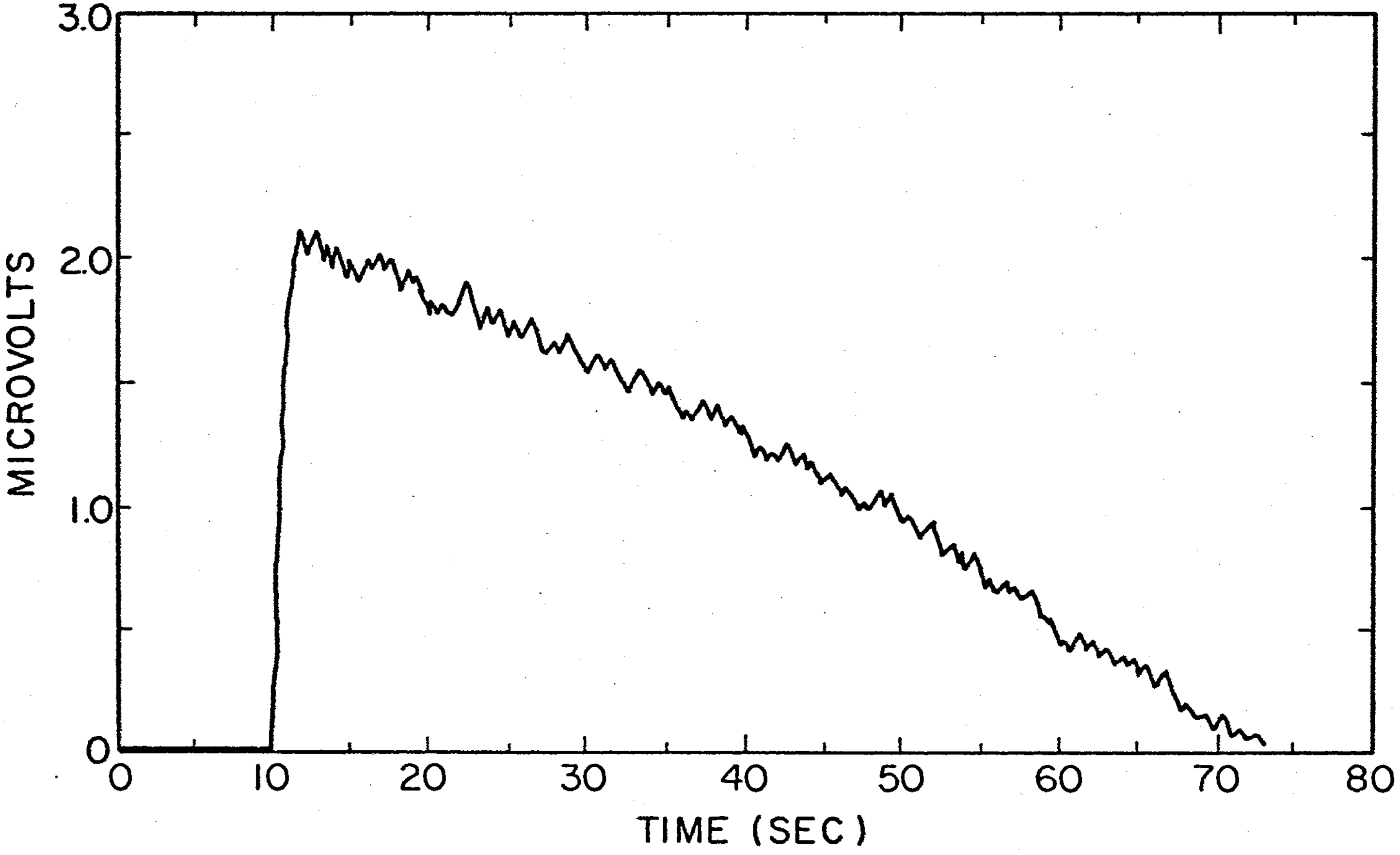

Figure 10. Microvolt response to a molal suction of 4.54 bars as a function of time.

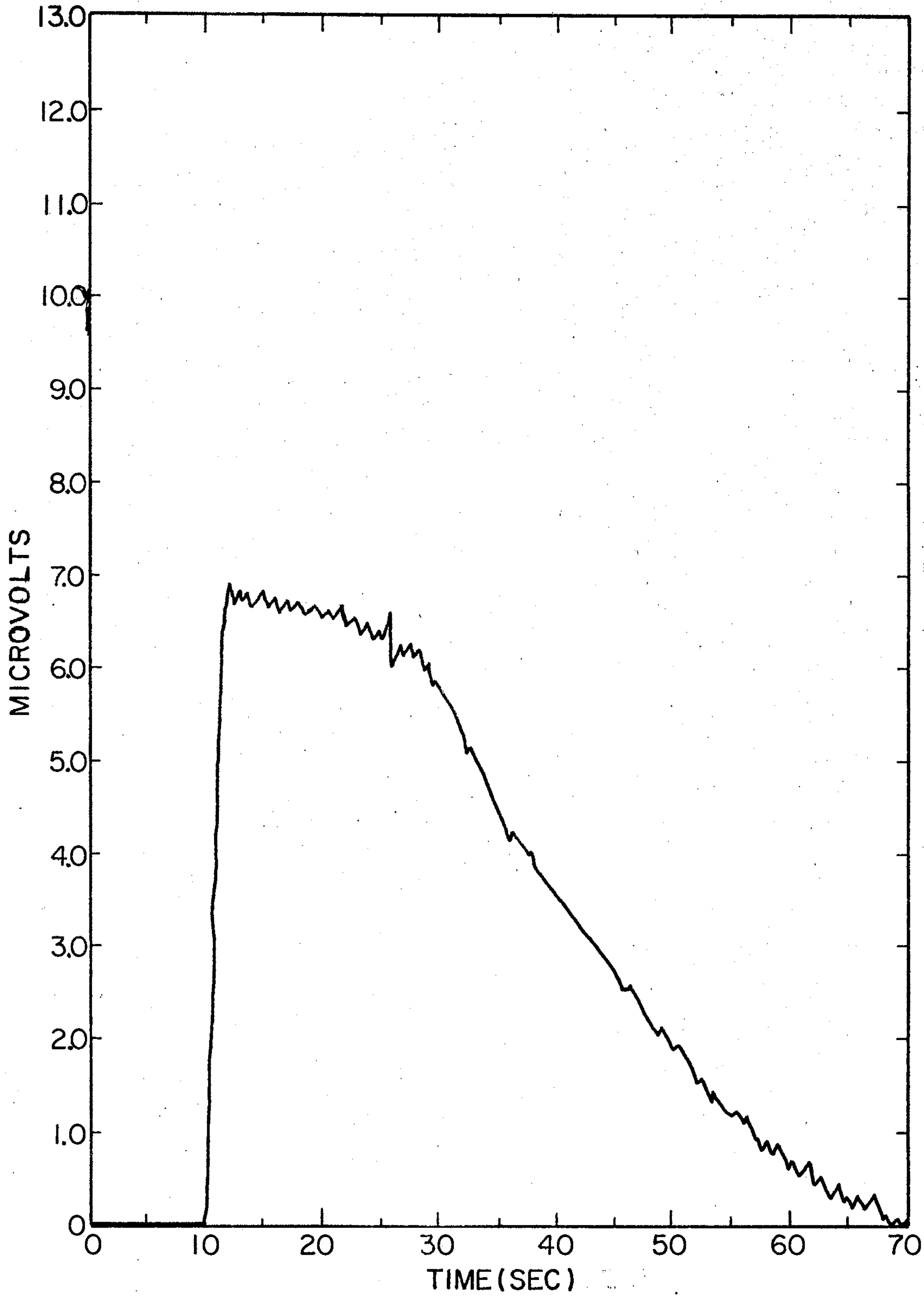

Figure 11. Microvolt response to a molal suction of 15.71 bars as a function of time.

