LEAF DIFFUSIVE RESISTANCE OF PEANUTS AS INFLUENCED BY ENVIRONMENT AND ROW SPACING

By

ALAA SALIH ABDUL AL-JABBAR

Bachelor of Science

University of Baghdad

Baghdad, Iraq

1974

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, 1978

LEAF DIFFUSIVE RESISTANCE OF PEANUTS AS
INFLUENCED BY ENVIRONMENT AND
ROW SPACING

Thesis Approved:

John F. Stone
Thesis Adviser

James E. Garton

M. B. Kirkham

Norman N. Durham
Dean of the Graduate College

ACKNOWLEDGMENTS

The author wishes to express his sincere appreciation to Dr. J. F. Stone, his major adviser, for his guidance and advice during the course of this study. Thanks are extended to Dr. J. E. Garton and Dr. M. B. Kirkham for serving on the author's advisory committee.

Thanks are also expressed to Dr. D. L. Nofziger for his suggestions in the course of this research.

Appreciation and thanks are also due to Mr. Harold Gray, Mr. Paul I. Erickson and Mr. Don Matlock for their kind assistance during the study.

I wish to express my sincere appreciation to my parents for their encouragement and support.

Acknowledgment is due to the Iraqi Government for the award of a scholarship to pursue this advanced study.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Figure | Page

CHAPTER I

INTRODUCTION

Water flow is caused by gradients in the water potential through the entire soil-plant-atmosphere system. The direction of transpiration (flow) is from a source of finite capacity, the water in the soil, through a gradient in total water potential to a sink of effectively infinite capacity, the atmosphere, through a series of conductors: root, xylem, leaves, and the leaf stomata. In each conductor, the same average amount of water flows, and the ratio of potential that drives the flow divided by the resistance to flow is the quantity of flow per unit time (58). Theoretically, decreasing the transpiration is only a matter of increasing any of the resistances. The resistance of the soil is too small to affect transpiration. In the root, in the xylem, and in the cells of the leaf within the epidermis, the resistance is so small that transpiration decreases only slightly as a leaf with open stomata dries (35). Nevertheless, it is in the epidermis of the leaf and in the air above it that most of the resistance to transpiration lies. Eeckhout and Slaats (14) have shown that crop stomatal resistance was five to ten times greater than the aerodynamic resistance within the crop boundary layer for grass.

Peanut (*Arachis hypogaeae* L.) plants have exhibited low evapotranspiration in narrow north-south rows (51). This was related to several factors including leaf diffusive resistance. In a preliminary study, Ouattara gathered data (unpublished data) which suggested that leaf resistance of peanuts was influenced by row spacing and environmental evaporative demand. The objective of this study was to follow the effect further. Rows were oriented in the north-south direction and spaced at 25 and 100 cm. Leaf diffusive resistance, leaf water potential, and leaf temperature were measured periodically through the day. Environmental demand was characterized by measurement of net radiation, solar radiation, air temperature, and wind velocity and direction. In this study, the hypothesis was that the physiological characters of the plants in narrow north-south rows interact with the environmental demand to cause a higher leaf diffusive resistance.

CHAPTER II

LITERATURE REVIEW

Reports of peanut (Arachis hypogaea L.) row spacing and directional orientation effects on leaf diffusive resistance have not been found in the literature. Stone et al. (51) found that on high evaporative demand days, net radiation was highest in north-south rows and that evapotranspiration (ET) was not necessarily highest in these plots but was strongly influenced by stomatal closure. Chin, Choy, Stone, and Garton (9) showed evidence that peanuts and grain sorghum (Sorghum bicolor Moench) grown in narrow rows had lower ET than those grown in wide rows. Gates and Hanks (20) listed plant species, light reflection by plants, plant population, row spacing, orientation, and other factors that influence evaporation from plant communities.

The following relationship for transpiration was reported by Ehrler and van Bavel (15):

$$E = \frac{\Delta dv}{R_A + R_L} \tag{1}$$

where E is the evaporation rate in $\mu g\ cm^{-2}\ sec^{-1}$, Δdv the difference in water vapor density between the leaf interior and the air, in $\mu g\ cm^{-3}$, R_A the boundary layer resistance in $sec\ cm^{-1}$, and R_L the leaf diffusive resistance in $sec\ cm^{-1}$. The leaf diffusive resistance is a component of two resistances: epidermal resistance and mesophyll resistance. Fortunately, the second resistance in many species is relatively constant and small compared to epidermal resistance (26). The epidermis offers two parallel resistances--stomatal and cuticular resistance. Stomatal resistance is of more interest than cuticular resistance, since it varies more with environmental changes. More water is lost through the stomata. Slatyer (47) said that the primary mechanism by which the plant exercises control over transpiration is that of stomatal movement which affects the total diffusive resistance directly. Milthorpe and Spencer (35) showed that stomatal movement was found to exert a large controlling influence on the transpiration rate. The status of stomata in plants is dynamic and changes in response to many environmental factors. Troughton and Cowan (54) observed that for a particular plant, the stomatal aperture may vary with environmental condition. Ketellapper (29) discussed the behavior of stomata in response to many factors, such as light intensity, water deficit, and temperature. Under field conditions, light and water stress are two predominant factors affecting stomatal opening (11)(48). Stalfelt in 1959 called the light-induced movements "photoactive," and those caused by water deficit "hydroactive."

Light Intensity

Light is one of the main factors causing the opening of stomata. Ehrler and van Bavel (15) induced stomatal opening in eight plant species, as evidenced by a consistent decrease in leaf diffusive resistance, ranging from 15-70 sec cm^{-1} in darkness to about 1 sec cm^{-1} at approximately 40 Kilolux (.55 Ly min^{-1}) "greater illuminance" provided water was not a limiting condition. Kuiper (30) showed a hyperbolic relationship between the stomatal resistance of bean leaves and the light flux density. Turner and Begg (57) observed the same relationship in the field for maize (Zea mays L.), sorghum, and tobacco (Nicotiona tabacum L.) at high soil water potentials. Ritchie and Jordan (41) found that leaf diffusive resistance of sorghum was very high during midday, which indicates partial stomatal closure, and they related this to high evaporative demand and soil-water deficit. Denmead and Millar (11) observed the same thing with wheat (Trificam aestrinam L.). Whiteman and Koller (59) reported an increase in stomatal resistance of sunflowers (Helianthus annuus L.) with an increase in light above 1000 ft-C (.15 Ly min^{-1}). Skoskiewicz (46) found that the light intensity increasing to 25 klux induces the opening of stomata, but that further increment of light intensity causes no further opening of stomata and at higher values (above 40 klux) may even cause their closing.

Water Potential

It is common knowledge that leaf-water stress induces partial to total stomatal closure. Al-Ani and Bierhuizen (1) concluded that stomatal resistance could be used to estimate plant-water deficit. Glover (21), who used a differential pressure porometer on sorghum leaves, Dale (10), who used the infiltration method on cotton (Gossypium hirsutum) leaves, Rosenberg et al. (43) who made microscopic observations of stomatal aperture on bean (Phaseolus vulgaris) leaves, and other investigators have presented evidence that stomata began to close earlier in the day as the deficit was increased. Leaf diffusive resistance decreases to a minimum when the leaf-water potential is decreased and then increases as leaf-water potential continues to fall (34). Raschke and Kuhl (38) have shown that a small water deficit is necessary for maximum stomatal opening. Considerable quantitative data which have been reviewed recently (23)(41) imply that in many species, stomata are unaffected by leaf-water status until the water potential or content is reduced beyond a threshold level. This level varies with species and possibly with growing conditions. Leaf conductance (cm sec^{-1}) was linearly related to the net irradiance of the leaf provided that leaf-water potential was higher than a certain critical value (11). Below the critical water potential, stomatal aperture was controlled by leaf-water status rather than irradiance (11)(3)(55). This critical value differs with the species.

Thomas et al. (52) observed that the stomata of plants preconditioned to stress, remained open at a water potential lower than those required to close the stomata of well-watered plants. Leaf diffusive resistance exhibited marked differences between the irrigated and nonirrigated plots, and it was two to three times higher in nonirrigated than irrigated plots (16). It has been observed (48) that stomata did not open when plants were rewatered after a period of drought even though leaf water potential content recovered.

For a given plant, the leaf resistance varies depending on the leaf position on the stem. In addition, the resistance varies between the adaxial and abaxial surface. These changes are due to the light intensity and water potential. In some species at least, adaxial stomata apparently require more light to open than do abaxial stomata (15)(17)(53). Ehrler and van Bavel (15) divided eight species into two groups on the basis of epidermal difference in stomatal resistance readings at a specific illuminance. The abaxial stomata of snap beans (Phaseolus vulgaris L.) are not affected significantly by water deficit at leaf-water potentials higher than -11 bars. In comparison, the adaxial stomata are not affected significantly at leaf-water potentials higher than -8 bars (12). The resistance for the middle leaf of soybeans planted in potometer was higher than the upper leaf (49), and these differences occurred because of reduced illumination of the leaves within the canopy. The leaf-water potential of wheat decreases as the position changes from the bottom to the top of the stem (34), and the critical value decreases also. Others (57) found a steep gradient between the upper and lower leaves after sunrise in maize, sorghum, and tobacco, and that this gradient was small at low soil-water potential (55). The diurnal changes in the leaf stomatal resistance and water potential are greater for leaves in the upper canopy than for those in the lower canopy.

Aerodynamics

Wind is the vehicle which transports the moisture away from a surface from which water has been evaporated. The main effect of wind on leaf performance is to alter the boundary-layer diffusive resistance between the leaf surface and the ambient air. This boundary layer depends on wind speed, crop height, surface roughness, and distance upwind (fetch) (6).

Rosenberg (42) reported that sugar beets generally had a lower stomatal resistance in shelter in comparison to exposed sugar beets (Beta vulgaris). In another study (4), however, he found that the mean stomatal resistance is independent of the wind speed except in an extreme case where the presence of a front caused high winds and the influx of dry air. Grace (22) showed that grasses grown in winds of 1 to 3.5 m/sec had higher transpiration rates and lower stomatal resistances. Brown and Rosenberg (4) reported that the midday closure for sugar beets was more pronounced in an open plot than in shelter.

Other Factors

The literature contains little information involving the relationship between temperature, relative humidity, and stomatal resistance. In general, within a normal range of temperature (10 to 25^{o}C), the temperature has little effect on stomatal aperture. Temperatures higher than 30 to 35^{o}C have a closing effect on stomata and increase the leaf resistance (39). Leaf resistance decreases gradually with temperature up to a rather broad optimum (13)(33). Dale (10) showed that stomatal aperture for cotton is highly significantly correlated with the hour of day and solar radiation, and also, for stomata in the upper epidermis, with temperature. He also found that leaf resistances were higher in dry than in moist air at constant air temperature. Others (13) found that the leaf resistances were higher (less transpiration) in dry than in moist air at constant air temperature. This result varied with the predicted equation (equation 1) of transpiration. More recent data show that in some species, a low absolute humidity causes stomatal closure that is independent of the bulk water status of the leaf (31)(44).

Stomatal opening depends on the developmental stage of the leaf. Field and growth chamber studies have demonstrated gradients of stomatal opening along leaf positions (56). Senescence can be expected to reduce the degree of opening.

The mineral nutrition of a plant may also affect stomatal opening. Transpiration of nasturtium (Tropacolam maius L.) was reduced by deficiencies of boron, copper, manganese, and zinc that were severe enough to cause obvious visual symptoms (45).

Water Use

Stone et al. (50) reported 30-cm rows with north-south orientation used less water than did 90-cm rows of north-south spacing. In other reports (51) they found that 30-cm north-south rows (N 30) used essentially less water than N 90, E 30, and E 90. Chin Choy et al. (7) found also that N 30 conserved water better than the other treatments of peanuts. Ritchie and Burnett (40) state that decreasing the row spacing to increase plant population should be very effective in increasing water use efficiency. Wide rows of sorghum canopy used about ten percent more water than did narrow rows. This reduction was related to sensible heat, which was greater over wide rows than over narrow rows (8). Yao and Shaw (60) found that with low evaporative demands, the water loss was similar in all treatments, E 42, E 32, E 21, and E 42, but was higher in wide rows than in narrow rows in high evaporative demand. The differences were due mainly to differences in the total net radiation.

Yield

Considerable attention has been given to closer row spacing of agronomic crops to increase yield. Several investigators have reported that corn yield increases with decreasing row spacing (32)(5). Yield of peanuts was higher in narrow rows (30 cm) than in wide rows (90 cm) (50)(9)(7). Blum (2) observed in sorghum that with sufficient soil moisture, narrow-row water efficiency was higher than that of wide rows. Under a limited soil moisture, water efficiency was higher in narrow rows (37) than in wide rows.

CHAPTER III

MATERIALS AND METHODS

The research in this study included two treatments--25 and 100-cm-spaced rows of north-south orientation, replicated three times. The experimental site was the Perkins Experiment Station, Perkins, Oklahoma, N. Latitude 35.59, W. Longitude $97^{o}.03$ on a Teller loam, with zero to one percent slope. The variety of peanut studied was "Comet," a Spanish-type peanut (*Arachis hypogaea*, L.). Planting date was June 1. Skips were replanted June 9. Irrigation dates were June 10, 17, July 18, 30, August 5, 12, 19, 26, 1977. Approximately 10 cm of water was applied each irrigation by sprinkler except for June 10, 17, and August 19, when 5 cm was applied. Measurements were taken in the northern one-fifth of the plots to give about 15 meters fetch. Measurements were taken from July 25 to August 25.

