Reprinted from *Agronomy Journal*
Vol. 75, Nov.-Dec. 1983, p. 961-968

Soybean Water Status and Canopy Microclimate Relationships at Four Row Spacings[1]

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ABSTRACT

There is little field data relating plant water status and canopy microclimate of determinate soybean [*Glycine max* (L.) Merr.] cultivars grown in humid environments. Also, few observations of these parameters have been reported for the period prior to complete canopy closure. A field study was conducted in South Carolina in 1979 to determine these basic relationships for two determinate soybean cultivars, Davis (Group VI) and Coker 338 (Group VIII) grown in 1.02, 0.76, 0.51 and 0.36-m row spacings. The experiments were conducted on a Norfolk loamy sand (fine-loamy, siliceous, thermic, Typic Paleudult). Thermistor-determined leaf temperatures (T_L) and ambient temperatures (T_A) were highly correlated, and no significant improvement in the correlation resulted from treating row spacing or diurnal periods separately. Both T_L and ΔT ($T_L - T_A$) were highly correlated with pressure chamber determination of xylem pressure potential (Ψ_X). Parallel leaf diffusive resistance (R_s) was not highly correlated with any of the canopy microclimate or water status parameters observed. Atmospheric vapor pressure deficit (VPD) was correlated with ΔT. Xylem pressure potential was very highly correlated with leaf vapor pressure deficit (LVPD). No row spacing effect on Ψ_x was observed, but mean seasonal midday Ψ_x was 0.10 MPa lower for Coker 338 than for Davis ($P \leq 0.001$) and osmotic potential was 0.20 MPa lower for Coker 338 than for Davis ($P \leq 0.01$). The authors propose that the slope of ΔT vs. VPD may be influenced by high prevailing relative humidity and heating of the canopy from exposed soil between rows in the period prior to complete canopy coverage.

Additional index words: **Plant water potential, Leaf diffusive resistance, Vapor pressure deficit, Canopy temperature, Leaf temperature.**

DETERMINATE soybean [*Glycine max* (L.) Merr.] production has rapidly increased in the humid southeastern United States and much of Brazil to levels of significant economic importance in the past two decades. In recent years, a need has developed for a better understanding of canopy-environment relationships to serve the aims of irrigation scheduling, crop modeling, and remote sensing investigations. Most of the literature of soybean crop water status and canopy environment has been derived from studies in dry environments using indeterminate cultivars which are commonly grown at narrower row spacings than those generally employed for determinate soybean production. Frequently, determinate cultivars do not achieve canopy closure until mid-flowering (R1) which may account for over half the active growing period. When water stress during the vegetative stages has been significant, complete canopy coverage is never achieved since vegetative growth ceases with flowering in determinate cultivars.

Periods of low xylem pressure potentials (Ψ_X) within a given water regime were shown by Sojka et al. (1977) to correspond with periods of high pan evaporation for the determinate cultivar Lee '74. They also showed that the sensitivity of Ψ_x to pan evaporation was greater in irrigated treatments than in nonirrigated and that even this sensitivity dissipated rapidly following irrigation. Reicosky and Deaton (1979) showed that even though the leaf temperature (T_L) of nonirrigated Davis soybean was as much as 7°C higher than irrigated, Ψ_x was not appreciably different between irrigation treatments. They also found that despite large differences in soil water regimes, there were relatively small differences in Ψ_x for both Davis and McNair 800 soybean. In addition, their data demonstrated that while Ψ_x of both cultivars, when irrigated, were sensitive to diurnal fluctuations in solar radiation, there was no Ψ_x response to fluctuations in solar radiation in the nonirrigated Davis and only a partial response in the nonirrigated McNair 800. Jung and Scott (1980) found that with 'Forrest' soybean also, irrigation had only a small effect on Ψ_x at midday. They found that mean seasonal predawn and midday Ψ_x were -0.42 and -1.16 MPa for irrigated and -0.52 and -1.29 MPa for nonirrigated soybean, respectively. Mean seasonal midday leaf diffusive resistances (R_s) were 0.6 and 2.7 sec cm^{-1} for irrigated and nonirrigated treatments, re-

[1] Contribution of USDA-ARS, Coastal Plains Soil and Water Conservation Research, P. O. Box 3039, Florence, SC 29502,, in cooperation with the South Carolina Agric. Exp. Stn., Clemson, SC 29631. Received 1 Mar. 1982.

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spectively. Jung and Scott hypothesized that the higher R_s in the nonirrigated treatment reduced water vapor loss, thus maintaining Ψ_x at similar levels in the two treatments. Others have hypothesized that diurnal water stresses cause reduction in root diameter, lessening root to soil water-film contact (Huck et al., 1970; Cole and Alston, 1974; Tinker, 1976; and Faiz and Weatherly, 1978). This would result in a rapid loss in sensitivity of well-irrigated plants to further reduction in soil water potential once significant loss of root to soil water contact had occurred. The loss of water film contact between the root and soil becomes very important in the coarse-textured soils of the southern Coastal Plains of the United States where much of the southern soybean crop is grown.