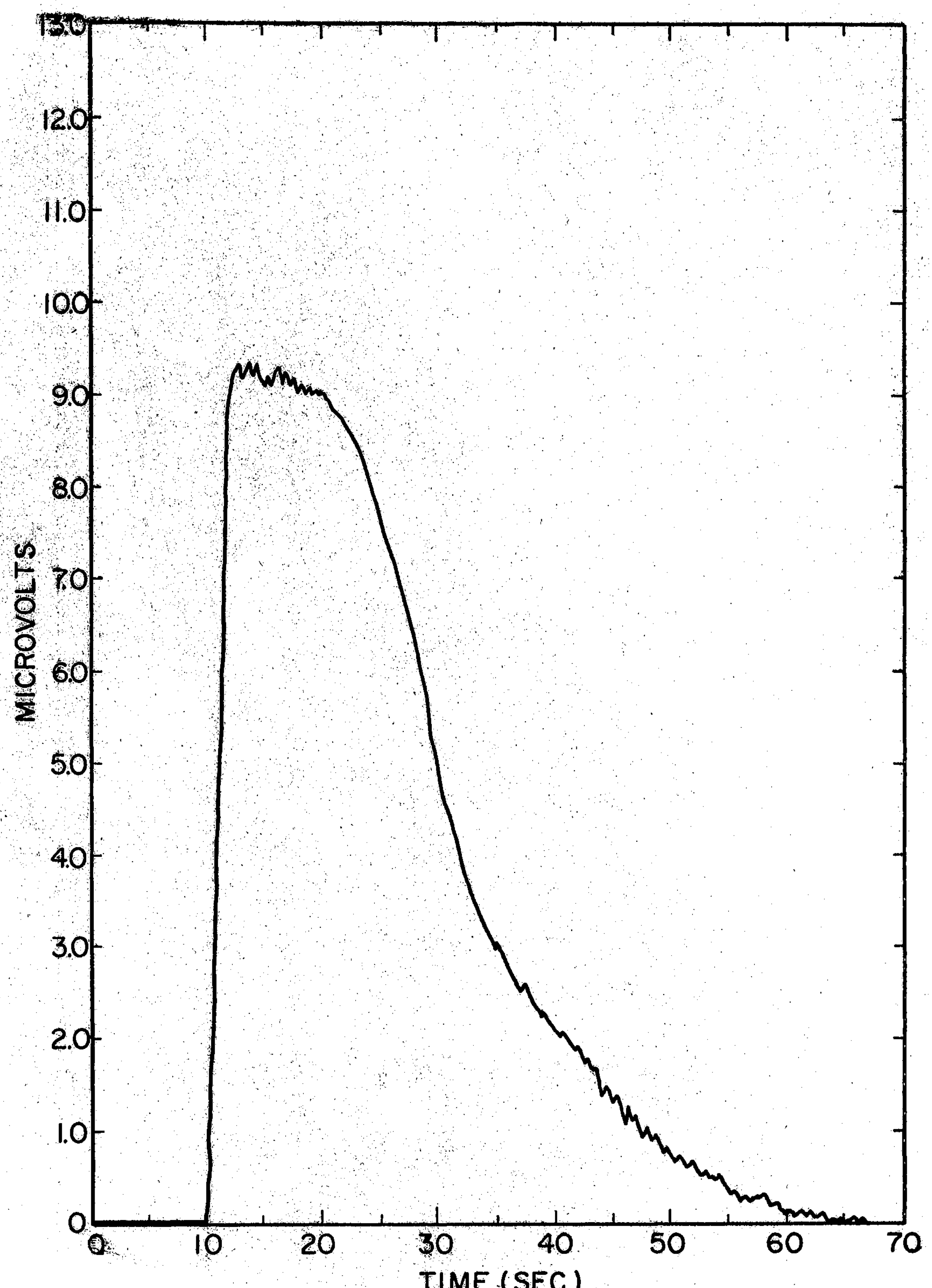

Figure 12. Microvolt response to a molal suction of 22.44 bars as a function of time.

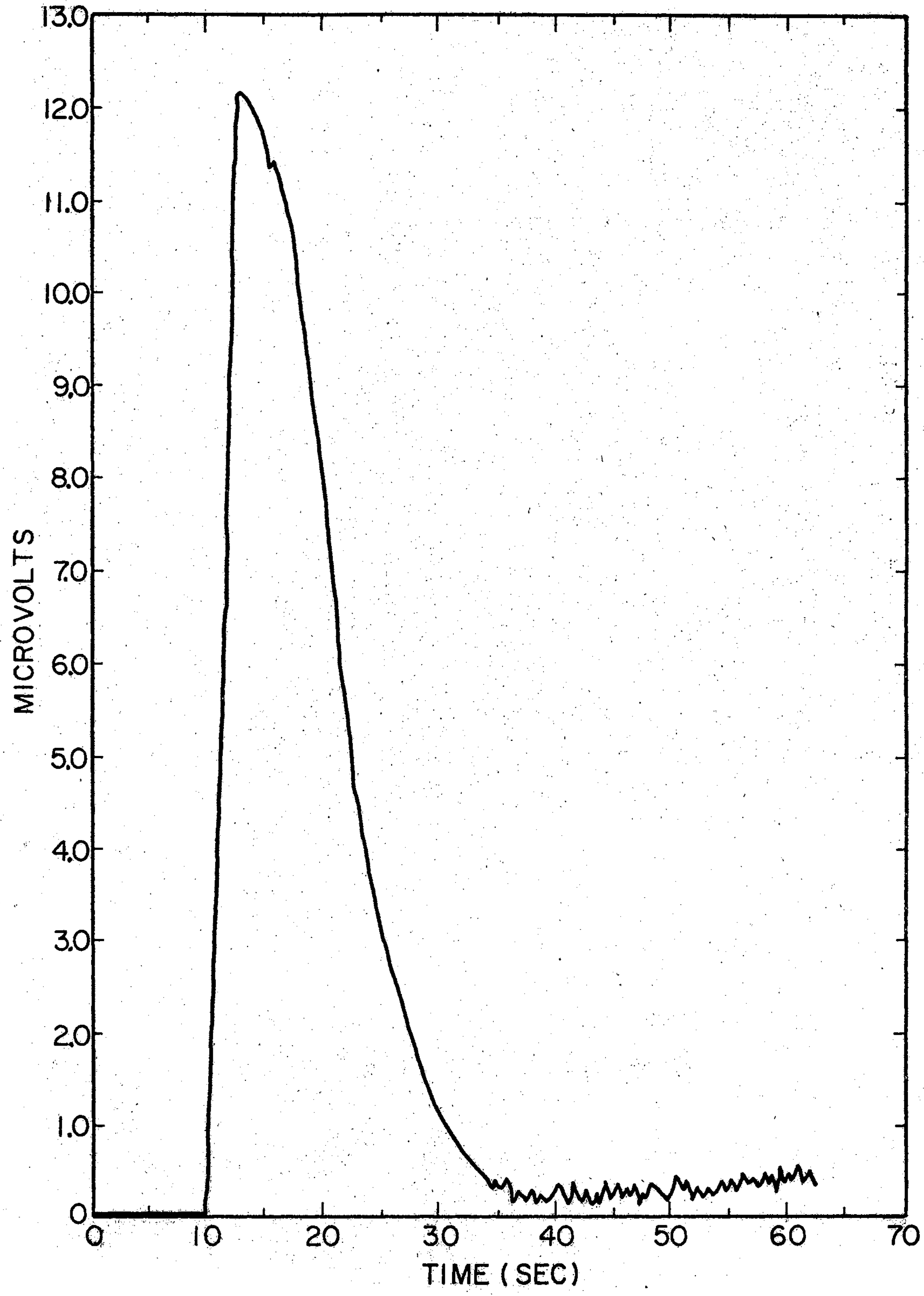

Figure 13. Microvolt response to a molal suction of 29.28 bars as a function of time.