Measurements were taken daily beginning after dew evaporation (around 8:30 to 9:30 A.M.) and continued until the sun angle was very low (about 19.00 hours). This was carried out throughout the week if the weather permitted. Plots were irrigated on Fridays.

Plot number 5, Table I exhibited a higher resistance and leaf water potential than did the others. The plants in this plot looked weak with yellow leaves, which seemed to indicate diseased plants.

TABLE I

ROW SPACING FOR PLOT

Plot Number	Replicate	Row Spacing
1	I	25 cm
3	II	25 cm
6	III	25 cm
2	I	100 cm
4	II	100 cm
5	III	100 cm

Physiological Measurements

Leaf diffusion resistance measurements were made in each plot. The measurements were averages of readings made on three or four of the upper leaves made at 30-min intervals throughout the day when the leaves were fully exposed to the sun. Leaf resistance readings were made using a Lambda Instrument Company diffusive resistance meter (LI-65 Auto porometer) with an LI-20S sensor. The diffusion porometer was calibrated in the laboratory using the method described by Kanemasu et al. (28).

Individual leaf-water potential measurements were made in each plot. The measurements were made at 30-min intervals throughout the day on upper leaves which were selected randomly. The readings were made using a Wescor C-51 sample-chamber psychrometer. The sample chamber was read on a Wescor Company Inc. HR-33T dewpoint microvoltmeter. The measurements were made in the field directly on the plant. Leaf canopy temperature was measured using a Barnes Engineering IT-3 infrared thermometer. The sensing head was held about 50 cm from the crop surface. The measurements were made at one-hour intervals throughout the day.

Microscopic measurements of leaf stomata were made on September 9 and 29. The September 9 sampling was at 2 P. M. On September 29, the plants were senescing and lodged. Samples were taken from two 100-cm-row plots and two 25-cm-row plots. On September 9, the plots sampled were 1, 2, 3, and 5. On September 29, the plots sampled were 1, 3, 4, and 5.

Meteorological Measurements

Solar radiation was measured by a Kipp and Zonen CM3 Solarimeter. The solarimeter was mounted on a platform 1.5 m above the ground and placed at the edge of the field. Net radiation is the difference between total upward and downward radiation fluxes and is a measure of energy available at the plant canopy. It was measured by net radiometers which were constructed in the laboratory and were similar to the miniature net radiometer described by Fritschen (18)(19)(17) with the modification described by Idso (24)(25). These net radiometers were placed about one meter above the top of crop canopy. The solar and net radiometers were read on a Keithley Instrument Company 163 Digital Voltmeter installed in an instrument trailer at the edge of the field. Air temperature was measured by a shaded thermocouple for the first three days and then changed to readings taken from a shaded standard mercury thermometer. Wind velocity and direction were measured by a Path F. Milton ML-433 A/PM portable anemometer at a height of 2 m. All of the meteorological factors mentioned above were measured hourly throughout the day.

Soil Water

Soil water was studied through use of the neutron probe, Nuclear Chicago Model P-19 (modified). Measurements were made to a depth of 120 cm. Access tubes were installed in plots 1 and 6 (25-cm row), and 2 and 5 (100-cm row). The measurements were made weekly, just before irrigation. Total water potential gradient across the 120-150 cm depth was monitored with tensiometers. The tensiometers were constructed in the laboratory and were similar to those described by Perrier and Evans (36). They were read every morning.

CHAPTER IV

RESULTS AND DISCUSSION

In determination of leaf diffusive resistance, only adaxial measurements were made. Early measurements of both surfaces showed adaxial stomata resistance was consistently lower than abaxial, as shown in Figure 1. Adaxial was considered to be the controlling factor for transpiration. Both had similar trends, but the differences were higher in the afternoon; microscopic measurements showed that there were more stomates on the adaxial. The ratios of adaxial to abaxial stomata were 1.23 and 1.22 for September 9 and 29, respectively.

The days were classified as low evaporative demand and moderate to high evaporative demand according to the meteorological data. Characteristics of these days are shown in Table II. A low evaporative demand day defined as "maximum temperature" is 30^{o}C, partly cloudy to cloudy skies, and low wind velocity. The variation in leaf resistance values was almost identical for both treatments throughout the day. Figure 2 shows the lowest value of leaf resistance (.75 to 1.05 sec cm^{-1}) was observed at hour 1000. The solar radiation was near its peak (1.19 Ly min^{-1}) at hour 1015. The plant was not under stress, and the average value of leaf water potential at that time was -15 bar. The above value of resistance did not occur when the plant was under stress (Figure 3); the average value of leaf water potential at hour 1530 was -31 bar. In addition, there is a peak for resistance at hour 1530, and

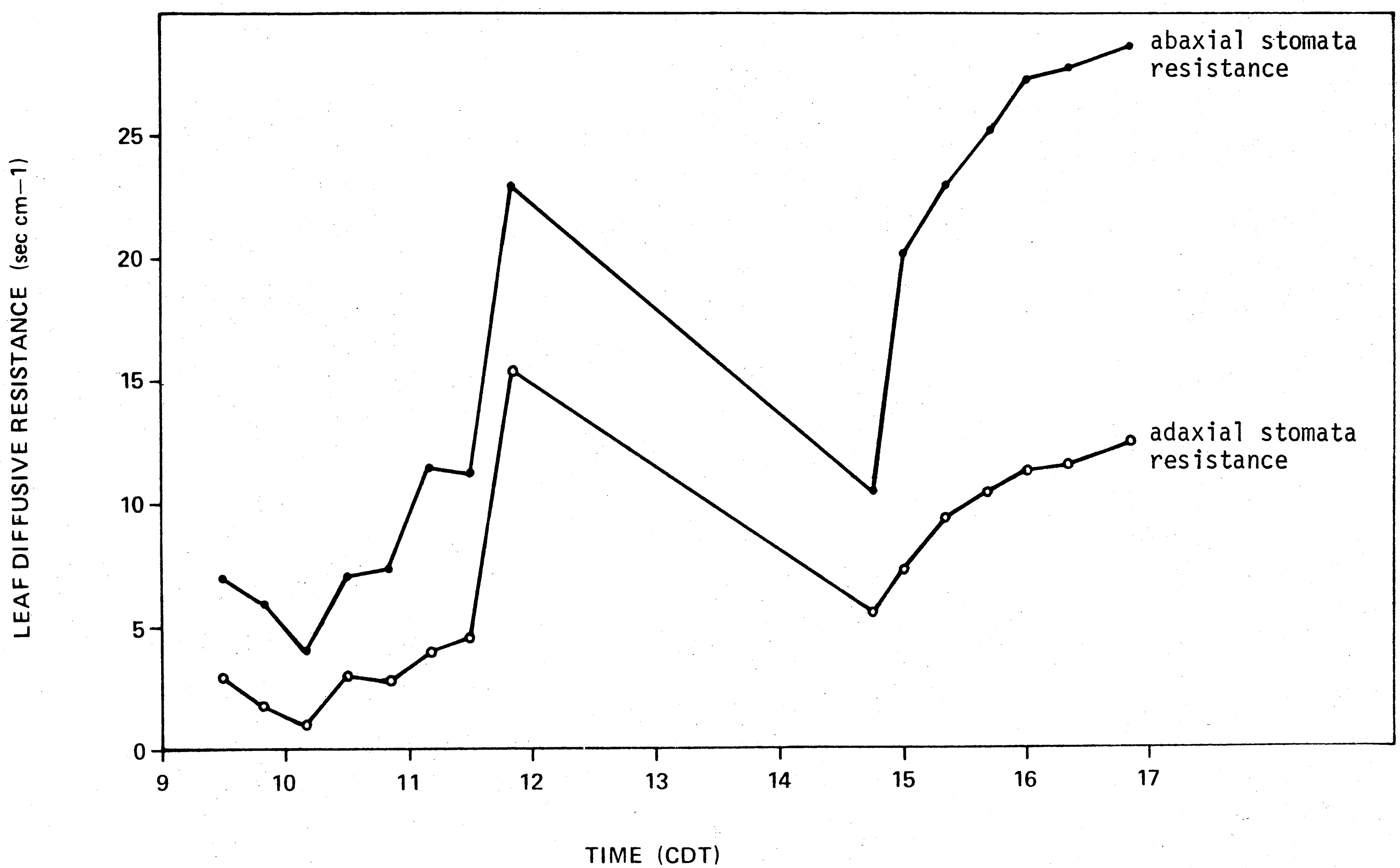

Figure 1. Leaf Resistance of Abaxial Stomata and Adaxial Stomata for July 21

TABLE II

METEOROLOGICAL DATA DURING THE PERIOD JULY 26-JULY 25, 1977, AT THE PERKINS RESEARCH STATION

Date	Maximum Temperature °C	Maximum Wind Speed Km/hour	Wind Direction	Cloud Cover	Classified
July 26	34.5	12.87	N-NE	pt cloudy	mod-high
27	34.7	11.26	NW-SE	pt cloudy	mod-high
28	37.0	11.26	S-SE	pt cloudy-clear	mod-high
Aug. 2	36.0	8.05	NW-E	clear	mod-high
3	35.9	16.09	S-SE	pt cloudy-clear	mod-high
4	35.5	24.14	S-SE	clear	mod-high
8	37.3	16.09	S-SE	pt cloudy	mod-high
9	38.0	17.70	S	pt cloudy	mod-high
10	39.0	19.31	SW-SE	pt cloudy	mod-high
11	28.5	16.09	N-NW	cloudy	low
16	40.0	17.70	S-SW	pt cloudy	mod-high
18	29.8	9.65	E-S	cloudy	low
22	33.2	14.48	E-SE	pt cloudy	mod-high
23	37.2	12.87	SE	pt cloudy	mod-high
24	36.0	12.87	E-NE	pt cloudy	mod-high
25	36.0	24.14	S-SE	clear	mod-high