Various plant, soil, and atmospheric measurements have been proposed to determine crop water needs. Recently, T_L and/or ΔT have been proposed as indicators of crop water requirement (Jackson et al., 1977; Ehrler et al., 1978). Ehrler et al. (1978) specifically pointed out that although their data indicated T_L is a reliable indicator of crop water status, their data base was limited to the arid conditions of the Southwest. Their research group has since proposed the concept of a normalized plant water stress index (Idso et al., 1981a, 1981b; Jackson et al., 1981; Idso, 1982) to cope with environmental variability. The concept has been developed, however, for use in completely closed canopies and has not been verified in humid environments such as that which characterizes most of the southern and eastern USA during the dominant growing season.

Little information is available relating T_L and crop water status of determinate soybeans from the humid southern environment where row-cropping can delay canopy coverage until late in the growing season. Therefore, a field experiment was conducted to explore the relationships of T_L and plant water status to meteorological and soil conditions in the southeastern Coastal Plains over a range of row spacings prior to canopy closure.

METHODS AND MATERIALS

The field experiment was conducted in 1979 at the USDA-ARS, Coastal Plains Soil and Water Conservation Research Center in Florence, S.C. Soybean cultivars, Davis (Maturity Group VI) and Coker 338 (Maturity Group VIII), were planted in a randomized split block design with four replications on 1 May 1979. The soil, a Norfolk loamy sand (fine-loamy, siliceous, thermic, Typic Paleudult), was fallowed the previous year and prepared in the spring by cross-subsoiling to 0.45 m and disking twice before planting. Fertilizer applied was 5-10-30 at the rate of 225 kg ha.$^{-1}$ Weed control was achieved by pre-plant incorporation of Treflan[3] (α, α, α-trifluoro-2, 6-dinitro-*N*, *N*-dipropyl-*p* toluidine) at 1.75 L ha^{-1} and through timely cultivation and/or hand weeding. Four row spacings were used, consisting of 1.02, 0.76, 0.51, and 0.36 m. Plots had row spacing main plots with variety split plots. Each variety subplot was 10.67 m in length and was four rows wide, except in the 0.36-m row spacing, which had five rows per subplot. Rows were in NE × SW alignment. Plant population was 204 000 plants ha.$^{-1}$ Soil matric potential was monitored using tensiometers placed in the row at 0.30-, 0.60-, and 0.90-m depths. Tensiometers were serviced and read two to three times each week. Leaf temperatures (T_L) were measured using a thermistor taped to the abaxial mid-vein of the center leaflet of the most recently matured trifoliate leaf not directly exposed to sunlight on a plant in the center of each plot. This leaf was usually one or two nodes below the terminal node. Only mainstem trifoliates were used. Thermistors were placed in this position to dampen short-term leaf surface temperature fluctuations common to the uppermost sunlit leaf associated with transient cloud cover in this humid environment, and to avoid direct exposure of the thermistors to sunlight or the possibility of thermistor detachment during leaf flutter. In so doing, leaf temperature was also more representative of overall canopy temperature and provided better agreement with 30-min intergrated atmospheric temperatures obtained at the automatic weather station (described below). Leaf temperature of the uppermost, fully mature, sun-exposed leaf was also measured in conjunction with R_s determinations via the thermistor in the porometer cup (described below).

Xylem pressure potential (Ψ_x) was measured in a pressure chamber (Scholander et al., 1965) on the cut petiole of the uppermost, sun-exposed, most recently matured trifoliate leaf. Again, only mainstem trifoliates were used. Following excision, trifoliates were immediately placed in plastic bags containing moist paper towels and carried to the pressure chamber where Ψ_x was measured in 30 sec following excision. Xylem pressure potentials were only determined on clear days or relatively cloud-free portions of days throughout the summer and were not determined for all measurements of T_L.

Osmotic potential of the same standard trifoliate was determined in a manner similar to the method of McComb and Rendig (1960) by placing the center leaflet in a tygon tube, sealing the tube and freezing it, and upon removal from the freezer, compressing the tube on a hard surface with a heavy roller. The osmotic potential of the sap was then determined by soaking a small filter paper disc with the sap and sealing it in a calibrated chamber psychrometer.

Leaf diffusive resistance was determined on both sides of the same trifoliate prior to excision for Ψ_x determination, employing a Licor LI-65 meter and sensor, similar in design to one described by Kanemasu et al. (1969). The abaxial and adaxial resistances were determined on the first and third leaflet of the trifoliates, respectively, to avoid sensor-induced leaf conditioning. The porometer was foil-covered and shaded during actual measurement to avoid leaf heating and was kept shaded between readings. Parallel leaf diffusive resistance (R_s) was calculated from the individual surface resistances, using the relationship:

$$1/R_s = (1/R_{ab}) + (1/R_{ad}), \quad [1]$$

where R_{ab} and R_{ad} are the resistances of the abaxial and adaxial surfaces, respectively.