The overall shapes of the response curves in Figures 7, 8, and 9 are quite different from the rest of the response curves obtained. These response curve types may be the result of zero drift. However, repeated measurements with the same thermocouple psychrometer yielded nearly identical response curves. These results suggest that the individual responses may be due to inherent properties of the individual thermocouples.

The response curves shown in Figures 10, 11, 12, and 13 are the types generally exhibited as typical thermocouple psychrometer responses. Note that after the voltage surge, each of the response curves return to the initial zero setting.

Another difficulty associated with the readings is not depicted in the recordings. When a voltmeter was used to make the determination by reading the maximum deflexion after cooling, an initial voltage surge appears when the cooling current is stopped. If the voltage surge had not been filtered out by the recorder, a large initial voltage spike would have appeared in Figures 5, 6, 7, 8, 9 and 10. Such a voltage spike would lead to even more deviations from a linear relation between water suction and response. Figure 14 shows a plot of readings obtained with the nanovoltmeter for osmotic suctions below 5.0 bars at the same time that voltages were recorded (Figures 5 through 13). The initial maximum microvolt response recorded per bar of osmotic suction is exhibited in Table III. It is interesting to compare this with the meter reading and the calculated suction from the linear portion of the curve in Figure 2. It was clear, after examining the curve in Figure 14 and the microvolt response per bar of osmotic suction in Table III, that the initial voltage "spike" was not related directly to water potential.

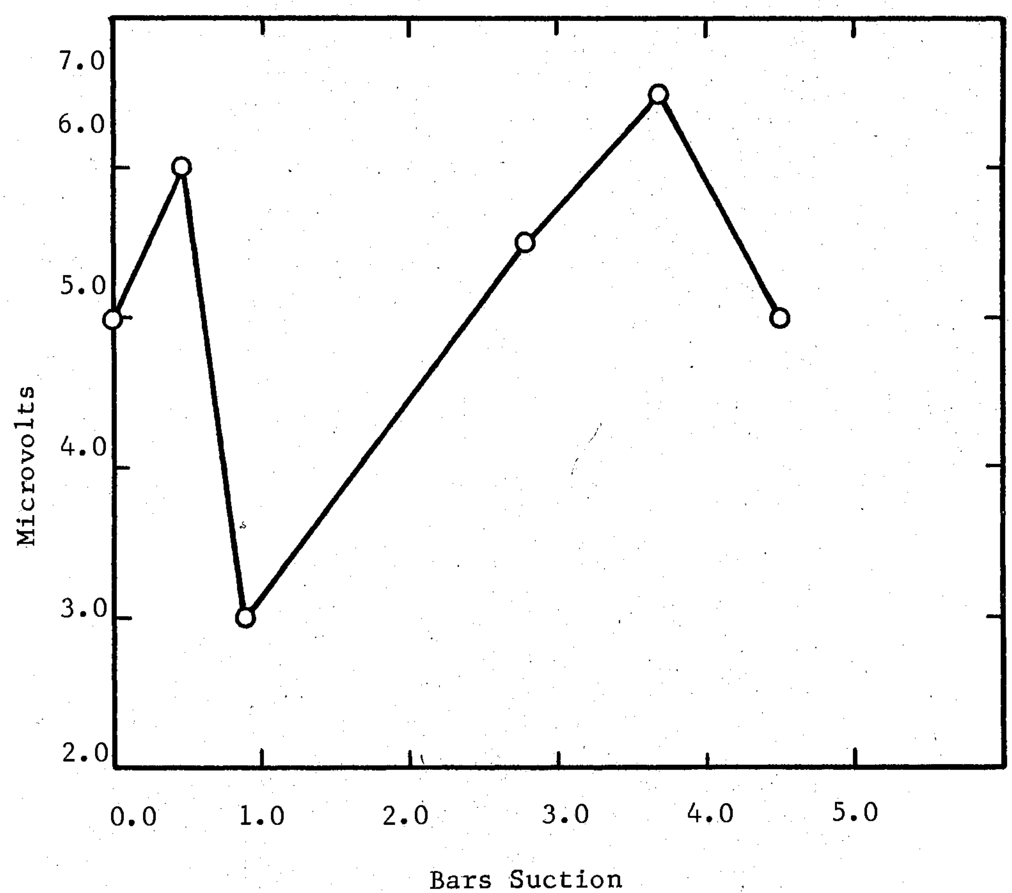

Figure 14. Microvoltage response as a function of molal suctions less than 5 bars.

TABLE III

MICROVOLTAGE RESPONSE OF THERMOCOUPLE PSYCHROMETERS VERSUS OSMOTIC SUCTIONS AND METHODS OF READING

Osmotic Tension (Bars)	Recorded Voltage Response			Voltmeter Response		
	Microvolts	Microvolts Per Bar Solution Suction	Calculated Suction (Bars)	Microvolts	Microvolts Per Bar Solution Suction	Calculated Suction (Bars)
0.00	1.0	--	2.18	5.0	--	10.64
0.49	2.0	4.08	2.13	6.0	12.24	12.7
0.90	2.0	2.22	2.13	3.0	3.33	6.34
2.80	1.2	0.42	2.55	5.6	2.00	11.91
3.68	1.5	0.40	3.19	6.3	1.72	13.41
4.54	2.2	0.48	4.68	5.0	1.10	10.64
15.71	7.0	0.44	14.90	7.5	0.47	15.96
22.41	9.3	0.41	19.79	10.9	0.46	22.13
29.28	12.2	0.41	25.96	14.0	0.47	29.79

A "spike" similar to that shown in Figure 13 was obtained when the nanovoltmeter was used for suctions below 5 bars. The "spike" had a voltage peak of about 4 to 6 microvolts for a 10 second cooling time or 1 to 3 microvolts for a 1 to 3 second cooling time. The water potential measurements reported in Tables IV and V (Appendix) were determined from the microvolt reading that occurred immediately following the initial voltage "spike". Such readings are referred to in Table IV and V (Appendix) as readings by method "B".

Data from the field experiment is plotted in Figures 15 and 16. The matric suctions for these samples were calculated using moisture characteristic curves in Figures 3 and 4. The scatter in the psychrometric response at the zero matric suction is quite broad. The standard error for the temperature measurements were 1.45 and 1.51^{o}C for the 30 cm and 60 cm depths respectively. These temperature errors give rise to an error in water potential of about 0.03 bars, which is negligible in relation to other errors involved. The error of 0.03 bars agrees with errors in water potential resulting from error in temperature measurement as reported by Richards and Ogata (1958) using a uniform equilibrated soil system. At the suctions depicted at both depths the thermocouple psychrometer readings are higher in every case than the membrane readings. The same relation was found by Rawlins and Dalton (1967). An ideal relation between the thermocouple psychrometers and membrane determinations should have given a straight line having a slope equal to one and passing through the origin. The pressure cooker technique is widely used as an acceptable procedure for soil-water suctions below 1 bar (Low and Deming, 1952). However, the thermocouple psychrometer readings are still excessively high using this salt free soil.