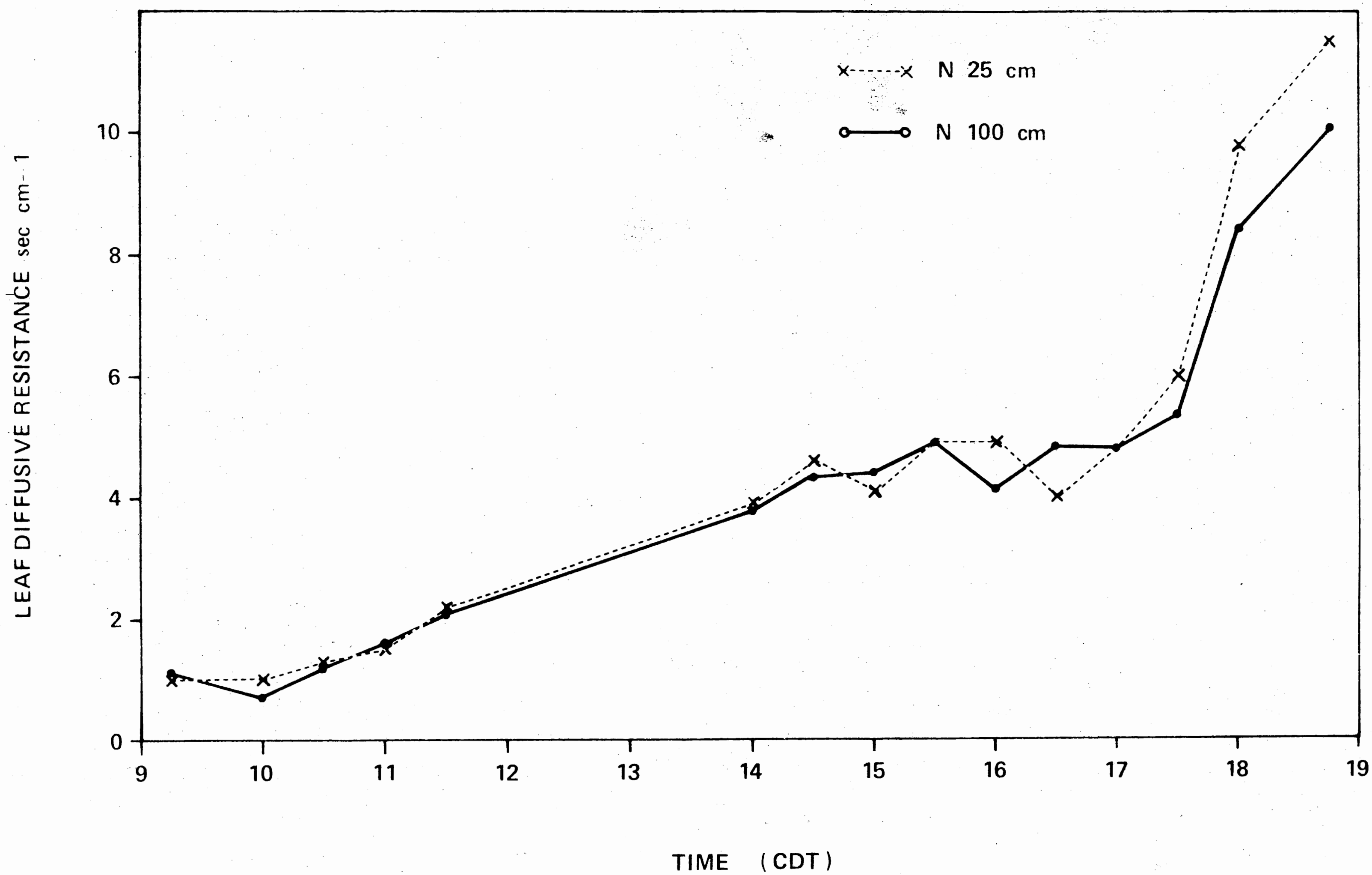

Figure 2. Leaf Resistance for Low Evaporative Demand Day August 18

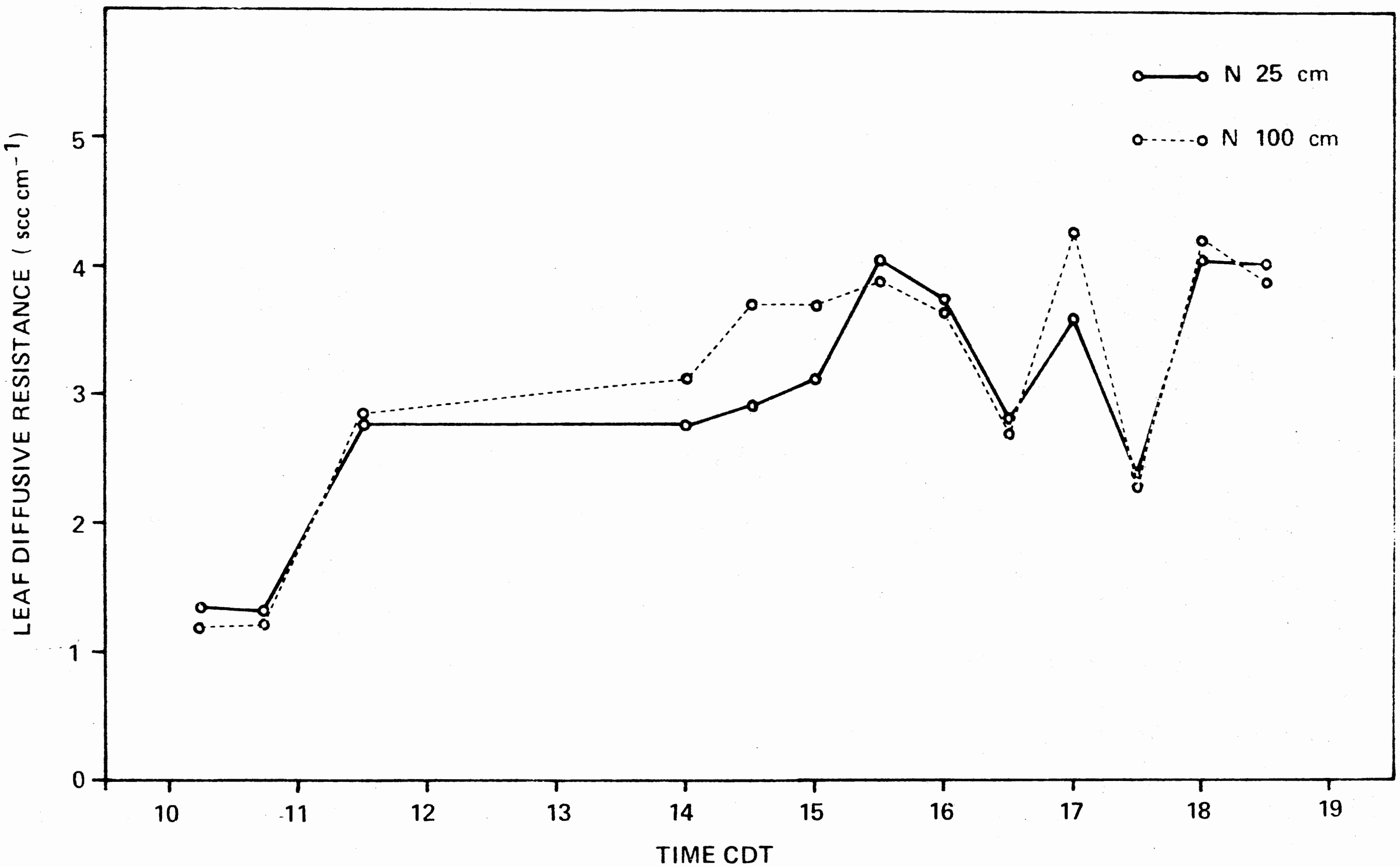

Figure 3. Leaf Resistance for Low Evaporative Demand Day August 11

this peak coincides with the peak of solar radiation (.707 Ly min^{-1}). These are typical days for low evaporative demand.

The steep increase in leaf resistance late in the afternoon was a result of a large decrease in light intensity due to presence of clouds; the resistance was slightly higher in later afternoon in narrow rather than in wide row plots. The leaf water potential was slightly lower (more negative) in the narrow rows than in wide rows. The resistance increased with the decrease in leaf water potential, as shown in Figure 4, where measurements were made at subsequent time intervals throughout the day. The right-hand part of the graph shows a steep increase in the resistance even though the leaf water potential increased (plant recovery). This is due to a large decrease in light intensity. In comparison, Figure 5 shows that the resistance (right-hand part of the graph) did not increase, even though the decrease in the solar radiation was similar to that of August 18. In this case, however, the plants were under stress.

The pattern of resistance in low evaporative demand was highly dependent on solar radiation when the leaf water potential was above -26 bar, and on leaf water potential more than on solar radiation when the leaf water potential was below -30 bar.

In moderate to high evaporative demand days (daily maximum temperature greater than 32^{o}C, clear to partly cloudy skies and moderate to high wind velocity)) the pattern of resistance tends to have two distinguished peaks throughout the day (Figures 6 and 7 are typical days for high evaporative demand). The first one is in the morning, the second in the afternoon. These peaks coincided most of the time with the peak or greater change in light intensity. Figure 6 shows that the

