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APPARENT PHOTOSYNTHESIS OF SOYBEAN PLANTS AS AFFECTED BY CHANGES IN LEAF WATER POTENTIAL, UNDER FIELD CONDITIONS

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ABSTRACT

Apparent photosynthesis (AP) and leaf water potentials of 'Clark' soybeans, *Glycine max* (L.) Merr., were determined under field conditions. The diurnal course of solar radiation and water potential of leaves at 25, 50 and 75 cm canopy height were measured. AP of the soybean leaves started to decline at leaf water potential of -12 bars. At leaf water potentials of about -14 to -15 bars, the photosynthetic rate was 50% of fully turgid leaves. Leaf water potential of soybean plants grown with high soil moisture was -12 bars or lower for several top leaves on a high radiation day, indicating moisture stress was present and AP rates were reduced. The leaves at 75 cm canopy height had lower water potentials than those at 25 cm height.

INTRODUCTION

One of the physiological processes affected by water stress is photosynthesis. Chen *et al*.(5) have reported that the decrease in AP due to reduction of leaf water content is curvilinear.

The initial reduction in AP rate in soybeans has been attributed to an increase in stomatal resistance and to the diffusion of CO_2 to the site of fixation (2). The objectives of our experiment were to determine the critical leaf water potential at which the AP rate of the mature soybean plants starts to decline. We also wished to measure the water potential gradient in a soybean canopy and the diurnal course of leaf water potential in a soybean field having high soil moisture.

MATERIALS AND METHODS

Soybeans, *Glycine max (L.)* Merr. variety 'Clark' were planted on a Flanagan silt loam in 71 cm spaced rows in a north-south direction at Urbana, Illinois. The plot consisted of four rows 7.5 m long. The seeds were planted on May 12, and the final stand was 344,000 plant/ha. The plot was irrigated every day to insure soil moisture at the field capacity. During the pod-filling stage, several plants were cut at the soil surface early in the morning and tied upright to a metal rod, and allowed to dry out during the day. At periodic intervals a fully developed leaf was inserted into a portable single chamber to measure AP as described by Beuerlein and Pendleton (1). Leaf water potentials were measured using the pressure chamber described by Boyer and Ghorashy (4). For measuring the AP of the leaves with high leaf water potentials, measurements were taken between

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7:00 to 8:00 A.M. on intact plants by tilting the single leaf chamber toward the sun and adding of extra light. Light intensities for each AP measurement were above 7,000 lux as measured by a Weston Model 756 sunlight Illumination Meter. In another study the diurnal course of leaf water potential of the fully expanded leaves were measured during pod-filling (August 1 through August 6) from 6:30 A.M. to 8:00 P.M. The total radiation received on the top of the crop canopy was also measured using a pyronometer (Pyreheliometer 180^{O}). Water potential of leaves was also measured at height of 25, 50 and 75 cm above the soil surface on August 6 and August 7 within one hour of the solar noon. A total of 15 samples were taken at each level and the data were combined for the two days for each stratum.

RESULTS AND DISCUSSION

The AP decreased curvilinearly as leaf water potential decreased in mature soybean leaves Figure 1. The maximum leaf water potential obtained in this study was -9 bars and the minimum was -25 bars. The initial decrease in AP was at leaf water potential of -11 to -12 bars. This is in the range reported by Boyer (2) working with young soybean plants. At leaf water potentials of -14 to -15 bars, the AP rates were half of the maximum rate. Gravimetric determinations indicated that soil moisture during the leaf water potential measurements was at field capacity, the general relationship of leaf water potential and radiation were the same for the six days, therefore only data for August 6 is reported. The leaf water potentials of fully expanded leaves at the top of soybean plants on August 6 were high (-5 bars), only early in the morning (Figure 2). As the radiation increased the leaf water potential started to decrease and by 10:00 A.M. the leaf water potential was below the level for maximum photosynthetic activity and until 6:00 P.M. leaf water potential remained low. This indicated that soybean plants during most of the day were under water stress and could not carry on the process of photosynthesis at their maximum rates.