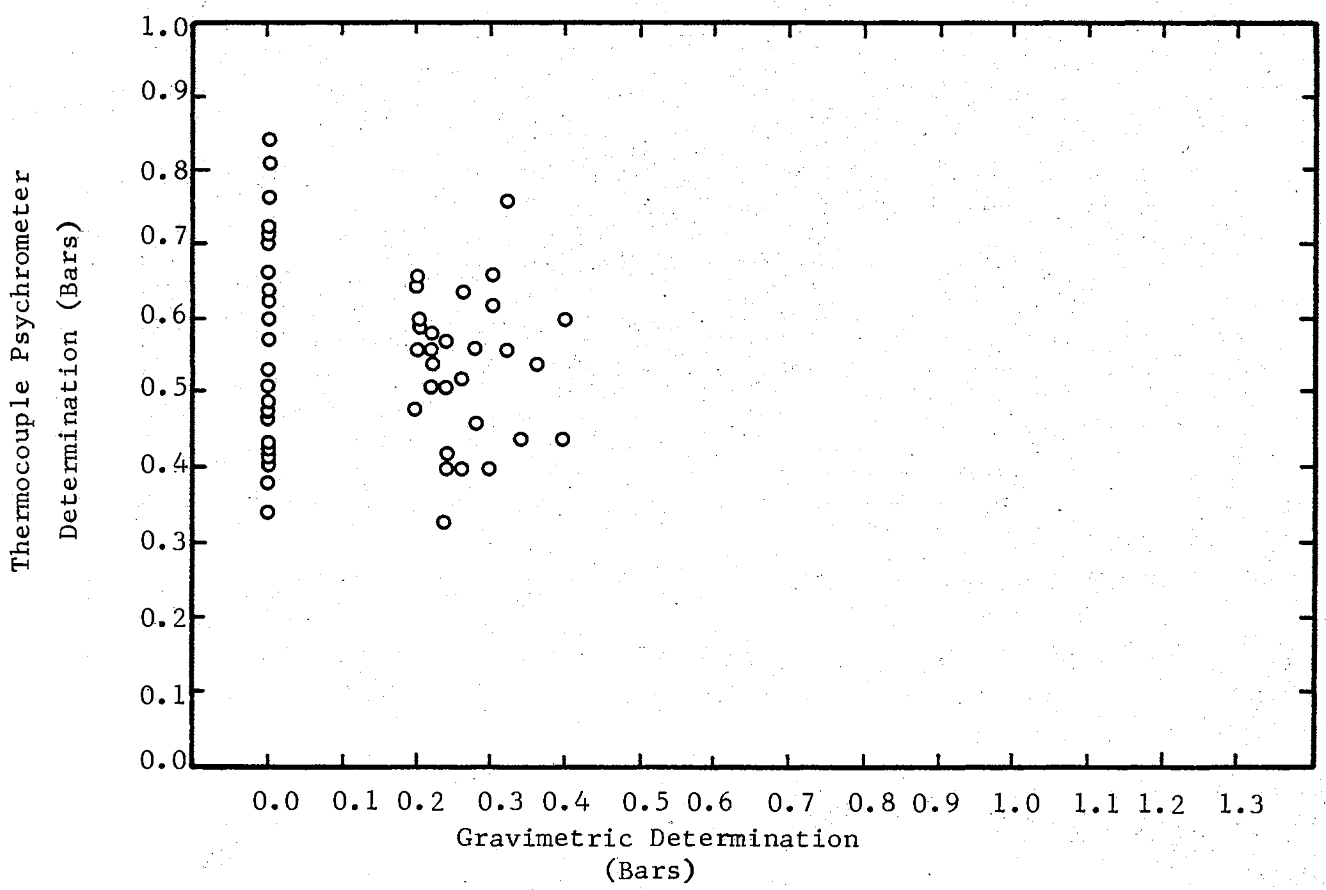

Figure 15. Water suction determined by thermocouple psychrometer vs. water suction determined by moisture characteristic curve - gravimetric procedure. Data are for 30 cm depth.

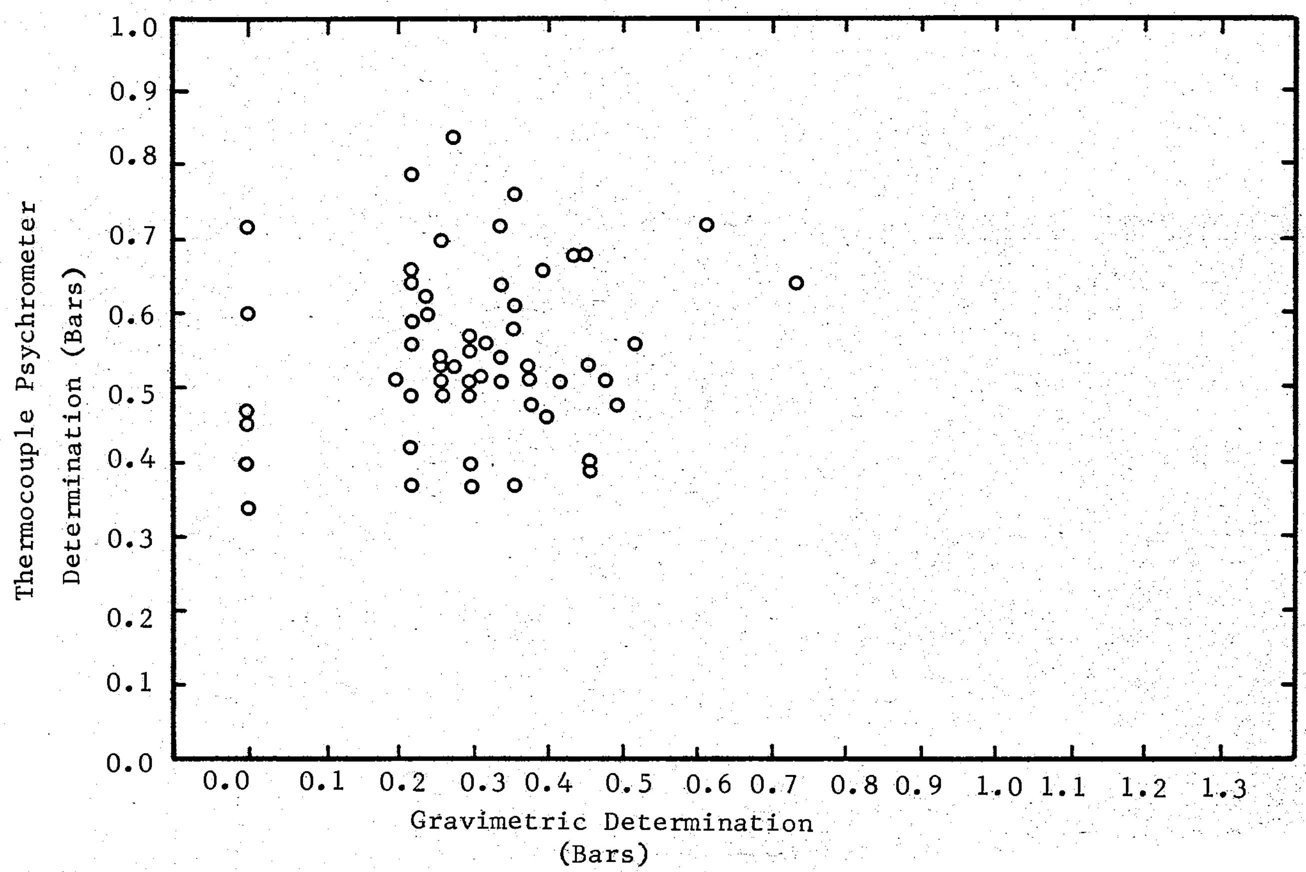

Figure 16. Water suction determined by thermocouple psychrometer vs. water suction determined by moisture characteristic curve - gravimetric procedure. Data are for 60 cm depth.