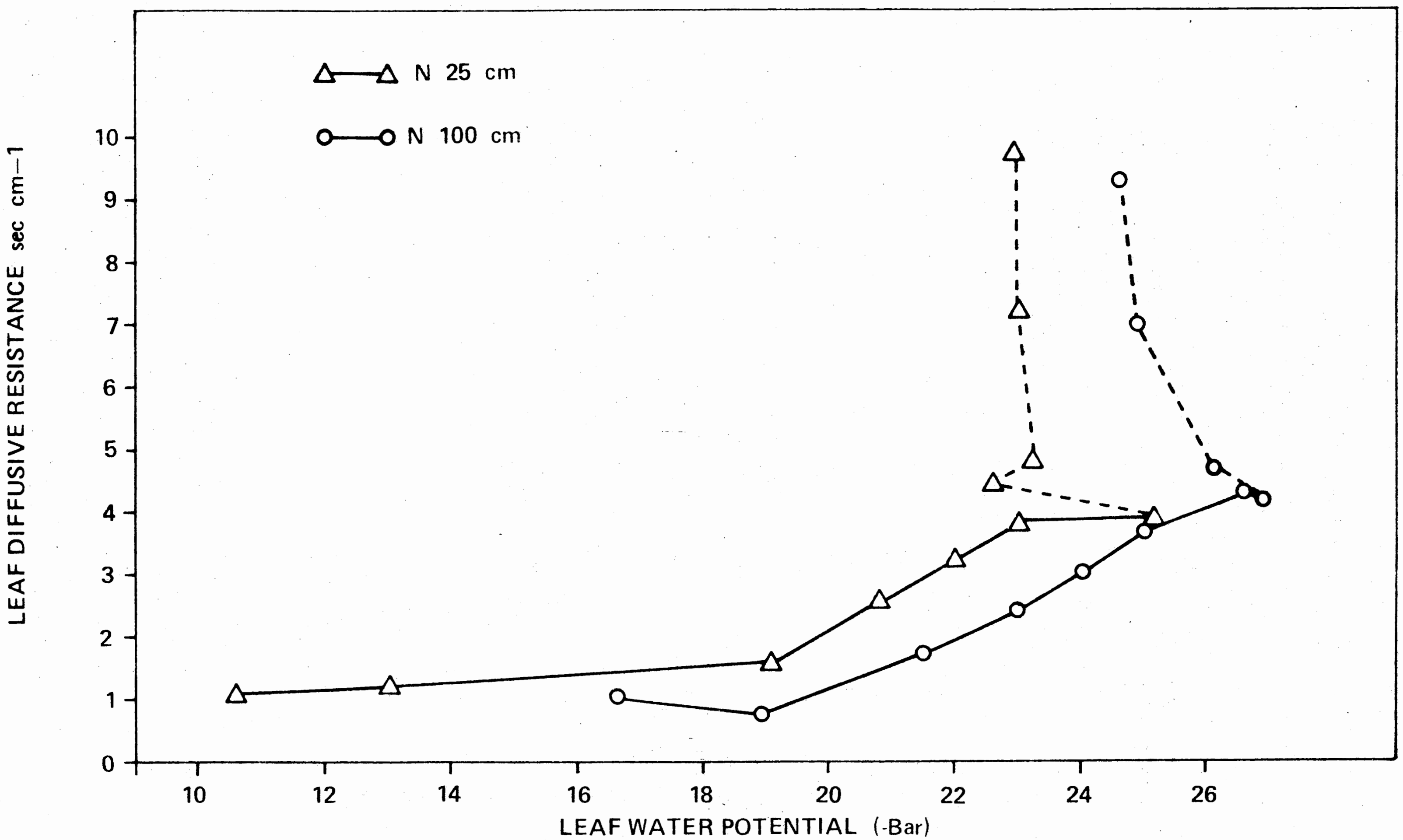

Figure 4. Leaf Resistance vs. Leaf Water Potential for August 18

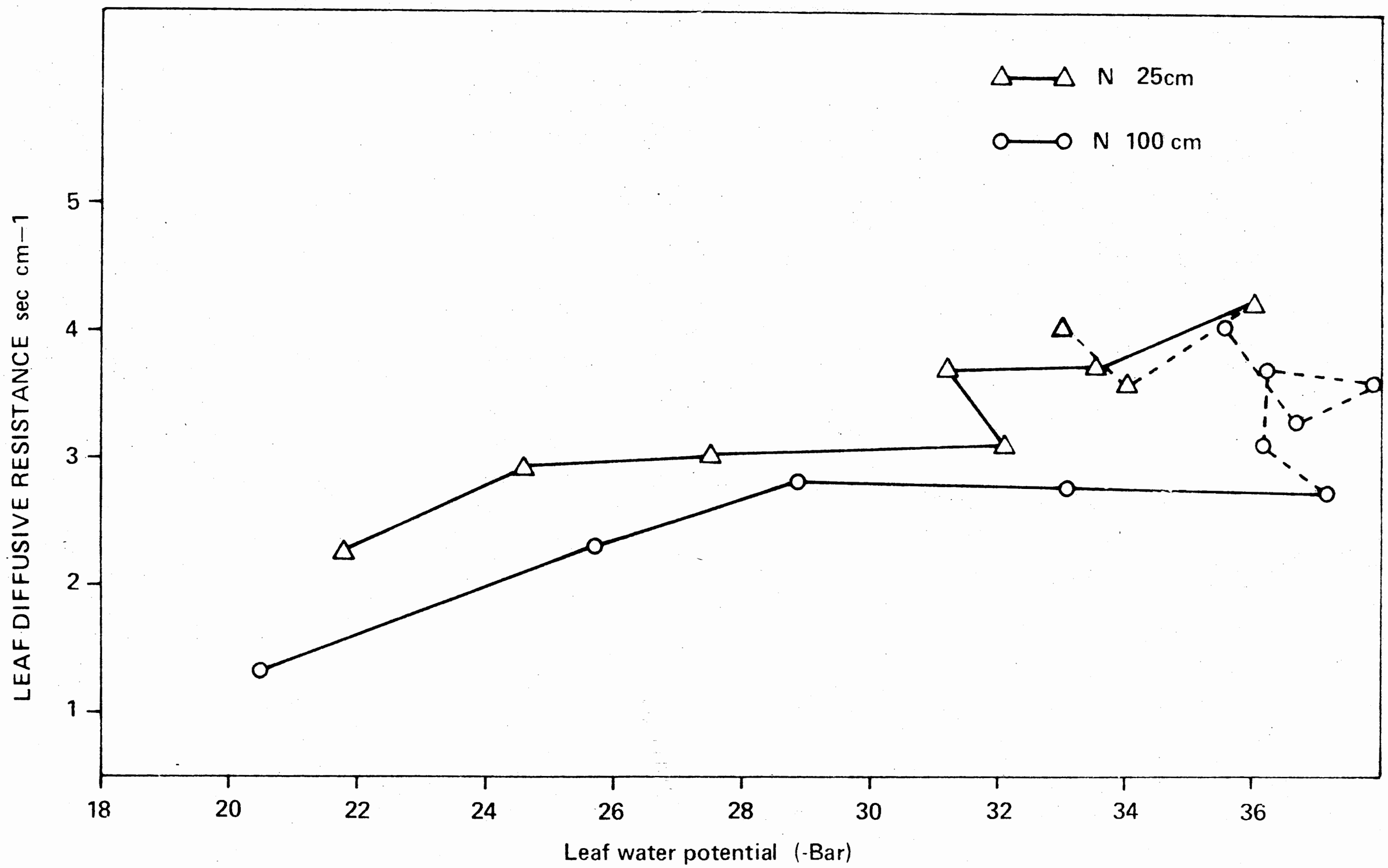

Figure 5. Leaf Diffusive Resistance vs. Leaf Water Potential for August 11

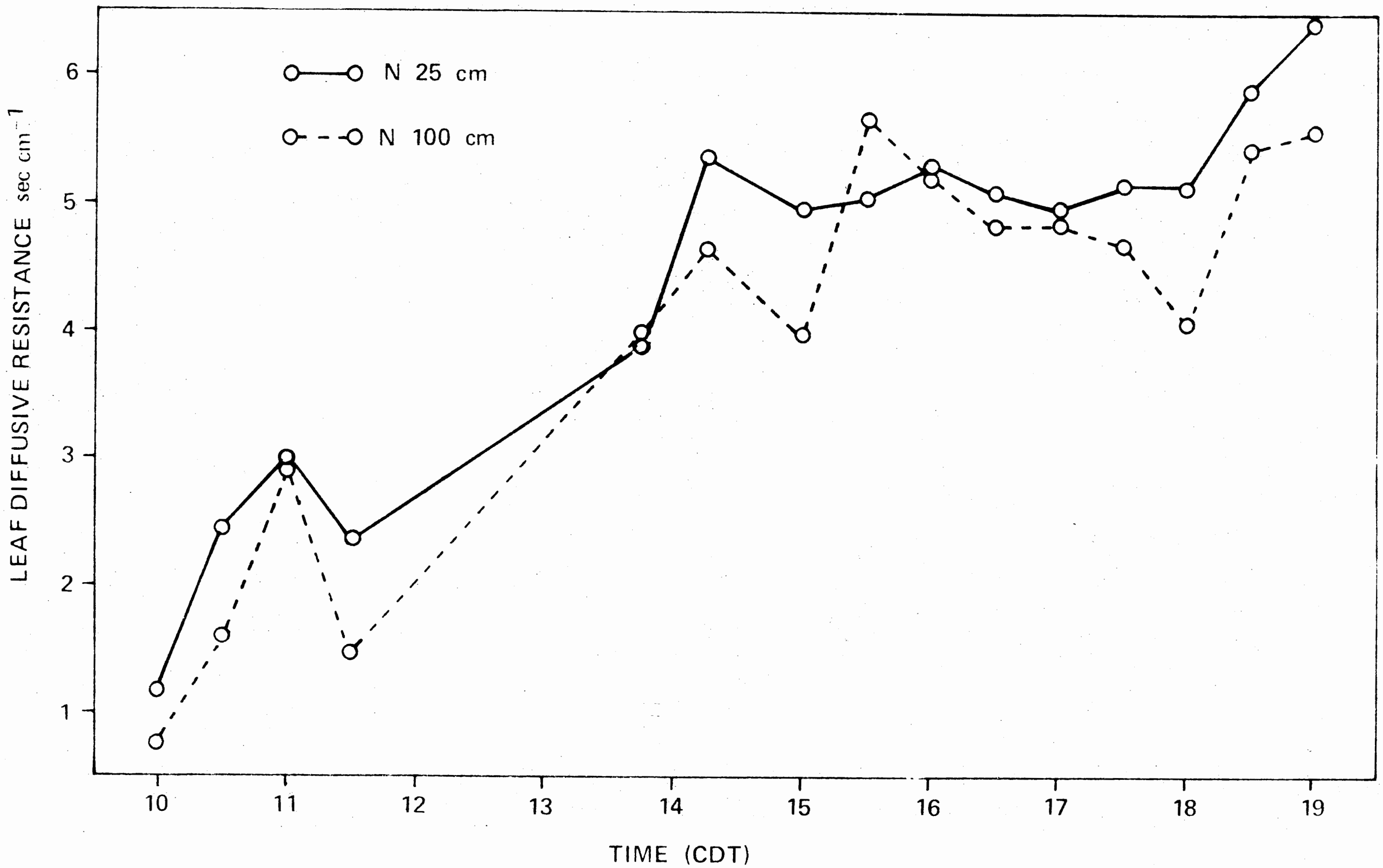

Figure 6. Leaf Diffusive Resistance vs. Time for August 25

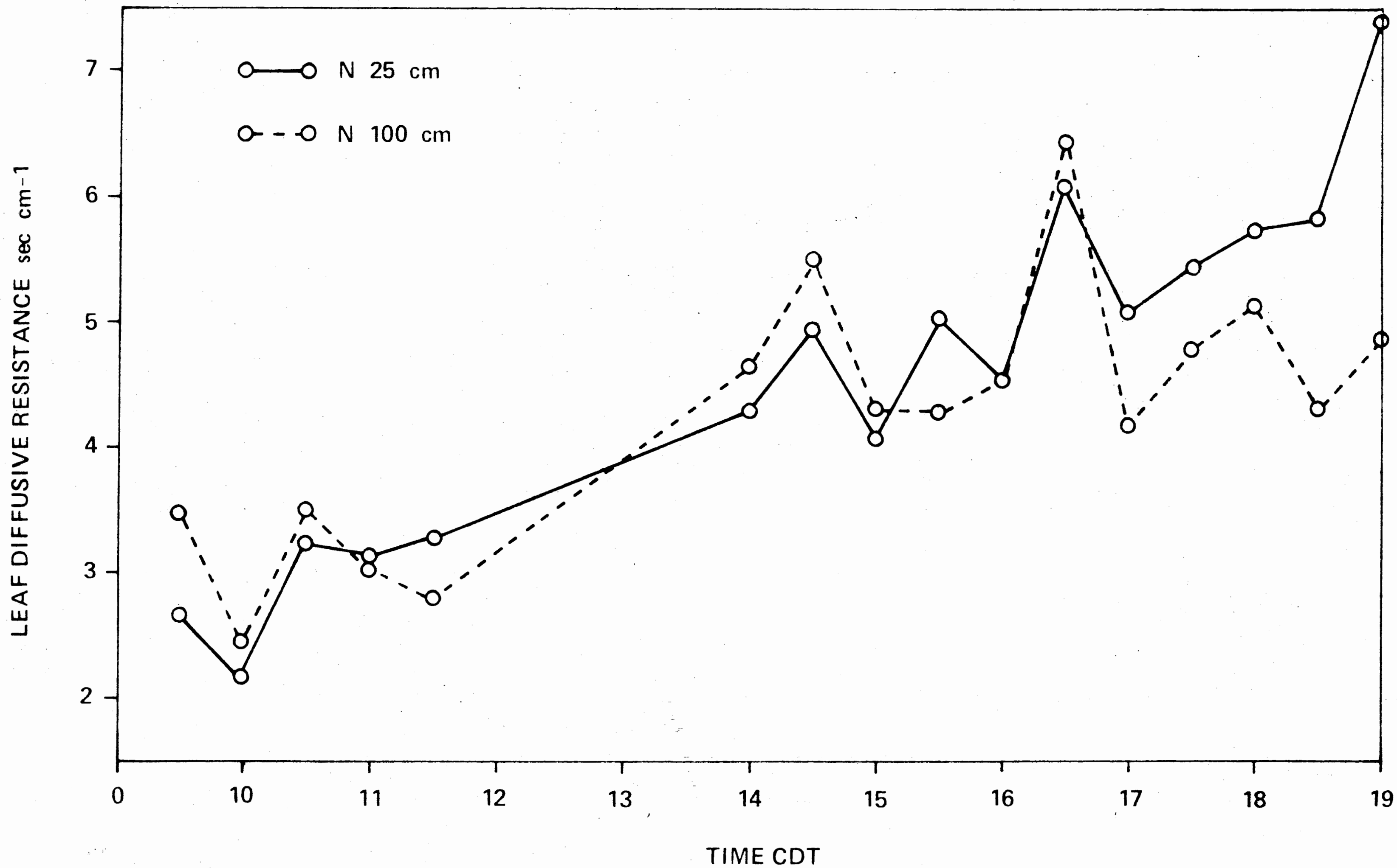

Figure 7. Leaf Diffusive Resistance vs. Time for August 4

resistance tends to be slightly higher in narrow than in wide row plots up to the peak resistance in the afternoon. After that, the row effect is more obvious and the fluctuation in resistance tends to have a line of positive slope in the narrow row while the fluctuation in resistance in the wide row plots tends to have a line of zero to negative slope. This is shown clearly in Figure 7. Table III shows the slope of resistance for days on which narrow row effect exists. The row effect, high resistance in narrow rather than wide was observed also on July 25, 26, and August 10, 22, 23, and 24. Stone et al. (51) observed a sharp increase in leaf resistance in treatment N 30, which was not observed in the others (N 90, E 30, E 90). This means that N 30 may have less evapotranspiration than did the others.

TABLE III

SLOPE OF THE RESISTANCE-TIME LINE IN THE AFTERNOON

Date	Narrow Row	Wide Row
(1977)		
July 26	0.16	0.03
Aug. 4	0.53	-0.04
10	0.55	0.20
22	0.65	0.35
23	0.31	0.02
24	0.33	0.09
25	0.38	-0.07

As shown in Figures 8 and 9, which are typical days for high evaporative demand, the leaf resistance increased as the leaf water potential decreased to its minimum value. This minimum value was about -29 to -33 bar on August 4 and 24; about -35 to -38 bar on August 10 to 25. The resistance then increased as leaf water potential increased, and further decrease in leaf water potential caused a decrease in resistance. The increase in resistance was proportional to that of the leaf water potential after the minimum value. The increase in resistance was proportional to that of the net radiation before the minimum value of leaf water potential. Figure 10 shows that the net radiation was higher in narrow than in wide row plots. This occurred only when the minimum value of leaf water potential coincided with or was near the peak of the solar radiation as shown in Figures 11 and 12. Regression analysis by the least squares method was used with the model $y \doteq ax + b$ where y is leaf resistance and x is leaf water potential. The coefficients are shown in Table IV. Figures 13 and 14 show that the row effects occurred when the points deviate from the principal regression line near the right-hand side of the graph.

Leaf resistance tended to peak when a cloud came over. Figure 15 shows that the peak was slightly higher in the wide row. This peak coincides with the lowest value of solar radiation, 0.3 Ly min^{-1}.

The row effect was marginal when clouds came over as a result of a decrease in solar radiation, as shown in Figure 16. The row effect failed to exist when the leaf water potential continued to decrease. This is clearly shown in Figure 17, and also observed on August 2 and 16.

The air temperature was always higher than the leaf temperature throughout the study. This means that the leaf is always extracting