Leaf water potentials measured at increasing height above the soil indicate, that there was a water potential gradient in the soybean canopy, Figure 3. The leaves at 75 cm height had the lowest water potential and the leaves at a height of 25 cm from the soil had the highest water potential. The reason for this water gradient is probably due to the amount of light energy received at each stratum and/or differences in the age of leaves. According to Shaw and Weber (6) leaves at the top of the canopy received more radiation than those on the bottom. This might increase transpiration in the upper leaves more than lower leaves and cause lower water potentials in upper leaves.

Soybeans grown under sufficient soil moisture can be under moisture stress (Figure 2) and apparently can not extract soil moisture fast enough to meet the evaporative demand on high radiation day. Therefore, water deficits occur in the top leaves of soybean plants. Boyer (3), using a transient flow method measured resistance to water transport in whole plants and plant segements of soybean, sunflower, and bean. He showed that the resistance to water transport in whole soybean plant was twice that of the sunflower and bean. He attributed the high resistance in soybeans to a high resistance in the root tissue. Our data confirm this resistance in the water transport in soybeans, because even under high soil moisture water stress occurred in the top leaves of soybean crop grown under high radiation regimes.

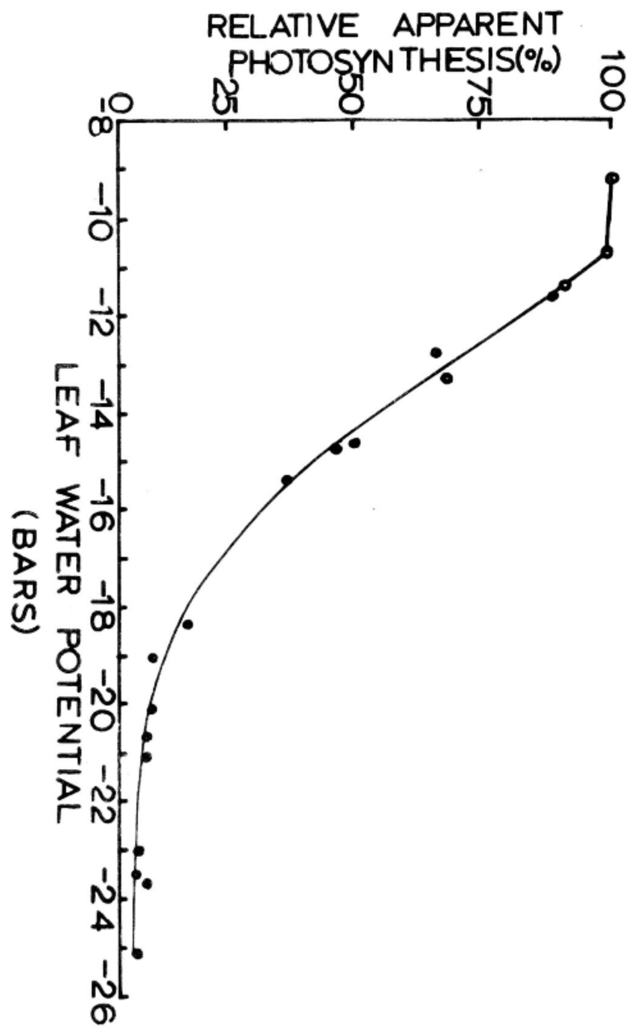

Figure 1: The response of AP to decreasing leaf water potential in mature leaves of soybeans.