CHAPTER V

SUMMARY AND CONCLUSIONS

1. Soil thermocouple psychrometers of the type and quality used in this study gave erratic readings below an osmotic suction of approximately 5 bars. Evidently, the cause is some combination of zero drift, inherent properties of the soil thermocouple psychrometers, and voltage measuring instrument.

2. There is no correlation between soil thermocouple psychrometer response and matric suction below 5 bars in relatively salt free soil.

3. Before soil thermocouple psychrometers can be used with any degree of confidence above 5 bars, one must become thoroughly familiar with the typical or atypical type of voltage responses that may be obtained at water suctions less than 5 bars.

4. Laboratory studies and calibration curves coupled with reports of other investigators indicate that at water suctions above 5 bars the thermocouple psychrometers may be satisfactory for field work.

5. If an instrument were used to filter out the initial voltage surges found at low water suctions and thermocouple psychrometers were selected to give responses at low suctions such as that exhibited in Figure 6, water suctions less than 5 bars could probably be determined.

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APPENDIX

TABLE I

SOIL WATER SUCTION DETERMINED BY THERMOCOUPLE PSYCHROMETERS USING READING METHOD "A" AND A CONVERSION FACTOR OF 0.47 MICRO-VOLTS PER BAR

Plot No.	Date / Depth(cm)	May 10 60	May 10 30	May 17 60	May 17 30	May 19 60	May 19 30
101		8.89	10.45	7.97	6.00	12.20	14.11
102		8.09	11.82	4.15	3.98	13.72	13.30
103		9.19	15.12	8.20	6.00	11.40	11.11
104		10.45	13.23	8.33	6.46	10.90	14.08
105		5.35	12.90	3.17	7.38	6.34	17.54
106		8.23	9.98	5.79	6.09	9.85	9.46
201		10.45	14.11	4.75	7.96	12.90	12.27
202		8.23	10.28	6.47	3.80	9.02	9.22
203		--	14.35	--	8.06	--	13.55
204		8.09	13.44	4.28	5.74	8.59	11.44
205		6.07	12.64	3.80	6.27	8.71	10.17
206		9.95	12.34	7.96	6.75	10.31	12.28
301		9.19	5.90	4.98	2.41	8.30	3.62
302		8.51	11.35	5.06	4.15	9.41	7.61
303		6.34	12.02	7.47	5.93	9.09	10.75
304		9.31	10.29	7.13	5.74	10.60	7.17
305		8.60	8.30	8.42	4.93	14.75	7.00
306		15.43	9.68	12.44	6.09	14.50	10.45
401		6.18	9.54	5.88	5.70	7.20	7.61
402		9.80	9.80	8.82	7.51	8.90	8.21
403		8.82	7.84	7.35	5.70	8.16	5.60
404		10.62	8.33	4.09	6.37	7.61	7.46
405		13.44	8.46	9.17	4.15	10.30	8.06
406		11.63	10.29	8.96	4.03	10.45	8.63
Simple Statistics							
Sum of Squares		2049.22	2993.896	1151.668	829.669	2477.864	2647.027
Total		210.86	262.46	154.64	137.20	233.21	240.70
No. of Observations		23	24	23	24	23	24
S^2		5.28	5.37	5.09	36.07	5.14	10.13
S.E.		2.30	2.32	2.26	6.01	2.27	3.18
Mean		9.17	10.96	6.72	5.72	10.14	10.03

TABLE I (Continued)

Plot No.	Date Depth(cm)	May 21 60	May 21 30	May 24 60	May 24 30	May 26 60	May 26 30
101		11.63	13.93	6.97	14.91	8.96	5.53
102		11.27	15.43	10.45	12.72	10.98	5.00
103		10.79	15.68	10.14	9.67	8.39	5.58
104		10.95	15.68	10.60	16.16	10.45	6.97
105		7.95	16.42	5.43	15.44	--	8.33
106		9.95	13.50	8.30	9.41	9.27	6.75
201		13.65	13.93	12.35	12.63	9.50	10.29
202		8.46	13.23	8.55	10.29	10.60	3.57
203		9.10	14.95	9.27	15.20	8.33	8.73
204		10.62	13.72	8.30	13.69	10.00	8.42
205		9.10	15.92	6.82	11.76	8.18	6.75
206		11.63	14.61	10.45	12.09	11.01	6.75
301		9.31	5.97	7.84	4.75	5.56	--
302		8.33	13.23	8.08	10.00	7.30	5.56
303		10.12	13.99	8.55	10.14	10.00	7.54
304		9.31	15.19	10.13	7.61	9.68	7.09
305		15.43	11.76	8.20	10.14	8.30	4.76
306		11.27	15.92	15.20	9.54	15.24	5.95
401		8.33	12.83	6.72	9.58	8.89	5.95
402		11.27	13.30	8.96	10.93	10.90	10.59
403		9.17	12.17	8.83	10.01	11.76	8.27
404		9.98	12.63	9.54	11.92	11.23	6.75
405		11.27	11.40	8.63	5.70	14.04	5.09
406		10.29	11.58	9.98	9.71	11.99	7.54
Simple Statistics							
Sum of Squares		2655.598	4565.493	2075.917	3091.453	2550.715	1146.483
Total		249.18	326.97	218.23	264.00	236.51	157.70
No. of Observations		24	24	24	24	23	23
S^2		2.98	4.82	3.98	8.15	5.39	2.96
S.E.		1.73	2.20	2.00	2.85	2.32	1.72
Mean		10.38	13.62	9.09	11.00	10.28	6.86

TABLE I (Continued)

Plot No.	Date / Depth(cm)	May 28		May 31		June 2	
		60	30	60	30	60	30
101		8.33	10.61	8.74	7.84	5.57	5.23
102		8.08	10.76	7.35	7.38	4.15	4.73
103		8.82	11.58	8.96	7.95	6.62	5.93
104		10.45	10.29	10.45	7.27	7.61	6.01
105		7.14	12.63	7.01	9.71	4.97	7.20
106		8.82	9.32	8.89	7.30	7.96	5.16
201		8.18	12.14	7.24	9.27	5.07	7.63
202		8.20	8.30	8.68	4.06	5.62	3.53
203		9.03	10.76	8.39	9.14	5.74	7.20
204		8.55	10.45	7.96	8.20	6.18	5.93
205		5.39	9.22	5.79	8.33	3.18	5.10
206		10.13	10.14	9.50	7.84	7.60	6.36
301		6.00	4.48	6.00	3.30	4.30	2.30
302		6.00	9.03	6.27	6.72	5.30	4.66
303		8.55	10.30	7.47	7.73	5.91	7.20
304		8.42	10.75	8.55	8.05	6.82	5.16
305		7.73	8.27	7.96	6.53	5.00	4.66
306		15.24	9.09	15.44	6.36	14.25	5.09
401		7.13	8.71	8.20	8.68	5.30	5.51
402		9.98	11.81	8.89	11.16	8.06	8.33
403		8.76	9.71	9.03	7.61	6.46	5.16
404		9.03	9.88	8.55	7.51	6.09	5.93
405		9.54	6.34	9.68	7.07	7.84	3.14
406		8.89	8.16	10.45	7.49	8.51	5.51
Simple Statistics							
Sum of Squares		1857.676	2332.090	1843.146	1452.822	1096.190	778.662
Total		206.39	232.73	205.45	183.10	154.11	132.68
No. of Observations		24	24	24	24	24	24
s^2		3.60	3.27	3.67	2.43	4.64	1.96
S.E.		1.90	1.81	1.92	1.56	2.15	1.40
Mean		8.60	9.70	8.56	7.63	6.42	5.53