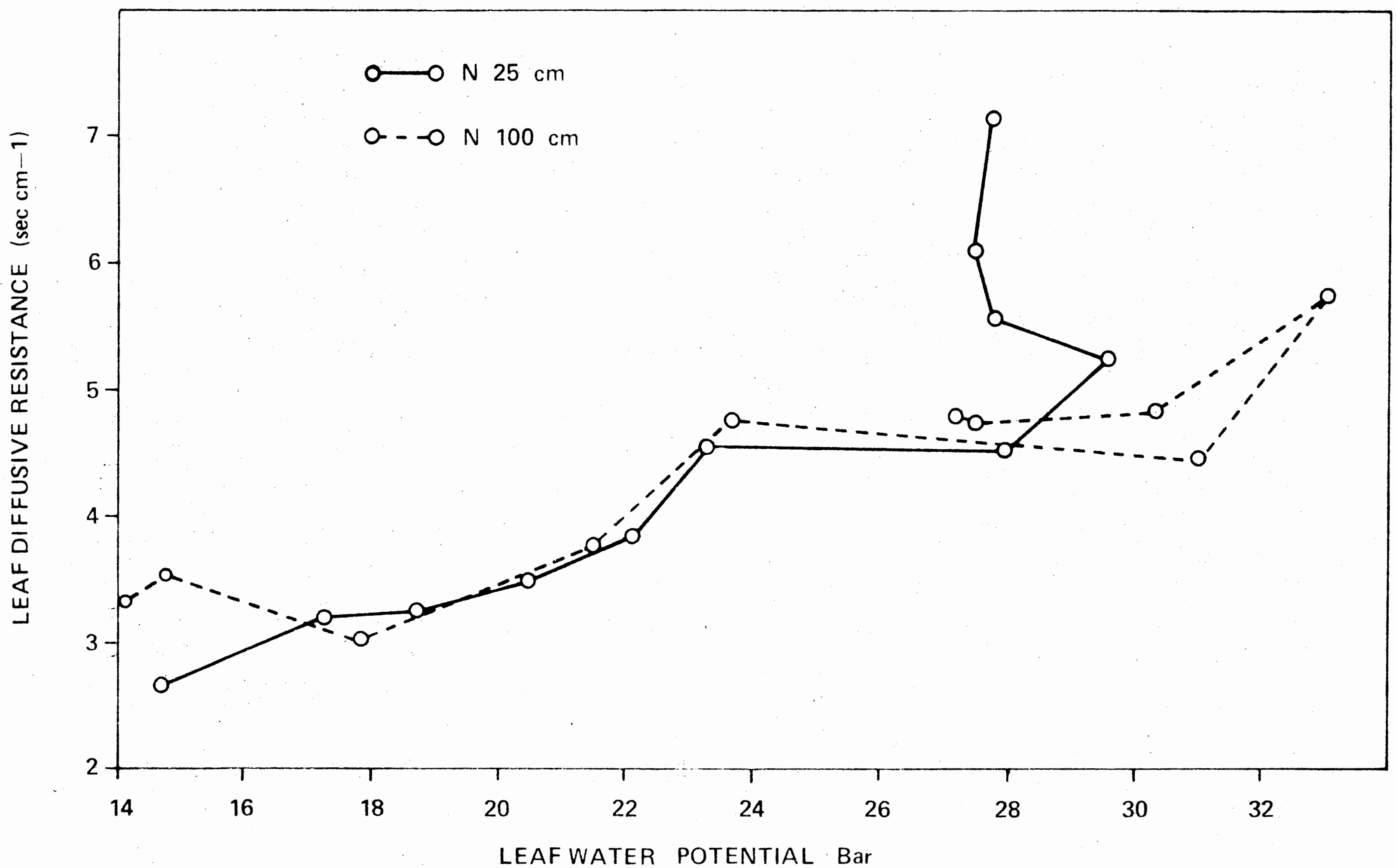

Figure 8. Leaf Diffusive Resistance vs. Leaf Water Potential for August 4

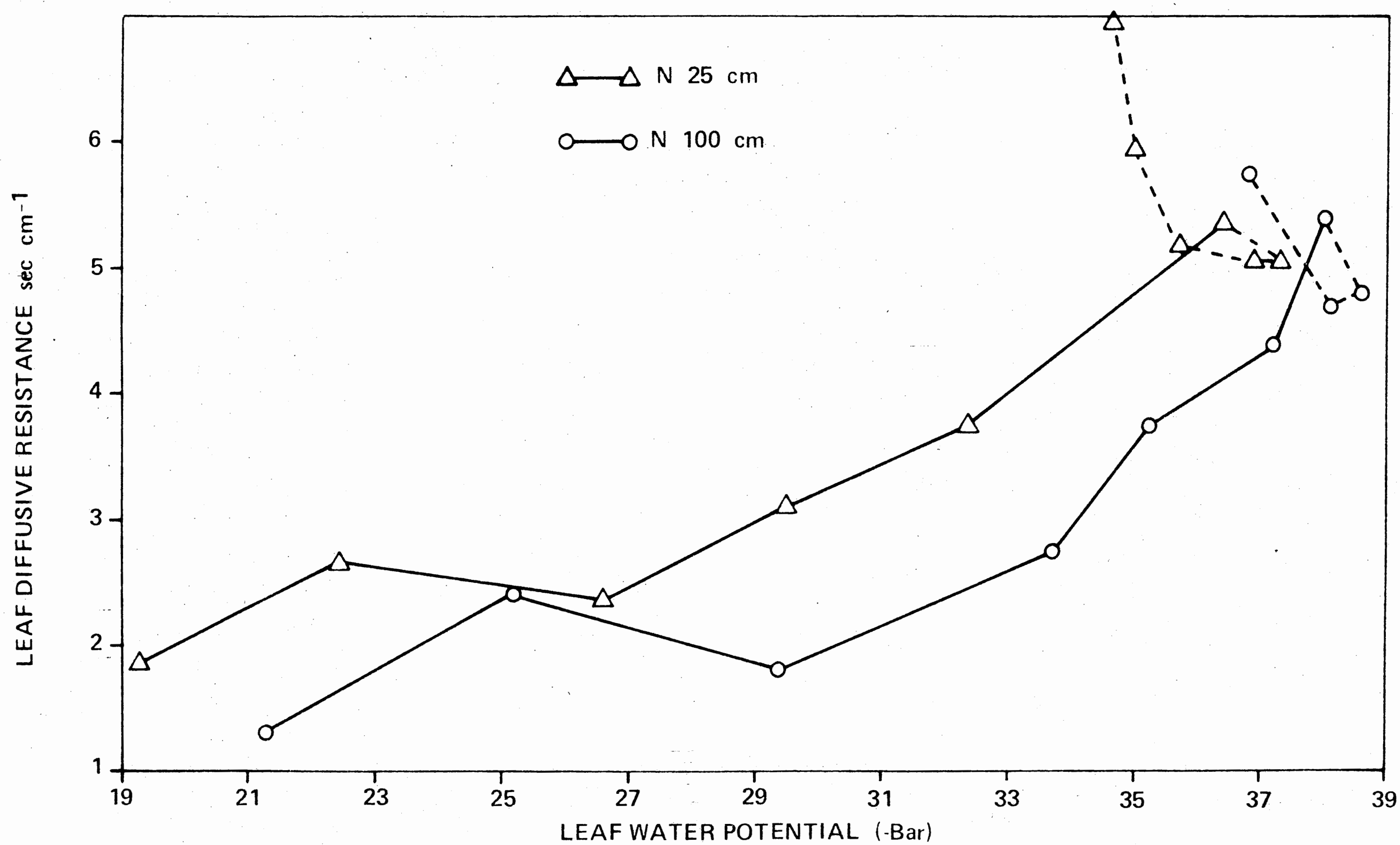

Figure 9. Leaf Diffusive Resistance vs. Leaf Water Potential for August 25

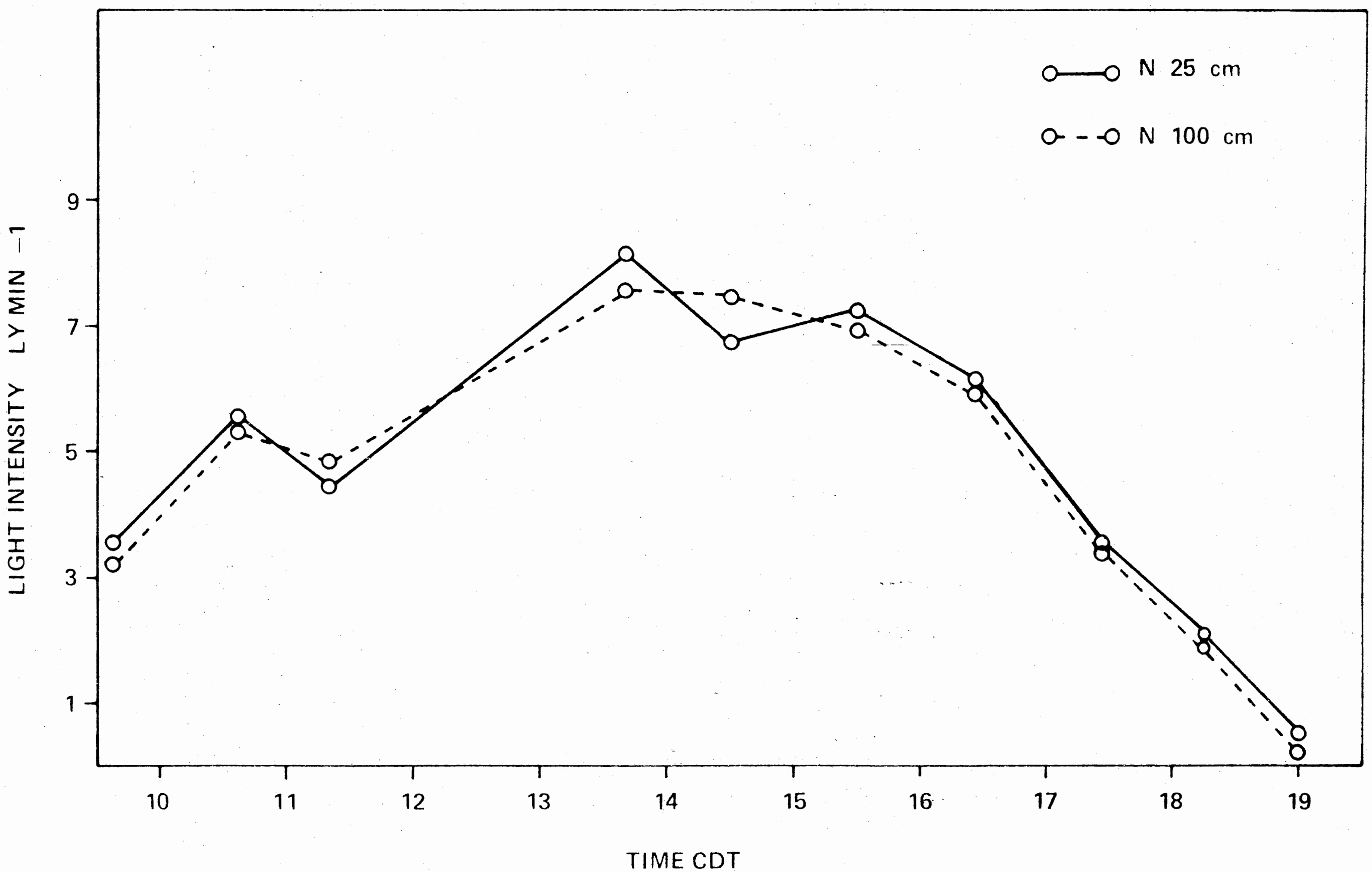

Figure 10. Net Radiation for August 25

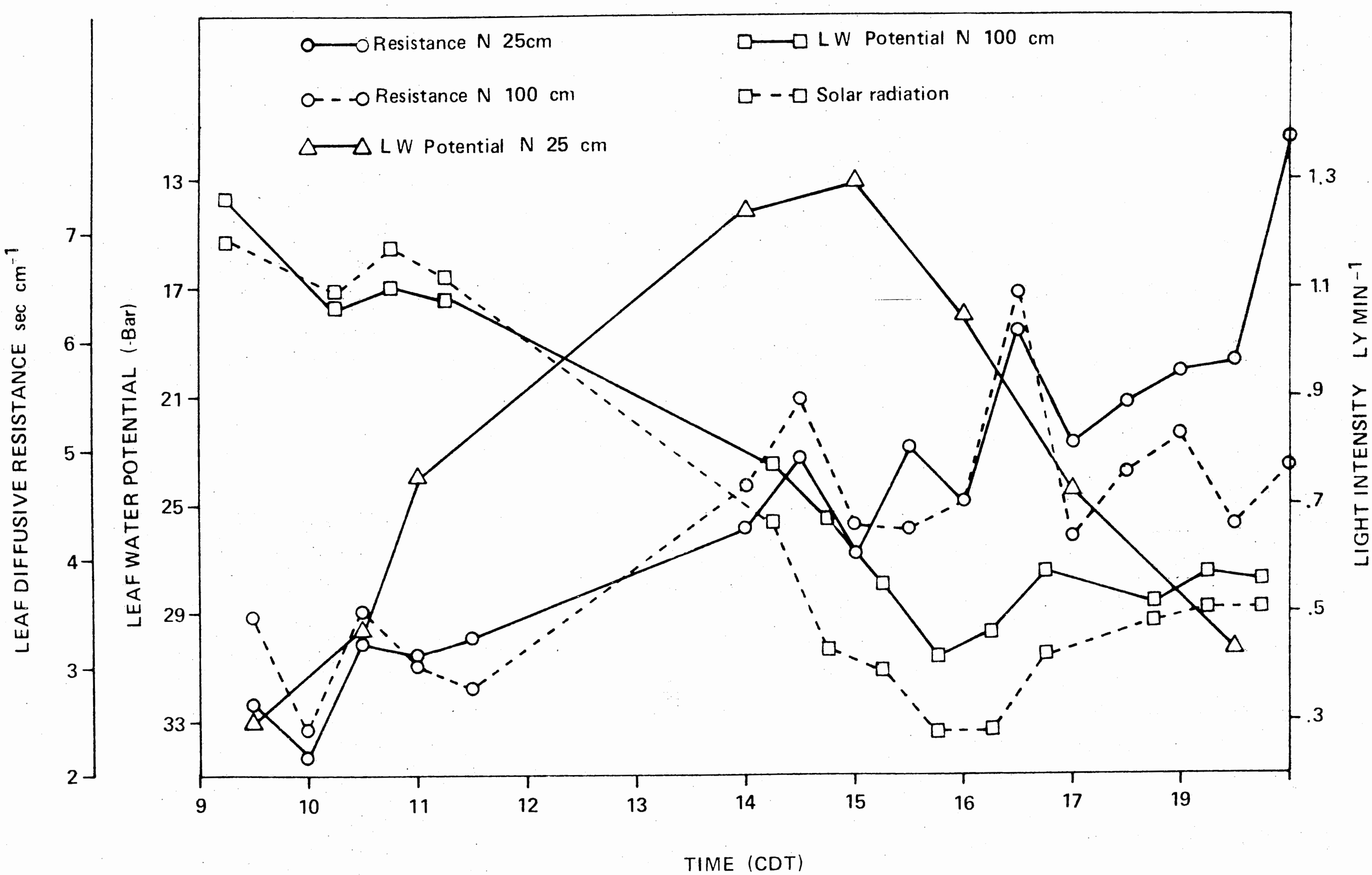

Figure 11. Leaf Resistance, Leaf Water Potential, and Solar Radiation for August 4