Atmospheric vapor pressure deficit (VPD) and leaf vapor pressure deficit (LVPD), as defined by Burrows and Milthorpe (1976), were calculated from the ambient temperature, the ambient vapor pressure, saturated vapor pressure at ambient temperature, and the saturated vapor pressure of the leaf at the observed leaf temperature at the time of each temperature observation.

A computer-based weather station was used to obtain 30-min. summaries of air and dew point temperatures, wind run, solar and net radiation, pan evaporation, and rainfall. Measurements were made over a turf area 100 m from the experimental site. Air and dew point temperatures were measured every minute and averaged over the 30-min. output period. Solar and net radiation measurements made every

[3] Mention of trademark, proprietary product, or vendor does not constitute a guarantee or warranty of the product by the USDA or the South Carolina Agric. Exp. Stn. and does not imply its approval to the exclusion of other products or vendors that may also be suitable.

30 sec were summed over the output period to obtain integrated totals. Wind velocity was measured every minute and summed over the output period for wind run. Screened and open pan evaporation were measured once per 30-min period. Three periods of observation within each diurnal period were defined as follows: AM (0800-1200 h), midday (1200-1400 h), and PM (1400-1800 h).

Plants were harvested in late October.

RESULTS AND DISCUSSION

The 1979 growing season could be characterized as nearly ideal. Adequate subsoil moisture was available at planting and over the period of plant water status observation (22 June through 17 July). Temperatures were moderate and rainfall was timely and sufficient to meet transpirational needs for all but a 7 to 10 day period in mid-August (Fig. 1). In-row soil matric potentials remained favorable throughout the season due to the intermittent rainfall. Periods between rainfall were short and only mild stresses were observed. As Fig. 2 shows, 0.90 m soil water had only begun to be extracted briefly in late July, soon after which full profile recharge occurred. Reicosky and Deaton (1979) have shown that under significant stress, nonirrigated determinate soybean will extract soil water from as deep as 1.5 m in these soils. No appreciable difference in soil water extraction occurred between treatments, although the 0.51-m spacing maintained a slightly lower matric potential throughout the season.

Canopy closure occurred around 22 June in the 0.36-m spacing, and the remaining spacings were approximately 80% closed on that date. Canopy closure of the 1.02-m spaced rows occurred sometime after 17 July.

Numerous interrelationships between plant water status, T_L, and the ambient environment were found to be highly correlated. As one would expect, leaf and air temperatures (T_A) were highly correlated with one another. A linear regression of T_L on T_A was performed on 251 data pairs, and T_L was shown to equal $1.2\ T_A - 4.0$, with an R^2 of 0.858. No significant improvement in the correlation was achieved by treating individual row spacings or specific portions of the diurnal cycle separately. Reicosky et al. (1980) showed there is virtually no effect of leaf height within the canopy on thermistor-determined leaf temperatures from mid-canopy to the uppermost leaves in a soybean canopy. The senior author has accumulated data (unpublished) from subsequent studies indicating that canopy temperature as determined by noncontact infrared surface thermometry is somewhat sensitive to variations in canopy geometry prior to canopy closure. A further assessment of T_L was made to determine its relationship to xylem pressure potential (Ψ_x) and R_s.

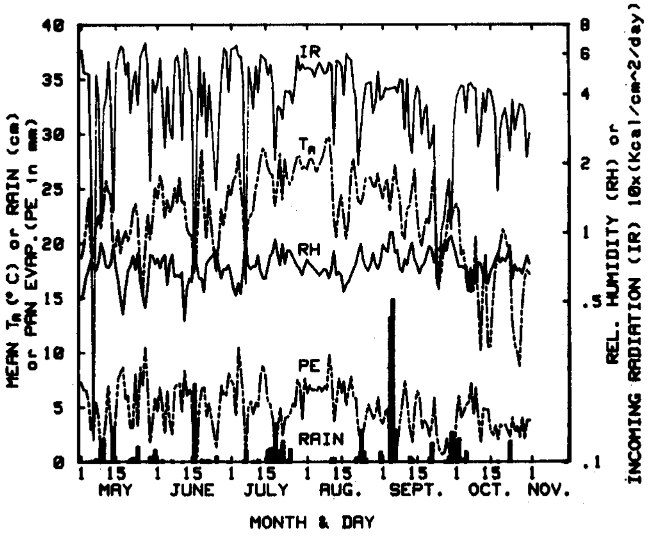

Fig. 1. Climatic data for the 1979 growing season for Florence, S.C. including: mean daily T_A (°C), rainfall (cm), pan evaporation (mm), R.H. (decimal fraction), and incoming radiation (10 × [Kcal $cm^{-2}day^{-1}$]).