TABLE I (Continued)

Plot No.	Date / Depth(cm)	June 4 60	June 4 30	June 11 60	June 11 30	June 14 60	June 14 30
101		4.75	5.09	17.60	14.17	19.53	13.74
102		4.93	5.51	5.51	9.14	6.36	13.50
103		5.66	6.75	7.73	4.43	5.51	4.85
104		6.97	6.36	9.22	6.18	11.86	3.97
105		4.97	7.45	--	7.40	--	5.16
106		6.01	6.27	6.53	7.84	5.23	8.42
201		4.86	7.05	5.58	13.31	4.66	13.55
202		5.45	3.92	5.45	2.65	5.23	1.70
203		4.66	7.14	6.36	8.59	6.36	5.93
204		5.30	6.35	6.97	7.54	5.66	5.79
205		3.14	5.49	5.82	4.37	3.92	2.97
206		6.82	6.35	7.95	7.20	5.93	5.95
301		3.49	2.68	4.89	--	4.24	--
302		4.24	5.10	5.16	4.76	4.37	3.97
303		5.51	7.05	6.46	5.16	5.09	7.94
304		6.18	6.27	8.06	6.78	7.40	6.87
305		16.98	5.56	20.33	8.73	21.47	9.13
306		13.74	5.88	13.93	9.02	12.45	5.93
401		4.73	6.36	14.13	7.30	17.36	8.73
402		6.97	8.47	7.95	12.90	9.88	9.52
403		6.78	5.88	8.71	5.16	5.09	3.97
404		5.74	6.66	5.38	9.74	5.93	8.33
405		17.06	12.71	21.04	19.48	19.04	19.44
406		7.73	5.93	12.36	11.64	14.28	13.49
Simple Statistics							
Sum of Squares		1424.012	1039.371	2502.172	1953.105	2552.531	1863.658
Total		162.63	152.27	213.12	193.49	206.85	182.85
No. of Observations		24	24	23	23	23	23
s^2		14.00	3.19	23.97	14.79	31.47	18.64
S.E.		3.74	1.78	4.90	3.85	5.61	4.32
Mean		6.78	6.34	9.27	8.41	8.99	7.95

TABLE I (Continued)

Plot No.	Date / Depth(cm)	June 16		June 18		June 21	
		60	30	60	30	60	30
101		14.33	8.05	13.43	9.02	12.28	6.35
102		4.30	9.14	3.87	8.05	4.24	6.75
103		5.45	9.74	4.79	8.33	5.09	7.54
104		6.18	8.05	7.27	9.36	5.66	6.62
105		2.85	9.32	2.30	7.94	4.85	8.90
106		5.09	7.20	5.28	8.06	4.73	6.36
201		8.47	10.17	7.30	9.32	5.16	7.94
202		5.23	7.20	3.98	7.38	3.18	4.76
203		5.38	10.17	3.64	9.85	4.30	7.20
204		4.93	7.84	3.44	9.83	3.87	6.78
205		3.54	10.45	3.82	8.47	4.24	7.20
206		6.53	9.85	6.78	7.51	6.36	7.20
301		3.44	3.80	3.23	--	3.39	2.24
302		4.79	7.14	4.48	7.20	5.09	5.16
303		5.82	8.90	4.86	9.13	4.66	7.20
304		5.58	9.74	5.74	10.31	5.09	6.36
305		21.18	7.54	18.21	6.75	13.13	6.35
306		11.76	8.16	13.31	6.78	11.32	5.58
Simple Statistics							
Sum of Squares		1219.956	1336.037	1054.387	1227.763	786.81	789.056
Total		124.85	152.46	115.68	143.32	106.64	116.51
No. of Observations		24	24	24	23	24	24
s^2		24.80	15.98	21.60	15.21	13.61	9.72
S. E.		4.98	4.00	4.65	3.90	3.69	3.12
Mean		5.20	6.35	4.82	6.23	4.44	4.85

TABLE I (Continued)

Plot No.	Date / Depth(cm)	June 23 60	June 23 30	June 25 60	June 25 30	June 28 60	June 28 30
101		11.44	5.23	12.02	6.35	13.49	5.97
102		2.38	7.20	3.92	8.33	3.97	5.51
103		3.39	9.92	3.57	--	3.97	7.14
104		5.66	5.95	5.09	9.45	7.20	6.92
105		2.99	8.47	2.99	10.32	2.67	6.75
106		5.58	6.35	3.39	6.35	4.24	4.37
201		5.09	7.09	5.56	8.33	4.76	8.33
202		2.97	6.35	4.36	9.92	3.01	4.66
203		5.23	7.94	4.24	10.32	4.66	8.90
204		4.24	7.54	5.30	9.52	3.82	7.20
205		2.97	8.33	2.55	9.13	2.38	5.56
206		5.51	7.14	6.78	8.73	5.95	6.36
301		--	3.67	--	4.58	3.73	4.23
302		4.37	5.16	5.93	7.14	5.09	4.37
303		4.42	8.33	3.87	8.33	4.03	5.93
304		4.66	10.32	4.30	13.98	5.16	6.35
305		12.71	5.09	15.01	5.16	16.66	4.48
306		11.86	5.56	11.92	5.95	12.71	5.56
Simple Statistics							
Sum of Squares		701.935	928.727	803.412	1269.53	921.328	685.505
Total		95.47	125.64	100.80	141.91	107.50	108.59
No. of Observations		23	24	23	23	24	24
S^2		13.89	11.78	16.44	17.91	19.12	8.49
S.E.		3.73	3.43	4.05	4.23	4.37	2.91
Mean		4.15	5.24	4.38	6.17	4.48	4.52

TABLE IV

SOIL WATER SUCTION DETERMINED BY THERMOCOUPLE PSYCHROMETERS USING READING METHOD "B"
AND A CONVERSION FACTOR OF 0.47 MICROVOLTS PER BAR
FOR A 30 CM DEPTH