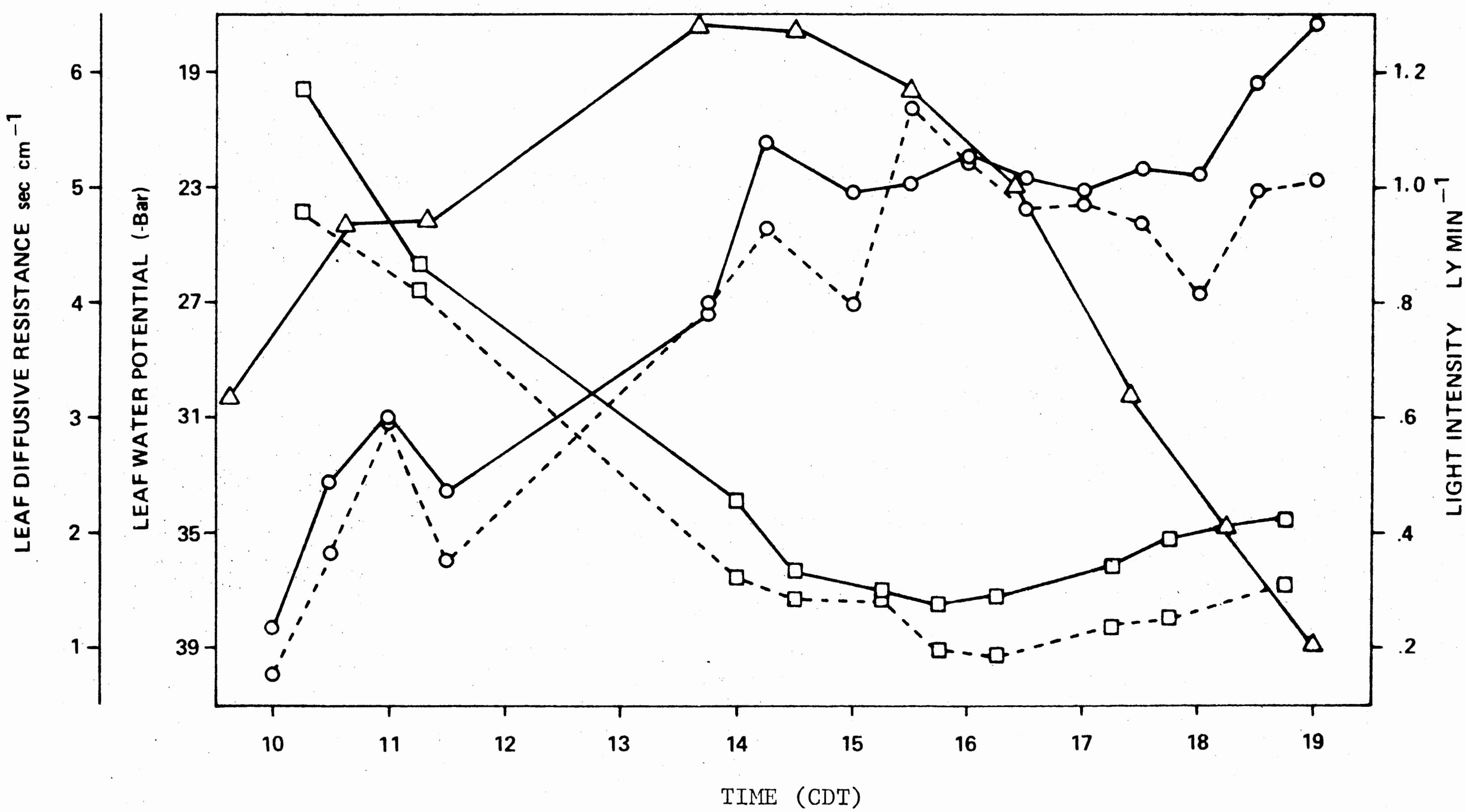

Figure 12. Leaf Resistance, Leaf Water Potential, and Solar Radiation for August 25