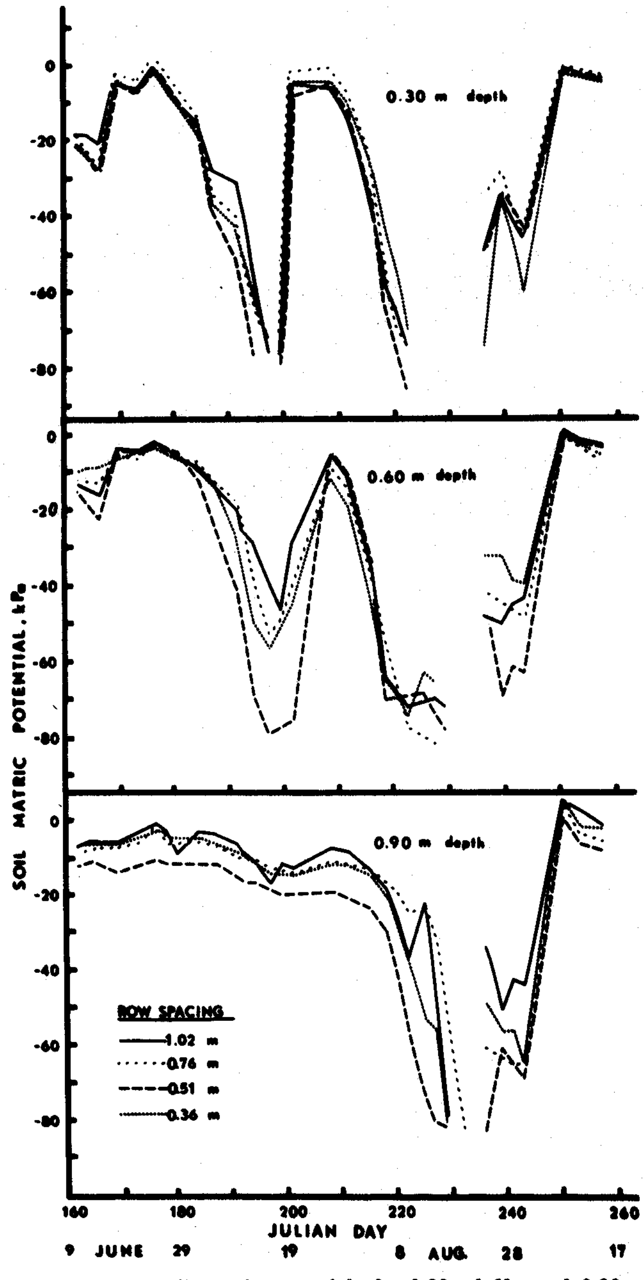

Fig. 2. In-row soil matric potentials for 0.30-, 0.60-, and 0.90-n depths for the 1979 growing season. Each line is the mean of fou observations.

Leaf temperature was highly correlated with Ψ_x. The relationship was relatively independent of diurnal effects (Fig. 3a). Using ΔT (where $\Delta T = T_L - T_A$) in association with Ψ_x, however, resulted in a slightly less reliable correlation than was achieved using T_L alone (Fig. 3b). No acceptable relationship between T_L and R_s was found. The best correlation of R_s with temperature was achieved using ΔT, where $R_s = 2.2 (\Delta T) + 3.7$ with an R^2 of 0.607. This relationship must be considered marginal.

Due to the poor correlations achieved with R_s, some concern arose that perhaps the porometer acted as a heat sink, and temperatures measured by its thermistor were a measure of porometer temperature more than leaf temperature. A comparison of the two leaf temperature determination techniques, however, showed a high correlation (Porometer °C = $0.95 (T_L) + 3.41$, $R^2 = 0.875$). Furthermore, regression analysis of Ψ_x or R_s vs. porometer-determined temperatures were nearly identical to those derived using the in situ leaf thermistors.

Satisfactory determination and interpretation of R_s from field-grown plants is a ubiquitous problem. Significant scatter has been observed by various workers for a variety of reasons (Jones et al, 1980; Squire and Black, 1981; Sojka et al., 1979, 1981; Kaufmann, 1982a, 1982b). Bell found variations of 25 to 35% with porometers he compared (Bell and Squire, 1981; Bell and Incoll, 1981). Numerous reviewers and theoretical treatments of porometry have identified a variety of problems in the development and application of theory (Chapman and Parker, 1981; Hack, 1980; Berkowitz and Hopper, 1980). Our data would suggest that a low level of precision and accuracy are attainable for soybean field data from humid environments.

Vapor pressure deficit is one of the most active environmental factors affecting stomatal response and leaf water potentials (Burrows and Milthorpe, 1976; Wien et al., 1979). Burrows and Milthorpe (1976) demonstrated, however, that the practice of using atmospheric VPD to characterize plant water stress can produce significant errors in the interpretation of plant water status. They suggested use of leaf vapor pressure deficit (LVPD), which is the difference between atmospheric vapor pressure and saturated vapor pressure at the temperature of the leaf. Our observations of LVPD were highly correlated with Ψ_x as shown in Fig. 4.