Plot No.	DATE									
	June 30	July 2	July 5	July 7	July 9	July 12	July 19	July 21	July 23	July 26
101	--	--	--	--	--	--	--	0.68	--	0.60
102	0.74	0.14	0.40	0.87	0.41	0.53	0.64	0.46	0.72	0.54
103	0.30	0.85	--	--	0.49	0.70	0.54	0.60	0.62	0.64
104	0.13	0.92	0.62	0.53	0.62	--	0.64	0.79	--	0.56
105	0.28	1.05	0.67	0.44	0.51	0.44	--	0.59	0.37	0.48
106	0.61	0.26	0.69	0.69	0.33	0.57	0.66	0.56	0.45	0.48
201	0.47	0.96	0.36	0.64	0.46	0.45	--	0.37	0.49	0.60
202	0.18	0.51	0.42	0.54	0.45	--	0.39	0.51	0.51	0.43
203	0.50	0.58	0.65	0.44	0.53	0.44	0.40	0.72	0.49	0.68
204	0.71	0.28	0.47	0.53	0.49	--	--	0.60	0.48	0.48
205	0.22	0.63	--	0.53	0.45	0.62	0.58	0.66	0.57	0.56
206	0.88	0.67	--	0.60	0.42	0.50	0.52	0.40	0.84	0.84
301	--	0.87	--	--	--	--	0.55	0.72	0.61	0.48
302	0.04	0.42	0.58	0.56	0.47	--	0.53	0.42	0.51	0.58
303	0.25	0.63	0.60	0.65	0.48	0.46	--	0.64	0.51	0.64
304	0.68	0.51	0.64	0.39	0.62	--	0.53	0.54	0.53	0.52
305	0.01	0.94	0.60	0.59	0.64	--	0.56	0.48	0.76	0.56
306	0.71	0.65	0.45	0.50	0.74	0.38	0.51	0.47	0.70	0.64
401	--	0.75	0.68	0.50	--	--	0.56	0.51	0.72	0.48
402	--	0.39	0.64	0.63	0.42	--	0.52	0.56	--	0.54
403	--	0.57	0.57	0.43	--	--	--	0.49	0.51	0.44
404	--	0.60	--	0.60	--	--	0.68	0.53	0.60	0.40
405	--	0.55	--	--	--	--	--	0.40	--	0.38
406	--	0.87	0.68	0.49	0.46	0.31	0.37	0.34	0.60	0.40

TABLE IV (Continued)

Plot No.	DATE June 30	July 2	July 5	July 7	July 9	July 12	July 19	July 21	July 23	July 26
Simple Statistics										
Sum of Squares	3.9659	10.5362	5.7466	6.4423	4.6565	2.772	5.0866	7.4084	6.9827	7.2425
Total	6.71	14.60	9.72	11.15	8.99	5.40	9.18	13.04	11.59	12.95
No.of Obser-vations	16	23	17	20	19	11	17	24	20	24
S^2	0.0768	0.05856	0.0118	0.0119	0.0237	0.0121	0.0081	0.0141	0.0140	0.0110
S.E.	0.277	0.243	0.109	0.109	0.150	0.110	0.0899	0.119	0.118	0.105
Mean	0.42	0.63	0.57	0.5575	0.473	0.490	0.54	0.54	0.58	0.54

TABLE V

SOIL WATER SUCTION DETERMINED BY THERMOCOUPLE PSYCHROMETERS USING READING METHOD "B" AND A CONVERSION FACTOR OF 0.47 MICROVOLTS PER BAR FOR A 60 CM DEPTH

Plot	DATE									
No.	June 30	July 2	July 5	July 7	July 9	July 12	July 19	July 21	July 23	July 26
101	0.31	0.16	0.80	0.48	0.45	0.47	0.56	0.60	0.76	--
102	0.38	0.36	0.47	0.41	0.58	--	0.56	0.59	0.56	0.48
103	0.15	0.48	--	0.53	--	0.40	0.52	0.71	0.48	0.56
104	0.26	0.42	0.52	0.44	0.55	0.53	0.60	0.76	0.76	0.60
105	--	0.67	--	--	0.35	--	0.33	0.43	0.84	0.56
106	0.12	0.38	0.61	0.55	0.39	--	--	0.40	0.48	0.56
201	0.76	0.52	1.05	--	0.45	--	0.56	0.64	0.40	0.68
202	0.68	0.58	0.51	0.51	0.43	--	0.44	0.58	0.62	0.56
203	0.41	0.26	0.52	--	--	--	0.64	0.51	0.66	0.64
204	0.71	0.59	0.45	0.48	--	--	0.40	0.51	0.57	0.50
205	0.17	0.38	0.39	0.38	0.05	--	--	0.51	0.42	0.56
206	0.12	0.53	0.69	--	0.37	0.40	--	0.38	0.41	0.64
301	--	0.87	--	0.37	--	--	0.60	0.72	0.57	0.47
302	0.12	0.53	0.47	0.44	0.43	0.48	0.53	0.42	0.57	0.53
303	0.75	0.57	0.48	0.60	0.60	0.41	0.46	0.64	0.53	0.48
304	0.65	0.55	0.56	0.53	0.27	0.43	--	0.54	0.49	0.54
305	0.62	0.89	0.46	0.59	0.72	--	0.75	0.48	0.72	0.46
306	0.65	0.51	1.15	0.33	1.15	0.72	--	0.47	0.66	0.40
401	--	0.47	0.45	0.52	--	--	0.54	0.51	0.70	0.56
402	--	0.49	--	--	--	--	--	0.56	0.81	0.43
403	--	0.68	0.40	0.43	--	--	0.64	0.49	0.57	0.60
404	--	0.83	0.53	0.60	--	0.33	0.40	0.53	0.66	0.52
405	--	0.60	0.44	0.59	0.46	--	0.44	0.40	0.66	0.54
406	--	0.23	0.52	0.47	0.42	0.51	--	0.34	0.62	0.38

TABLE V (Continued)

Plot No.	DATE June 30	July 2	July 5	July 7	July 9	July 12	July 19	July 21	July 23	July 26
Simple Statistics										
Sum of Squares	3.9068	7.3457	7.3735	4.6231	4.4895	2.2926	4.9131	7.0230	9.1360	6.6503
Total	6.86	12.55	11.47	9.25	7.67	4.68	8.97	12.72	14.52	12.25
No. of Obser-vations	16	24	20	20	16	10	17	24	24	23
s^2	0.0644	0.0340	0.0419	0.0182	0.0542	0.0114	0.0113	0.0122	0.0153	0.0057
S.E.	0.2537	0.1845	0.2046	0.1347	0.2328	0.1066	0.1061	0.1106	0.1236	0.0756
Mean	0.43	0.52	0.57	0.4625	0.48	0.47	0.53	0.53	0.61	0.53

TABLE VI

SOIL MOISTURE TENSIONS AS PREDICTED BY A GRAVIMETRIC-SOIL MOISTURE CHARACTERISTIC CURVE PROCEDURE FOR A 30 CM DEPTH

Plot No.	DATE July 19	July 21	July 23
101	0.26	0.23	0.26
102	0.37	0.20	0.17
103	0.13	0.00	0.12
104	0.17	0.12	0.10
105	0.16	0.12	0.11
106	0.20	0.12	0.00
201	0.22	0.18	0.15
202	0.23	0.17	0.13
203	0.15	0.00	0.11
204	0.17	0.00	0.19
205	0.18	0.12	--
206	0.16	0.00	0.14
301	0.15	0.00	0.18
302	0.19	0.11	0.10
303	0.16	0.12	0.24
304	0.23	0.17	0.13
305	--	0.25	0.18
306	0.21	0.00	0.13
401	0.26	0.15	0.31
402	0.16	0.16	0.18
403	0.22	0.13	0.19
404	0.22	0.14	0.00
405	0.19	0.23	0.12
406	0.15	0.00	0.12
Simple Statistics			
Sum of Squares	0.9564	0.4672	0.5998
Total	4.54	0.272	3.36
No.of Observations	23	24	23
s^2	0.0027	0.0069	0.0050
s	0.05	0.08	0.07
Mean	0.20	0.11	0.15