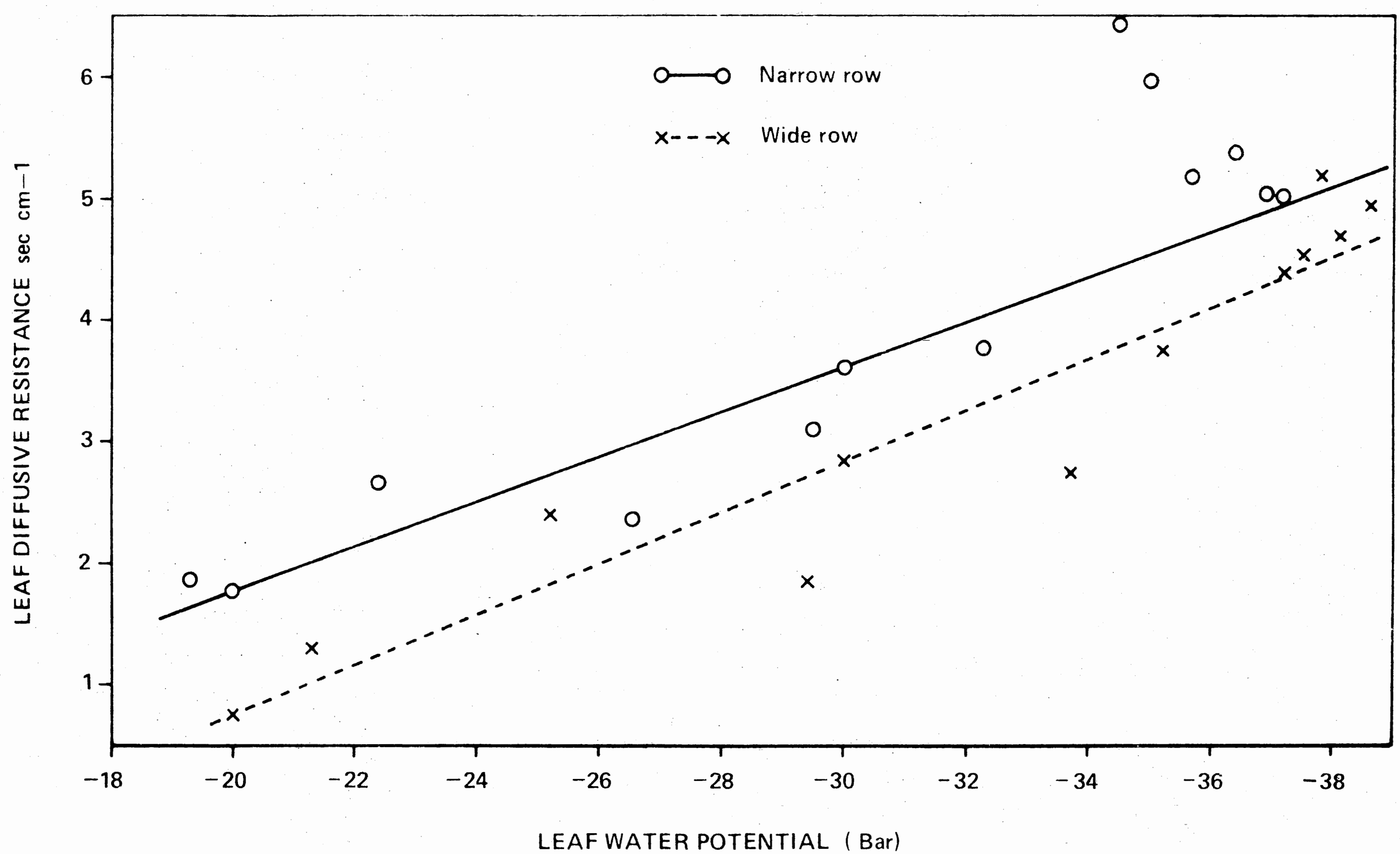

Figure 13. Regression Line for August 25

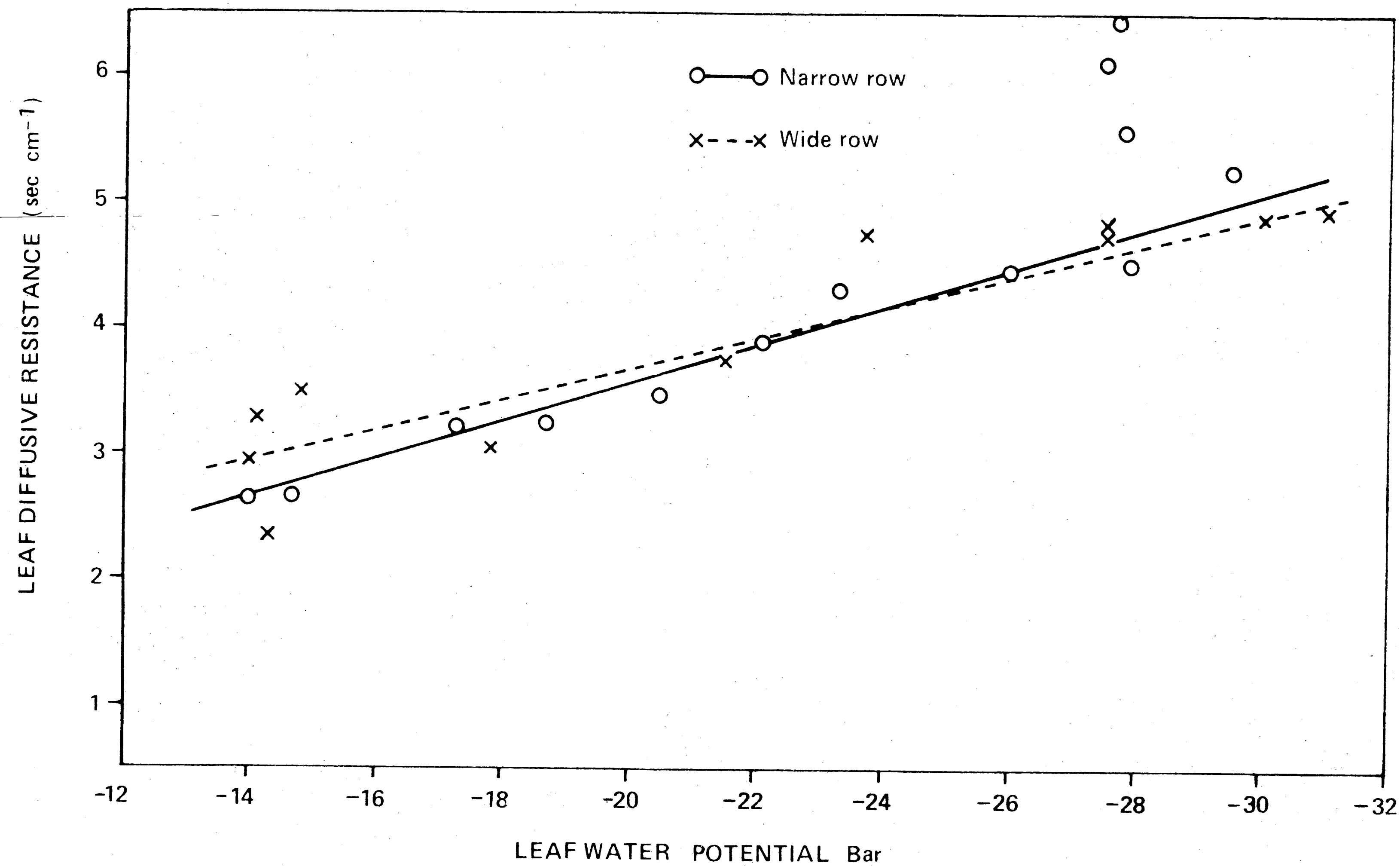

Figure 14. Regression Line for August 4

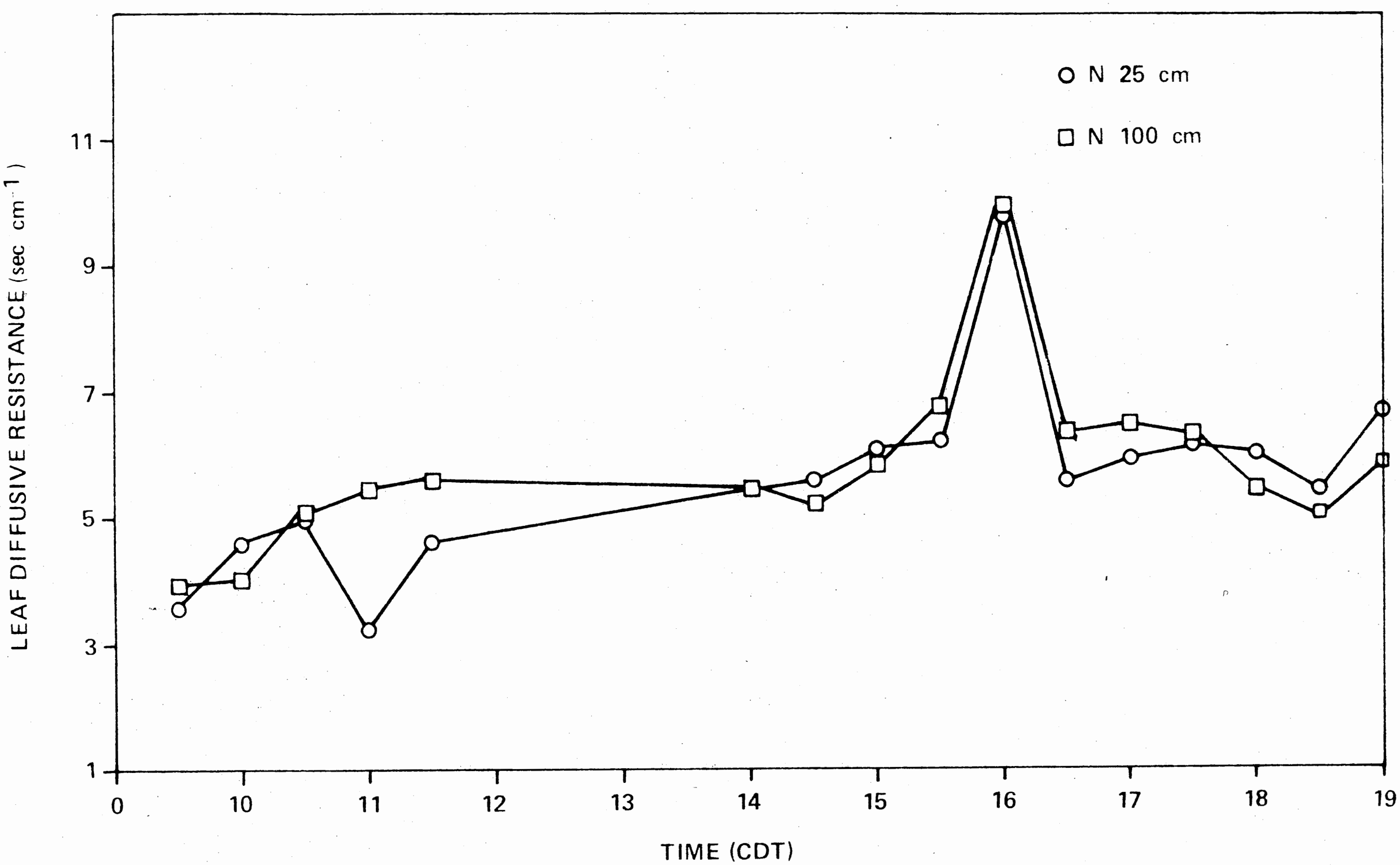

Figure 15. Leaf Diffusive Resistance vs. Time for August 9

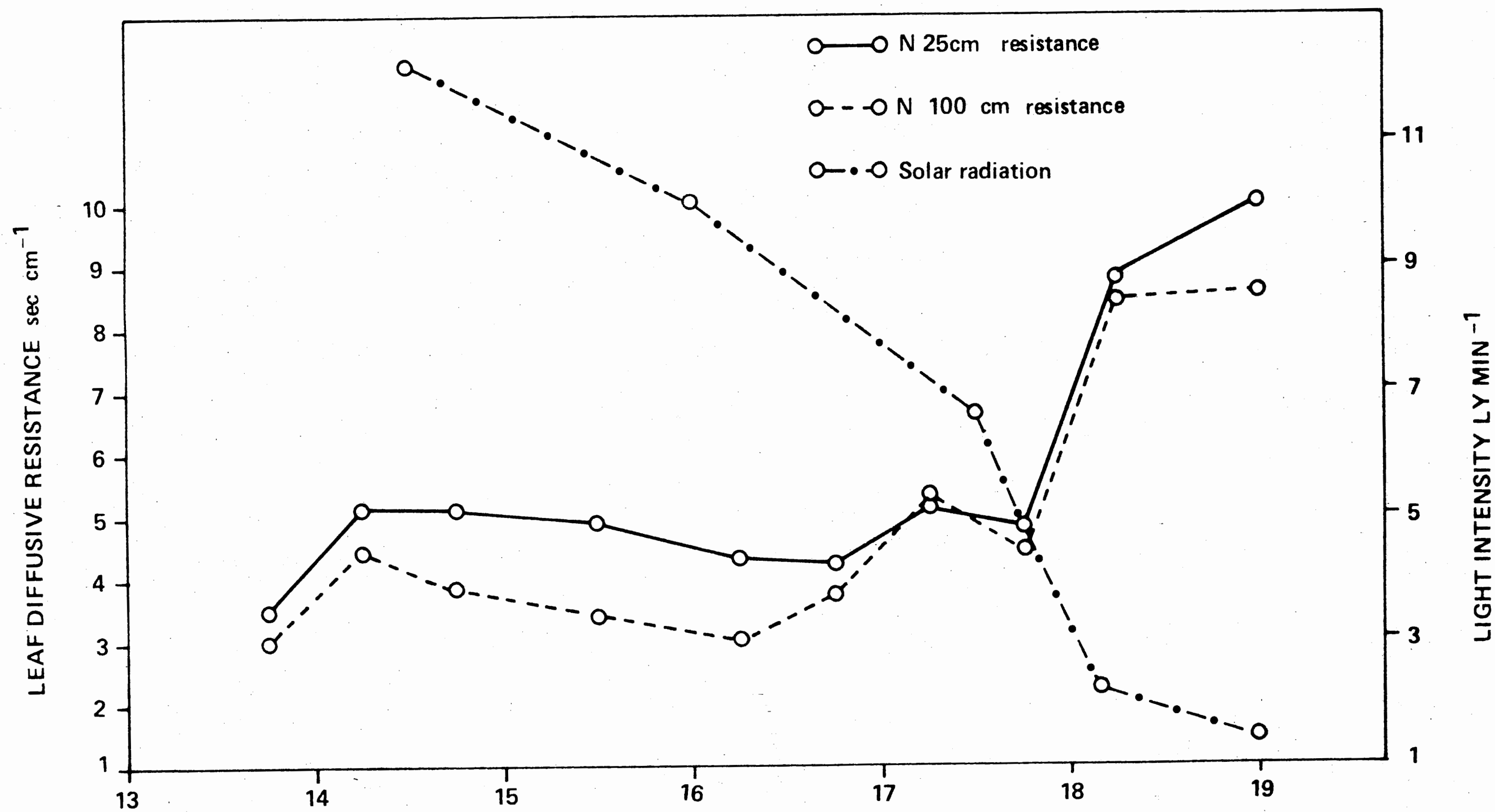

Figure 16. Leaf Resistance and Solar Radiation vs. Time for August 22

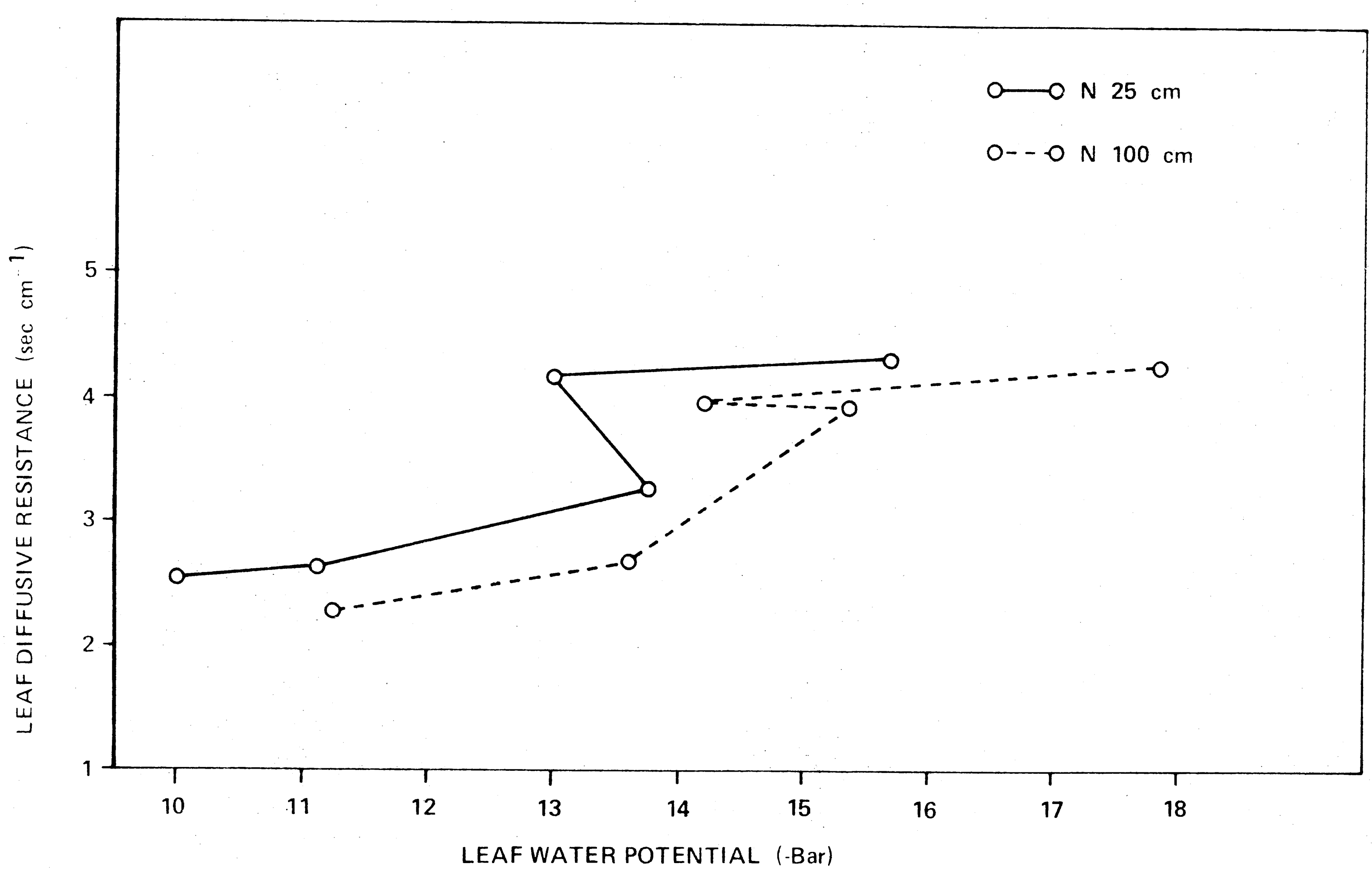

Figure 17. Leaf Resistance vs. Leaf Water Potential for August 2

energy from the air. The leaf temperature was almost always identical for both treatments.

TABLE IV

LINEAR REGRESSION (R) COEFFICIENTS FOR DAYS ON WHICH THE NARROW ROW EFFECT EXISTS. THE MODEL WAS y = ax + b, WHERE y is LEAF RESISTANCE (sec/cm) AND x IS THE LEAF WATER POTENTIAL (BAR)

Date (1977)	Narrow Row			Wide Row		
	R	a	b	R	a	b
Aug. 4	.948	.183	.069	.88	.123	1.219
10	.879	.156	-.733	.803	.162	-1.131
22	.25	.027	4.031	.150	.018	3.647
23	.74	.200	-1.09	.51	-2.127	8.96
24	.915	.140	-.801	.958	.146	-1.429
25	.939	.185	-1.929	.903	.209	-3.453

Figure 18 illustrates the water content of the soil through the study for the treatments averaged over replications. The right-hand portion of the graph indicates a higher water consumption for the wide row as compared to the narrow. The reverse is true for the left-hand portion of the graph; this might be due to less evapotranspiration.

As can be seen from Table V, the highest yield was exhibited by the narrow-row plots. This is consistent with results reported in the literature (50)(9)(7).

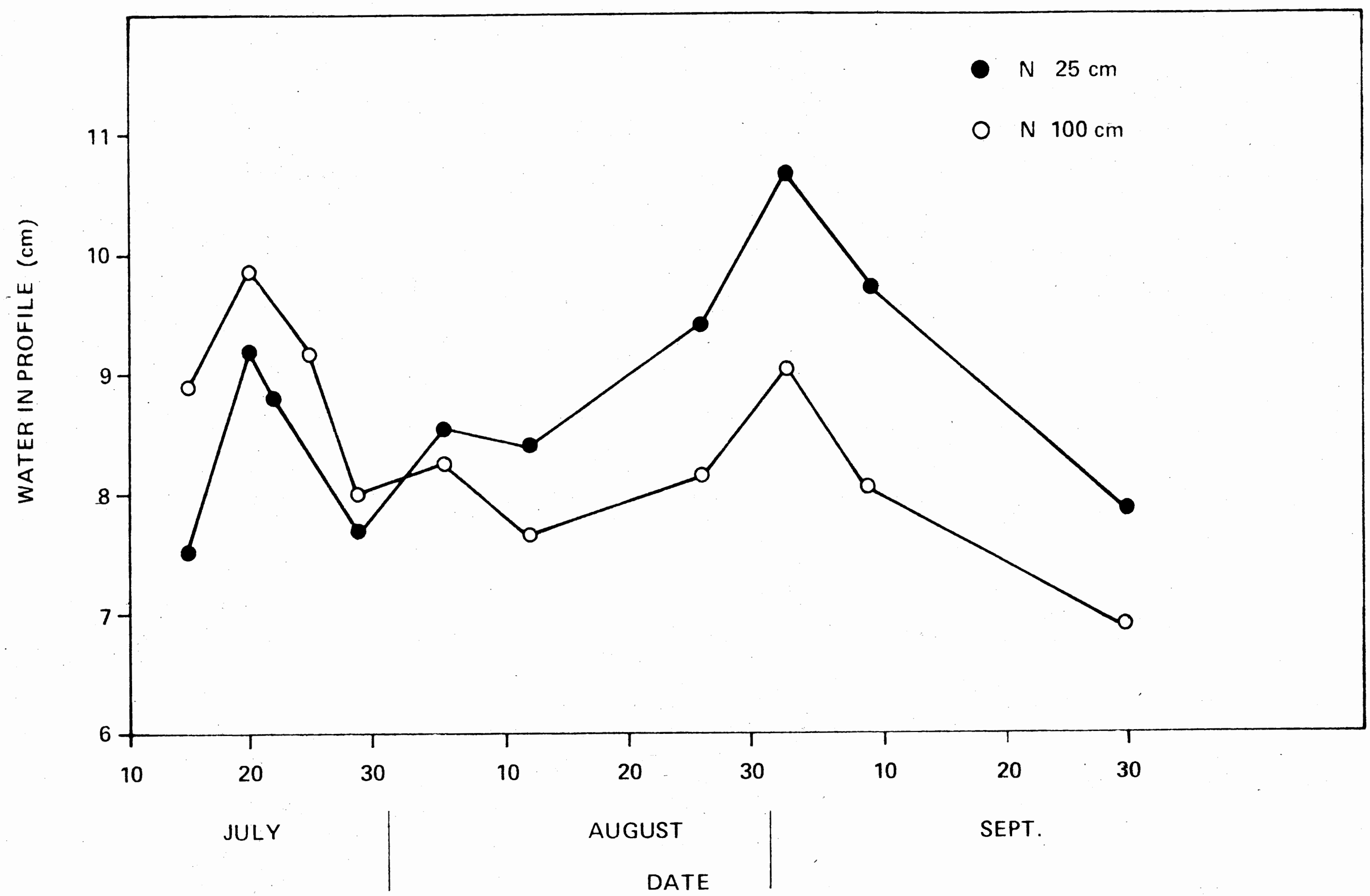

Figure 18. Soil Water Content

TABLE IV

YIELD OF PEANUTS (Kg/ha)

Row Spacing	Replication	Yield Kg/ha	Plant Population pl/ha
25 cm	I	5030	336,660
	II	4970	186,040
	III	4600	228,370
	mean	4860	250,000
100 cm	I	4040	74,810
	II	4510	97,450
	III	4240	68,900
	mean	4260	80,390
LSD (.05)		530	

CHAPTER V

SUMMARY AND CONCLUSIONS

Row spacing effects on leaf diffusive resistance was studied at the Perkins Research Station, Perkins, Oklahoma. Two treatments were considered, 25 and 100-cm row spacing oriented in a north-south direction. Leaf resistance, leaf water potential, and leaf temperature were measured periodically throughout the day. Meteorological factors: solar and net radiation, air temperature, and wind speed and direction were measured at one-hour intervals throughout the day. Soil water content was measured with a neutron moisture probe. Total water potential gradient across the 120-150 cm depth was monitored with tensiometers.