The mean Ψ_x for all measurements made at midday over the growing season showed no statistical difference for row spacing, although the varietal mean Ψ_x's of −1.03 MPa for Davis and −1.13 MPa for Coker 338 were significant ($P \leq 0.001$). Observation of osmotic potentials showed a corresponding difference of

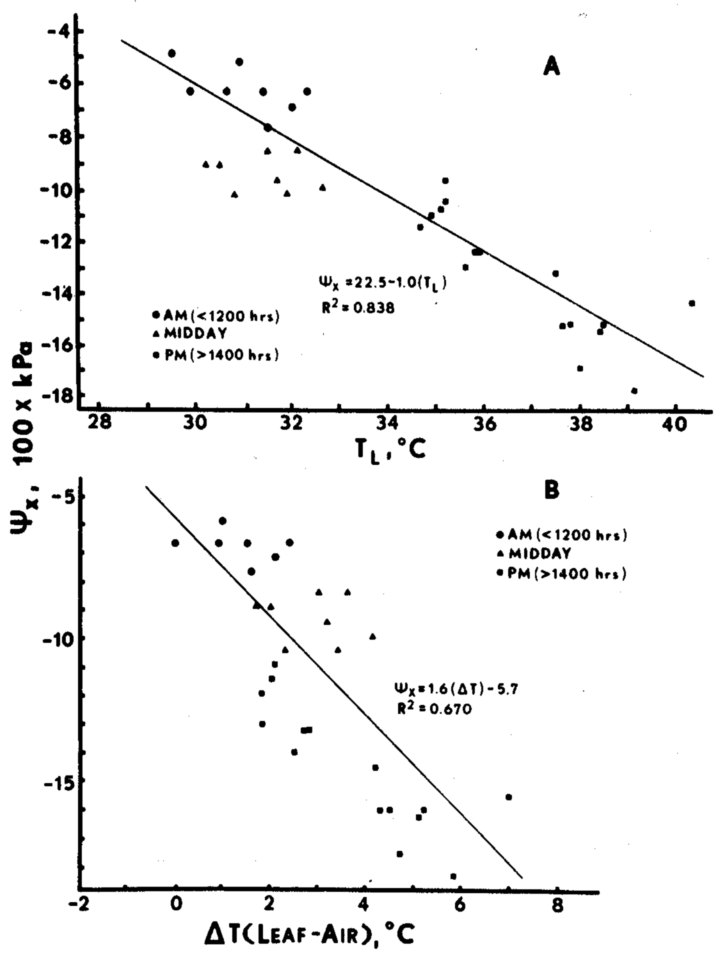

Fig. 3. Xylem pressure potential (Ψ_x) as a function of A. leaf temperature (T_L), and B. leaf minus ambient temperature (ΔT). Several observation dates are pooled.

−1.35 MPa for Davis and −1.55 MPa for Coker 338 ($P \leq 0.01$). An acceptable correlation of T_L with either VPD or LVPD was not observed.

Jackson et al. (1977) and Ehrler et al. (1978) presented observations of ΔT that were predominantly negative in value, indicating that transpiration was cooling the canopy. Positive ΔT's are generally regarded as an indication of stress, although as the relative humidity (R.H.) of the atmosphere increases transpirational cooling declines, and ΔT has been shown to become more positive (Linacre, 1967, Geiser et al., 1982). Jung and Scott (1980) expressed the relationship of T_L and T_A as the ratio of T_L/T_A for which values above unity are an indication of stress. Recently, others (Idso et al., 1981a, 1981b; Idso, 1982; Jackson et al., 1981) have proposed a method of normalizing canopy temperature measurements and have employed their technique on data from a number of locations in the upper Great Plains and the southwestern USA.

The southeastern USA is more humid than any of the environments from which the above cited data were collected. Consequently, one might assume that in the humid south ΔT relationships may be different than those observed under drier conditions. Idso et al. (1981b) assumed a linear relationship between ΔT and VPD under stressed conditions with a slope of zero (their calculated upper limit) when transpiration is close to zero. They further assume that this line intercepts the negatively sloped (well-watered, or potential evapotranspiration) line of ΔT and VPD at a negative VPD equal to the absolute value of the foliage to air vapor pressure gradient (which we have chosen to call LVPD since in this manipulation no distance term is involved) where VPD equals zero. Though not stated, one must assume that for constant, but intermediate soil water availability, the plots of ΔT vs. VPD also pass through this common point. Some of Linacre's early work (1967, 1969) and particularly the empirical work of Geiser et al. (1982) would suggest that unlike the relationship presented by Idso et al. (1981b), the regression of ΔT on VPD does not always result in a single linear relationship for a given soil water regime. In fact, Geiser's work implied that:

$$\Delta T = m_{R.H.}\mathrm{VPD} + b \qquad [2]$$

$$\text{or,} \quad m_{R.H.} = (\Delta T\text{-}b)/\mathrm{VPD}. \qquad [3]$$

The slope of this relationship ($m_{R.H.}$) will be less negative as relative humidity increases, for a given incoming radiation at a fixed value of soil water depletion since ΔT tends to be more positive. This effect becomes particularly pronounced at high R.H. (the approximate daily mean R.H. over the period we observed ranged from 70 to 80%). While R.H. and VPD are strongly related at a fixed temperature, a separate relationship exists for each isotherm. For example, a 2.0 k Pa VPD can exist at approximately 14, 37, 53, 64, and 73% R.H. when temperatures are 20, 25, 30, 35, and 40°C, respectively.