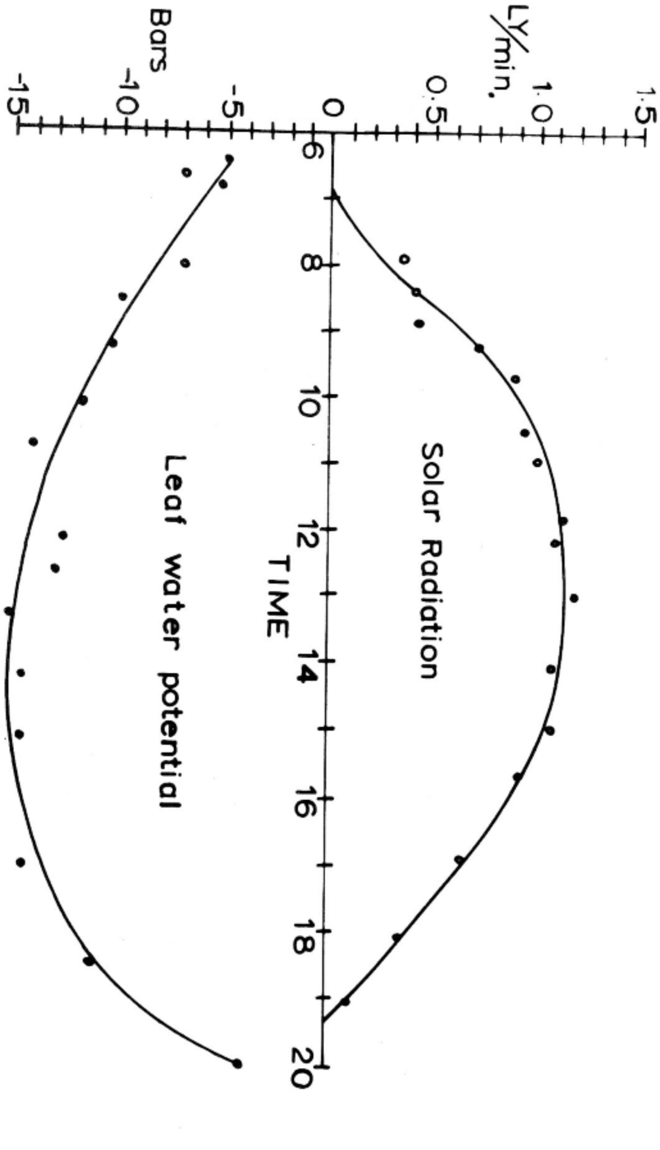

Figure 2: The diurnal course of leaf water potential of fully expanded leaves of soybeans and solar radiation received at the top of the crop canopy on August 6.

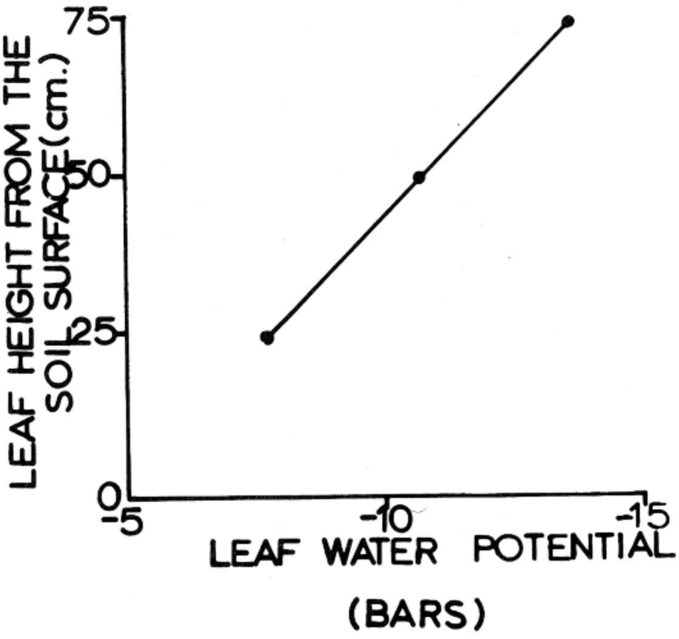

Figure 3: The canopy leaf water potential at height of 25, 50, 75 cm in a soybean crop.

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