TABLE VII

SOIL MOISTURE TENSIONS AS PREDICTED BY A GRAVIMETRIC-SOIL WATER CHARACTERISTIC CURVE FOR A 60 CM DEPTH

Plot No.	DATE July 19	July 21	July 23
101	0.16	0.00	0.00
102	0.11	0.10	0.11
103	0.13	0.00	0.10
104	0.20	0.00	0.16
105	0.12	0.00	0.00
106	0.15	0.12	0.00
201	0.14	0.00	0.00
202	0.20	0.11	0.00
203	0.10	0.12	0.00
204	0.15	0.00	0.00
205	0.16	0.00	0.12
206	0.14	0.00	0.00
301	0.10	0.00	0.12
302	0.00	0.00	0.00
303	0.14	0.00	0.00
304	0.00	0.11	0.00
305	0.58	0.17	0.11
306	0.11	0.00	0.15
401	0.18	0.11	0.00
402	0.12	0.10	0.00
403	0.13	0.00	0.00
404	0.13	0.00	0.10
405	0.17	0.00	0.00
406	0.12	0.00	0.15
Simple Statistics			
Sum of Squares	0.7708	0.114	0.1436
Total	3.54	0.94	1.12
S^2	0.0108	0.0034	0.0040
S.E.	0.10	0.06	0.06
Mean	0.15	0.04	0.05

TABLE VIII

MOISTURE CONTENT ON AN OVEN DRY BASIS FOR A 30 CM DEPTH

Plot No.	DATE July 19	July 21	July 23
101	10.42	10.9	10.44
102	9.11	11.5	12.11
103	11.98	14.4	13.41
104	12.07	13.5	14.06
105	12.11	13.6	13.88
106	11.54	13.4	16.82
201	11.26	11.9	12.52
202	11.06	12.2	13.26
203	12.78	15.0	13.72
204	12.24	15.1	11.70
205	11.90	13.5	--
206	12.38	16.1	12.92
301	12.66	14.2	11.91
302	11.74	13.9	14.02
303	12.39	13.3	10.80
304	11.02	12.0	13.16
305*	--	10.7	11.97
306*	11.24	14.6	13.11
401	10.45	12.6	9.71
402	12.33	12.4	11.83
403	11.28	13.2	11.77
404	11.17	12.8	14.23
405	11.77	11.0	13.41
406	12.73	14.2	13.50
Simple Statistics			
s^2	0.763	2.003	2.24
S.E.	0.87	1.42	1.50
Mean	11.64	13.16	12.79

TABLE IX

MOISTURE CONTENT ON AN OVEN DRY BASIS FOR 60 CM DEPTH

Plot No.	DATE July 19	July 21	July 23
101	11.56	13.9	14.19
102	12.89	13.4	13.18
103	12.42	13.7	13.35
104	10.80	13.9	11.57
105	12.75	13.8	13.89
106	11.77	12.6	15.97
201	11.99	14.2	14.26
202	10.68	13.1	14.31
203	13.40	12.7	16.91
204	11.77	13.7	15.17
205	11.58	15.3	12.68
206	11.94	16.4	15.49
301	13.45	14.6	12.64
302	13.58	14.7	15.14
303	12.29	14.6	15.15
304	14.57	12.9	13.67
305	--	11.4	13.15
306	13.28	13.8	11.87
401	11.08	13.2	18.28
402	12.69	13.4	17.58
403	11.12	14.2	16.58
404	12.20	14.9	13.47
405	11.42	13.7	15.98
406	12.69	15.1	11.94
Simple Statistics			
S^2	0.98	1.07	3.32
S. E.	0.99	1.03	1.82
Mean	12.3	13.9	14.43

TABLE X

TEMPERATURES MEASURED BY THE AUXILIARY CIRCUIT IN SOIL THERMOCOUPLE PSYCHROMETERS AT A 30 CM DEPTH

Plot No.	DATE July 5	July 7	July 9	July 12	July 19	July 21
1	25.4	30.7	28.7	30.2	27.7	25.2
2	28.2	28.2	27.2	29.7	27.7	26.4
3	30.2	30.0	28.2	28.7	29.0	25.2
4	28.7	30.2	26.4	28.5	27.7	26.4
5	28.2	28.2	28.2	27.7	27.7	25.9
6	29.0	27.2	25.9	29.7	26.4	27.7
7	27.7	30.2	28.2	29.7	27.7	27.7
8	29.7	****	26.9	28.5	26.2	26.4
9	28.2	30.2	26.7	30.2	27.5	25.2
10	29.0	27.7	27.2	28.2	28.0	25.2
11	29.7	32.2	30.2	30.2	25.2	27.2
12	32.2	****	29.7	30.2	30.2	27.7
13	****	****	****	****	****	23.7
14	29.0	25.2	28.5	27.7	30.0	26.4
15	30.2	27.2	27.7	29.7	28.2	27.7
16	30.2	29.0	26.4	28.7	29.5	25.2
17	27.7	28.7	27.7	30.2	24.7	26.4
18	30.0	****	26.7	30.2	28.2	26.4
19	27.7	30.2	29.7	24.7	27.2	24.9
20	28.2	30.2	29.2	30.7	25.2	24.7
21	30.2	27.7	30.7	26.7	25.2	25.2
22	29.7	28.7	31.0	31.2	27.5	29.0
23	27.7	28.2	29.7	30.0	24.7	27.7
24	27.7	29.0	29.2	31.5	30.2	29.0
Simple Statistics						
s^2	1.92	2.51	2.20	2.39	2.86	1.91
S.E.	1.39	1.58	1.48	1.55	1.69	1.38
Mean	28.9	2.89	28.2	29.3	27.5	26.4

TABLE XI

TEMPERATURES MEASURED BY THE AUXILIARY CIRCUIT IN SOIL THERMOCOUPLE PSYCHROMETERS AT A 60 CM DEPTH

Plot No.	DATE					
	July 5	July 7	July 9	July 12	July 19	July 21
1	23.7	27.7	27.2	28.2	27.7	25.2
2	25.2	27.2	26.2	30.7	27.7	20.1
3	29.7	30.2	27.7	27.7	27.7	26.4
4	27.7	28.2	25.7	26.7	27.7	25.9
5	28.2	--	28.2	27.7	--	21.2
6	24.7	25.7	25.2	27.7	27.7	27.7
7	27.2	--	29.0	27.7	27.7	26.4
8	25.2	25.7	25.4	27.7	29.7	25.2
9	23.7	27.7	28.2	27.7	28.2	25.2
10	27.7	31.2	25.7	28.2	27.7	25.2
11	25.4	25.2	24.7	29.0	28.0	26.4
12	25.7	29.0	27.2	31.2	30.2	25.2
13	--	30.7	27.7	27.7	--	25.2
14	28.2	28.2	28.7	24.7	27.2	27.7
15	24.7	25.2	25.2	26.7	29.0	27.7
16	25.2	26.7	24.2	29.0	28.2	26.4
17	25.7	25.7	25.2	29.0	28.0	27.7
18	25.2	26.2	25.2	27.7	27.5	25.2
19	24.7	28.2	30.2	28.0	27.7	26.4
20	27.7	28.7	29.2	29.0	27.7	27.7
21	27.2	30.2	--	26.4	28.2	23.7
22	27.7	--	28.7	30.2	27.7	30.2
23	25.2	25.2	27.7	27.2	23.7	27.7
24	27.2	27.7	29.0	28.7	29.0	29.0
Simple Statistics						
S^2	2.56	3.41	3.00	1.95	1.43	4.93
S.E.	1.60	1.85	1.73	1.40	1.19	2.22
Mean	26.2	27.6	27.0	28.1	27.9	26.03

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