Since nearly all published data relating ΔT to VPD have, to date, come from midday observations in relatively dry climates, ΔT has been heretofore correlated with VPD over only a very narrow range of low R.H. values. The ranges in VPD have come primarily from variations in ambient temperature. In developing the normalized stress index, Idso et al. (1981) stated that VPD's were collected over a temperature range of 10 to 40 °C. In addition, if one examines the scatter of alfalfa ΔT vs. Vapor pressure deficit data presented in several publications (Idso et al., 1981a, 1981b; Idso,

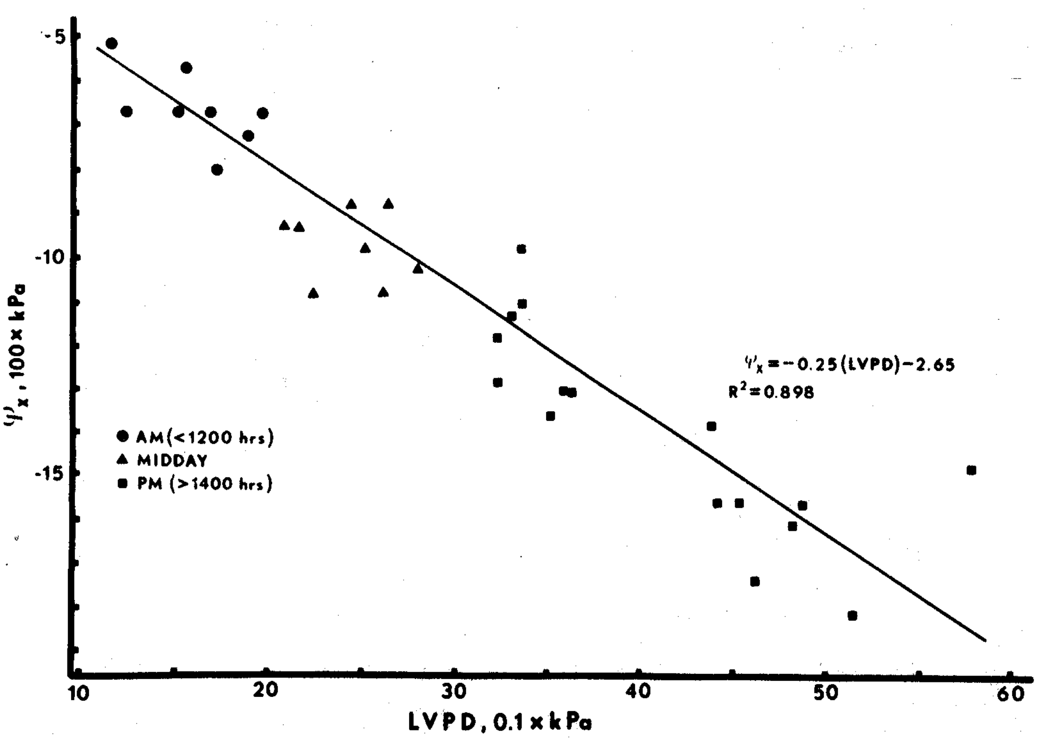

Fig. 4. The relationship of xylem pressure potential (Ψ_x) as a function of LVPD. Several observation dates are pooled.

1982), it is readily apparent that the environments with lower VPD's were, for the most part, ones that have higher R.H.'s.

When we regressed our 251 ΔT observations for the period from 3 to 17 July against VPD, the slope was dependent on the period of observation; highest for AM observations (0.25), intermediate for PM observations (0.15) and lowest for midday observations (−0.18). These data are presented in Fig. 5. The figure is similar to one presented by Jackson et al. (1981) with comparable scatter. They are, however, elevated in their range of ΔT, a result one would expect if Geiser's empirical relationships were correct. While the slopes of the three time periods also performed as predicted from the above discussion, the shift in slope was large for the small changes in mean R.H. Furthermore, R^2 values of the relationships were low. Therefore, while tending to perform as expected in the light of Geiser et al.'s (1982) work these observations remain inconclusive. Intriguingly, ΔT was more highly correlated with LVPD than VPD (Fig. 6). Here, slopes were all positive, suggesting significant stress, yet tensiometer data and the known soil water extraction patterns for soybean on these soils (Reicosky and Deaton, 1979) and the observed level of Ψ_x indicate the stresses were moderate. Again, the elevation of these slopes compliment the empirical relationships observed by Geiser et al. (1982).