The hypothesis that the physiological characters of the plant interact with environmental demand on plants in narrow north-south rows to cause higher leaf resistance in the narrow than in the wide rows was supported. The variation in stomatal resistance pattern differed with the degree of evaporative demand. The row effect was obvious on the moderate to high evaporative demand days, which are characterized by daily maximum temperature greater than 32^{o}C, clear to partly cloudy skies, and moderate to high wind velocity. The effect was evidenced in the afternoon, and the resistance-time pattern tended to have a positive slope with time in narrow rows. A negative to zero slope line was the characteristic of the wide row plot. The row effect was illustrated in graphs of resistances vs. potential as the points deviate from the early day regression line. The row effect is not significant in low evaporative demand days, which are characterized by daily maximum temperature below 30^{o}C, partly cloudy to cloudy skies, and low wind velocity.

SELECTED BIBLIOGRAPHY

1. Al-Ani, T. A. and J. F. Bierhuizen. 1971. Stomatal resistance, transpiration, and relative water content as influenced by soil moisture. Acta. Bot. Neerl. 20:318-326.

2. Blum, A. 1970. Effect of plant density and growth duration on grain sorghum under limited water supply. Agronomy J. 62: 333-336.

3. Boyer, J. S. 1970. Differing sensitivity of photosynthesis to low leaf water potentials in corn and soybean. Plant Physiol. 46:236-239.

4. Brown, K. W. and N. J. Rosenberg. 1970. Effect of wind break and soil water potential on stomatal diffusion resistance and photosynthetic rate of sugar beets. Agron. J. 62:4-8.

5. Brown, R. H., E. R. Beaty, W. J. Ethridge, and D. O. Hayes. 1970. Invluence of row width and plant population on yield of two varieties of corn (Zea mays L.). Agron. J. 62:767-771.

6. Chang, H. H. 1968. Climate and Agriculture, and Ecological Survey. Aldine Publishing Company, Chicago.

7. Chin Choy, E. W. 1972. The effects of plant population and geometry on yield and water utilization by peanuts. Unpublished Ph.D. thesis, Oklahoma State University.

8. Chin Choy, E. W. and E. T. Kanemasu. 1974. Energy balance comparisons of wide and narrow row spacings in sorghum. Agron. J. 66:98-100.

9. Chin Choy, E. W., J. F. Stone, and J. E. Garton. 1977. Row spacing and direction effects on water uptake characteristics of peanuts. Soil Sc. Soc. America 41:428-432.

10. Dale, J. E. 1961. Investigations into the stomatal physiology of upland cotton. I. The effects of hour of day, solar radiation, temperature, and leaf water content on stomatal behavior. Ann. Bot. 25:39-52.

11. Denmead, O. T. and B. D. Millar. 1976. Field studies of the conductance of wheat leaves and transpiration. Agron J. 68: 307-311.

12. Denmead, O. T. and R. H. Shaw. 1962. Availability of soil water to plants as affected by soil moisture content and meterological condition. Agron. J. 54:385-390.

13. Drake, B. G., R. Raschke, and F. B. Salisbury. 1970. Temperature and air transpiration resistance of xanthium leaves as affected by air temperature, humidity, and wind speed. Plant Physiol. 46:324-330.

14. Eeckhout, L. E. and M. Slaats. 1971. Evapotranspiration and canopy resistance of grass. Medelingen van de Landbouwhoge 36:607-615.

15. Ehrler, W. L. and C. H. M. van Bavel. 1968. Leaf diffusion resistance, illuminance, and transpiration. Plant Physiol. 43: 208-214.

16. Epstein, E. and W. J. Grant. 1973. Water stress relations of the potato plant under field conditions. Agron. J. 65:400-404.

17. Fritschen, L. J. 1960. Construction and calibration details of the thermal-transducer type net radiometers. Bull. Amer. Meteorol. Soc. 41:180-183.

18. Fritschen, L. J. 1963. Construction and evaluation of a miniature net radiometer. J. Appl. Meteorol. 2:165-172.

19. Fritschen, L. J. 1965. Miniature net radiometer improvement. J. Appl. Meteorol. 4:528-532.

20. Gates, O. M. and R. J. Hanks. 1967. Plant factors affecting evapotranspiration in Hagan, Haise, and Edminster, Editors. Irrigation of Agricultural Lands. Amer. Soc. Agron. Monegr. No. 11.

21. Glover, J. 1959. The apparent behavior of maize and sorghum stomate during and after drought. J. Agr. Sci. 53:412-416.

22. Grace, J. 1974. The effect of wind on grasses. I. Cuticular and stomatal transpiration. J. of Exp. Bot. 25:542-551.

23. Hsiao, T. C. 1973. Plant responses to water stress. Ann. Rev. Plant Physiol. 24:519-570.

24. Idso, S. B. 1970. The relative sensitivities of polyethylene shielded net radiometers for short and long wave radiation. Rev. Sci. Instr. 41:439-943.

25. Idso, S. B. 1971. A simple technique for the calibration of a long wave radiation probe. Agri. Meteorol. 8:235-243.

26. Kanemasu, E. T. 1975. Measurement of stomatal aperture and diffusive resistance. College of Agri. Resc. Center, Washington State University Bull. 809.

27. Kanemasu, E. T. and C. B. Tanner. 1969. Stomatal diffusion resistance of snap beans. II. Effect of light. Plant Physiol. 44:1542-1546.

28. Kanemasu, E. T., G. W. Thurtell, and C. B. Tanner. 1969. Design, calibration and field use of astomatal diffusion prometer. Plant Physiol. 44:881-885.

29. Ketellapper, H. J. 1963. Stomatal physiology. Ann. Rev. Plant Physiol. 14:249-269.

30. Kuiper, P. J. 1964. Dependence upon wave length of stomatal movement in epidermal tissue of *Sencio odoris*. Plant Physiol. 39-952-955.

31. Lange, O. L., R. Losch, E. O. Schulze, and L. Kapper. 1971. Responses of stomata to changes in humidity. Plants 100:76-86.

32. Lutz, J. A. Jr., H. Camper, and G. D. Jones. 1971. Row spacing and population effects on corn yields. Agron. J. 63:12-14.

33. Meidner, H. and T. A. Mansfield. 1968. Physiology of Stomata. McGraw-Hill Book Company, New York.

34. Millar, B. D. and O. T. Denmead. 1976. Water relations of wheat leaves in the field. Agron. J. 68:303-307.

35. Milthorpe, F. L. and E. J. Spencer. 1957. Experimental studies of the factors controlling transpiration. III. The interrelations between transpiration rate, stomatal movement, and leaf water content. J. of Exp. Bot. 8:413-437.

36. Perrier, E. R. and D. D. Evans. 1961. Soil moisture evaluation by tensiometers. Soil Sci. Soc. Amer. Proc. J. 25:173-175.

37. Plaut, Z., A. Blum, and I. Arnon. 1969. Effect of soil moisture regime and row spacing on grain sorghum production. Agron. J. 61:344-347.

38. Raschke, K. and J. Kuhl. 1969. Stomatal responses to changes in atmospheric humidity and water supply: Experiments in leaf section of *Zea mays* in CO_2-free air. Plants 87:36-48.

39. Rees, A. F. 1961. Midday closure of stomata in the oil palm *Elaeis guineensis* Jacp. J. Expt. Botany 12:129-146.

40. Ritchie, J. T. and E. Burnett. 1971. Dryland evaporative flux in a subhumid climate. II. Plant influences. Agron. J. 63: 56-62.

41. Ritchie, J. T. and W. R. Jordan. 1972. Dryland evaporative flux in a subhumid climate. IV. Relation to plant water status. Agron. J. 64:173-176.

42. Rosenberg, N. J. 1974. Microclimate: the Biological Environment. John Wiley and Sons, New York, 315 p.

43. Rosenberg, N. J., D. W. Lechor, and R. E. Neild. 1967. Wind shelter induced growth and physiological responses in irrigated snap beans. Proc. Amer. Soc. Hort. Sci. 90:169-179.

44. Schulze, E. D., O. L. Lange, U. Buschbom, L. Kappen, and M. Evenari. 1972. Stomatal responses to changes in humidity in plants growing in the desert. Plantar 108:259-270.

45. Schuttle, K. H. 1959. Micro-nutrient deficiency and transpiration in Tropaeolam majus L. J. Exp. Bot. 10:443-447.

46. Skoskiewicz, K. 1973. Stomatal movements in summer rape in dependence on the age of the leaf, water deficit, light intensity and CO_2 concentration. Hodowla Roslin Akl. 17: 359-386.

47. Slatyer, R. O. 1966. Some physical aspects of internal control of leaf transpiration. Agri. Meteorol. 3:281-292.

48. Slayter, R. O. 1967. Plant-water Relationships. Academic Press, New York.

49. Stevenson, K. R. and R. H. Shaw. 1971. Diurnal changes in leaf resistance to water vapor diffusion at different heights in a soybean canopy. Agron. J. 63:17-19.

50. Stone, J. F. 1972. Plant population effects on the efficient use of water: water uptake characteristics. Technical Completion Report to the Office of Water Resources Research, U. S. Dept. of Interior.

51. Stone, J. F., E. W. Chinchoy, and H. E. Reeves. 1976. Evapotranspiration Reduction by Field Geometry Effects. Final Technical Completion Report to the Office of Water Research and Technology, U. S. Dept. of Interior.

52. Thomas, J. C., W. H. Brown, and W. R. Jordan. 1976. Stomatal response to lead water potential as affected by preconditioning water stress in the field. Agron. J. 68:706-708.

53. Troughton, J. H. 1970. Response of adaxial and abaxial stomata to light. New Phytol. 69:647-653.

54. Troughton, J. H. and I. R. Cowan. 1968. Carbon dioxide exchange in cotton in some anomalous fluctuations. Science 161:281-283.

55. Turner, N. C. 1974. Stomatal behavior and water status of maize, sorghum, and tobacco under field conditions. II. At low soil water potential. Plant Physiol. 53:360-365.

56. Turner, N. C. 1969. Stomatal resistance to transpiration in three contrasting canopies. Crop. Sci. 9:3030-307.

57. Turner, N. C. and J. E. Begg. 1973. Stomatal behavior and water status of maize, sorghum, and tobacco under field conditions. Plant Physiol. 51:31-36.

58. van den Honert, T. H. 1948. Water transport in plants as a caternary process. Faraday Soc. 3:146-153.

59. Whiteman, P. C. and D. Koller. 1967. Interaction of carbon dioxide concentration, light intensity and temperature on plant resistances to water vapor and carbon dioxide diffusion. New Phytol. 66:463-473.

60. Yao, Y. M. and R. H. Shaw. 1964. Effect of plant population and planting pattern of corn on water use and yield. Agronomy J. 56:147-152.

VITA 2

Alaa Salih Abdul Al-Jabbar

Candidate for the Degree of

Master of Science

Thesis: LEAF DIFFUSIVE RESISTANCE OF PEANUTS AS INFLUENCED BY ENVIRONMENT AND ROW SPACING

Major Field: Agronomy

Biographical:

Personal Data: Born in Baghdad, Iraq, Southwestern end of Asia, the son of Salih and Rafika Abdul Al-Jabbar on July 1, 1952.

Education: Graduated from Al-Markisa High School, Baghdad, Iraq, in 1969; received the Bachelor of Science degree from the University of Baghdad in 1974; completed the requirements for the Master of Science degree at Oklahoma State University, Stillwater, Oklahoma, in May, 1978.

Professional Societies: Member of Soil Science Society of America.