An additional factor that would elevate the range of our observed ΔT values during this period could be the contribution of re-radiated heat from the exposed soil surface. This effect would continue to be a factor until canopy closure. During this period (3 to 17 July), the active front of soil water extraction remained be-

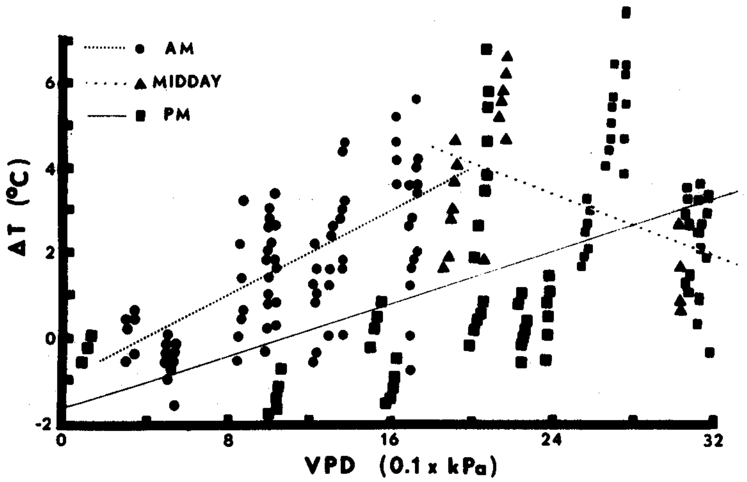

Fig. 5. Leaf temperature minus ambient temperature (ΔT) as a function of vapor pressure deficit (VPD) as observed over three portions of the diurnal cycle. Several observation dates are pooled. Slopes, intercepts, and R^2 for the three periods are: AM, 0.25, −1.1, and 0.507; midday, −0.18, 7.7, and 0.199; and PM, 0.15, −1.6, and 0.315, respectively.

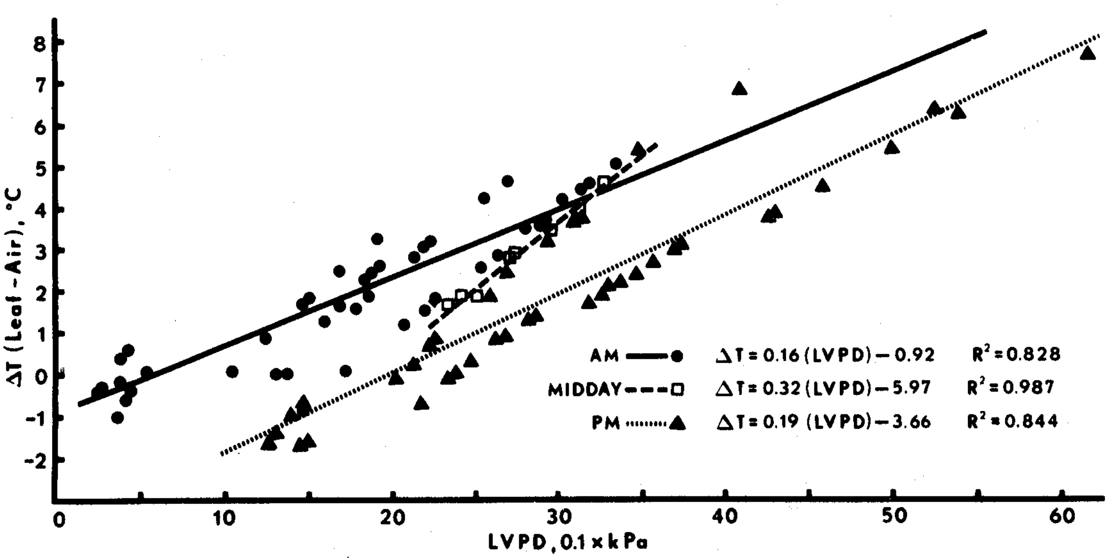

Fig. 6. Leaf temperature minus ambient temperature (ΔT) as a function of leaf vapor pressure deficit (LVPD) as observed over three portions of the diurnal cycle. Several observation dates are pooled.

tween 0.6 and 0.9-m depth, although the soil surface had become dry. The low water-holding capacity of the surface (and thus low heat capacity when dry) and high prevailing relative humidities (and therefore limited transpirational cooling) may further contribute to an overall elevation of ΔT.

Our experiment was not designed to evaluate these conflicting descriptions of plant water stress. They do, however, suggest that the normalized index needs testing across a range of ΔT at two roughly constant extremes of R.H. in a fixed range of incoming radiation and soil matric potential. This will require extensive collection of field data some of which will only be obtainable in the humid south.

In our data, there was also a high correlation between ΔT and Jung and Scott's (1980) ratio T_L/T_A (Fig. 7). Furthermore, both ΔT and T_L/T_A were greater in magnitude than has been reported for drier climates. The ratio of T_L/T_A, however, is probably no more desirable an index of stress than ΔT since they both can produce identical values for a wide range of actual temperature combinations. (The correlation was good in our case because the temperature ranges of both T_L and T_A were relatively narrow). As T_A becomes smaller, however, the ratio becomes increasingly large for an equal increment of ΔT when working in degrees Celsius. As Ehrler et al. (1978) and Jackson et al. (1977) recognized, an accumulation of heat increments (which they quantified in terms of stress degree days) is one of the active stress-producing factors in a drought period. It would, therefore, be more desirable over a period of time to integrate actual temperature differences, as a stress index, than temperature ratios.

Table 1. Variety and spacing yields.†

	Row spacing (m)				
Variety	1.02	0.76	0.51	0.36	Mean
	Yield t ha^{-1} at 13% moisture				
Davis	2.49	2.80	2.85	2.45	2.75
Coker 338	2.36	2.73	2.71	2.73	2.63
Mean	2.43	2.76	2.78	2.79	

† Significance: Spacing $P \leq 0.06$, Variety NS, Interaction NS.

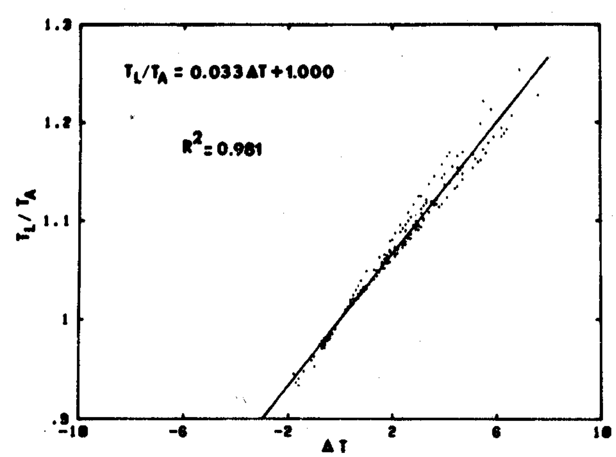

Fig. 7. The relationship of leaf temperature minus ambient temperature (ΔT) to the ratio of leaf temperature over ambient temperature (T_L/T_A) for 251 observations made from 3 to 17 July. The ratio $T_L/T_A = 0.033$ T + 1.000 with an R^2 of 0.981.

While the soil, canopy, and microclimate interactions, and not yield, were the main interest of this work, it is interesting that yields (Table 1) did reflect stress indicators at least with respect to varietal performance. Davis, which was less stressed, produced a 5% better yield (though not statistically significant).

SUMMARY AND CONCLUSIONS

Determinate soybean grown in the Southern USA are predominantly grown in wide row-space configurations and characteristically do not achieve complete canopy coverage until the onset of reproductive growth. Canopy closure occurs as the result of numerous first-order branches produced by determinate cultivars under these conditions. When plants are small, relative to the area of soil remaining exposed, or after canopy coverage approaches complete ground cover, differences in canopy configuration would not be expected to have a significant impact on crop water status or microclimate. When plants are small, each plant performs nearly as an independent entity, largely unaffected by the position of neighboring plants, and the canopy microclimate is dominated by soil-related factors. Once complete canopy coverage is achieved, differences in shading of the soil surface and variation in re-radiation of heat from the soil between rows as influenced by row spacing diminishes, and the entire exposed upper canopy begins to act as a more uniform evaporative surface. Before canopy closure, however, large differences in row spacing could result in differences in heat exchange between the exposed inter-row and the canopy surface. One might expect, therefore, that crop water status and microclimate would be significantly affected by large variations in row spacing during the observation period of this study (late vegetative, prior to canopy closure). The experimental conditions and measurement techniques employed in this study, however, indicated only limited effects on plant stress parameters and leaf temperatures. These results may not hold true for indeterminate cultivars grown in similar configurations since they are characteristically less prone to branching.

Canopy temperatures were highly correlated with ambient temperatures (T_A), and this relationship was not significantly affected by row spacing. Both T_L and the difference between canopy and ambient temperature (ΔT) were highly correlated with xylem pressure potentials (Ψ_x). The LVPD correlation with Ψ_x was also very high. Mean seasonal Ψ_x was unaffected by row spacing. None of the observed parameters produced an acceptable correlation with parallel leaf diffusive resistance (R_s).

The inability to develop reliable relationships between crop water status indicators or ambient measurements and R_s may be related to the high prevailing R.H. of the Coastal Plains environment. The generally low VPD's (high R.H.) produced in the southern environment may also be one factor surpressing large differences between Ψ_x of irrigated vs. nonirrigated treatments in studies conducted in this region.

Finally, the impact of incomplete canopy closure and high prevailing R.H. may affect the relationship of ΔT to VPD. Before canopy temperature monitoring can be endorsed for use in assessing crop water stress in the South, a thorough investigation must be made of the impact of high prevailing mean daily R.H.'s during the growing season. Furthermore, since determinate soybean frequently do not achieve full canopy closure by bloom, and since the vegetative portion of the life cycle is long and characterized by incomplete canopy coverage, the impact of canopy configuration on water-stress assessment by determination of canopy temperature relationships must also be thoroughly investigated before such temperature relationships can be used to schedule irrigation during the vegetative period.

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