PHYSIOLOGICAL AND AGRONOMIC RESPONSES OF WATER STRESSED COWPEAS

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Field evaluations of cowpeas were made during the summers of 1982 and 1983 in Tucson, Arizona, in order to investigate the effects of water stress imposed at various developmental stages on growth, reproductive structures, yield and certain physiological characters. In 1982, 'California Blackeye #5' (CBE 5), 'Speckle Purple Hull' (SPH), and AZ-54 cowpeas were compared under four irrigation treatments. In 1983, CBE 5 was further evaluated under five stress treatments. During both years, a Campbell Pacific neutron probe was used to measure soil water content, and a Li-Cor 1600 steady state porometer was used to measure transpiration, stomatal diffusive resistance, and leaf and ambient temperatures. Leaf water potential in 1983 was measured with a pressure chamber.

In 1982, cultivars did not show significant differences in vegetative growth and abscission of reproductive structures under any of the irrigation treatments. SPH, however, had numerically higher abscission and significantly fewer pods per peduncle.

Prolonged drought stress in 1983 significantly reduced vegetative growth, pods per peduncle, pods per plant, seeds per pod, and seed yield of CBE 5 (Table 1).

Table 1. Dry matter production, abscission of reproductive structures pod production, and yield of California Blackeye #5 subjected to five water stress treatments, 1983.

Water stress treatment X	Dry matter weight (gm/plant)	% Abscission	Peduncles per plant	Pods per plant	Pods per peduncle	Seeds per pod	Seed yield (gm/plant)
S-1	143 a**	82	29 N.S.	41 a**	1.8 a**	7.2 a**	54.2 a**
S-2	119 ab	85	25	33 ab	1.5 ab	6.2 ab	40.4 ab
S-3	69 bc	88	25	22 bc	1.1 bc	5.5 abc	25.6 bc
S-4	93 abc	88	26	25 b	1.2 bc	5.5 abc	31.0 b
S-5	42 c	91	16	11 c	0.9 c	4.1 c	11.7 c

X = S-1 = no stress, S-2 = stress at pod-filling, S-3 = stress at flowering S-4 = stress at flowering and pod-filling, S-5 = stress after seedling establishment.

N.S. = Treatment means are not significantly different.

** = Treatment means followed by the same leter within a column are not significantly different at the 0.01 level according to the LSD test.

Reduction of peduncles per plant and increase of reproductive structure abscission due to water were not significant.

Cowpea plants during both 1982 and 1983 depleted soil water from the profile as deep as 120 cm depending on the planting density and availability of moisture in the upper profile. No depletion occurred deeper than 90 cm in 1983 when adequate water was applied and plant density was not as high as in 1982.

Cultivars in 1982 exhibited some differences in stomatal resistance, transpiration, and leaf temperature. With optimal irrigation, stomata of SPH remained more open and transpired more than either CBE 5 or AZ-54. When stressed, stomata of SPH were more resistant to water vapor diffusion than that of the other two cultivars. Leaf temperatures were highest for AZ-54 when plants were adequately irrigated. Leaf temperature of CBE 5, which had the lowest transpiration rate, was as low as that of the high transpiring cultivar, SPH. When water stressed, CBE 5, which was intermediate in transpiration, had the lowest leaf temperature. This indicates that CBE 5 has leaf temperature regulating mechanisms that are either lacking or less expressed in the other two cultivars.

Statistical comparison of treatments in 1983 indicated that water stress significantly affects transpiration rate, stomatal diffusive resistance, and leaf temperature of CBE 5. Prolonged stress in some instances reduced transpiration as low as 20 percent of the non-stressed plants, and diffusive resistance of adequately irrigated plants was as low as 8 percent of the most stressed plants. Leaf temperature differences between well-irrigated and non-irrigated plants were as high as 4 degrees C. Depending on the level of soil moisture and transpiration rate, leaves of well-irrigated plants were cooler than the air temperature by 1 to 3.5 degrees. Leaf temperatures of stressed plants, on the other hand, were higher or lower than the air temperature by not more than 0.5 degrees. In 1982, transpiration tended to increase and leaf temperature and diffusive resistance values tended to decrease over the season (Fig. 1.) Although, this was not observed in 1983, well-watered plants had the highest transpiration and the lowest diffusive resistance values late in the season. The variation in transpiration rate for the most stressed CBE 5 plants was not large.

Leaf water potentials measured with the pressure chamber were significantly different for water stressed and non-stressed plants. The differences, however, were not large. Decrease in water potential due to progressive stress was also small.

Unlike drought tolerant crops such as sorghum that survive reduced tissue water status, the stress resistance mechanism of cowpeas appears to be avoidance of reduced tissue water. Results in this study, generally, indicate that water stressed plants can maintain high tissue water by closing stomata and reducing transpiration. Smaller evaporative surface as a result of reduced growth (Turk et al., 1980; Hall and Schulze, 1980), and leaf angle change in response to the direction of solar radiation (Shackel and Hall, 1979) when plants are water stressed also appear to contribute to the avoidance of tissue water loss. These drought avoidance characteristics, however, seem to occur at the expense of growth and yield.

References

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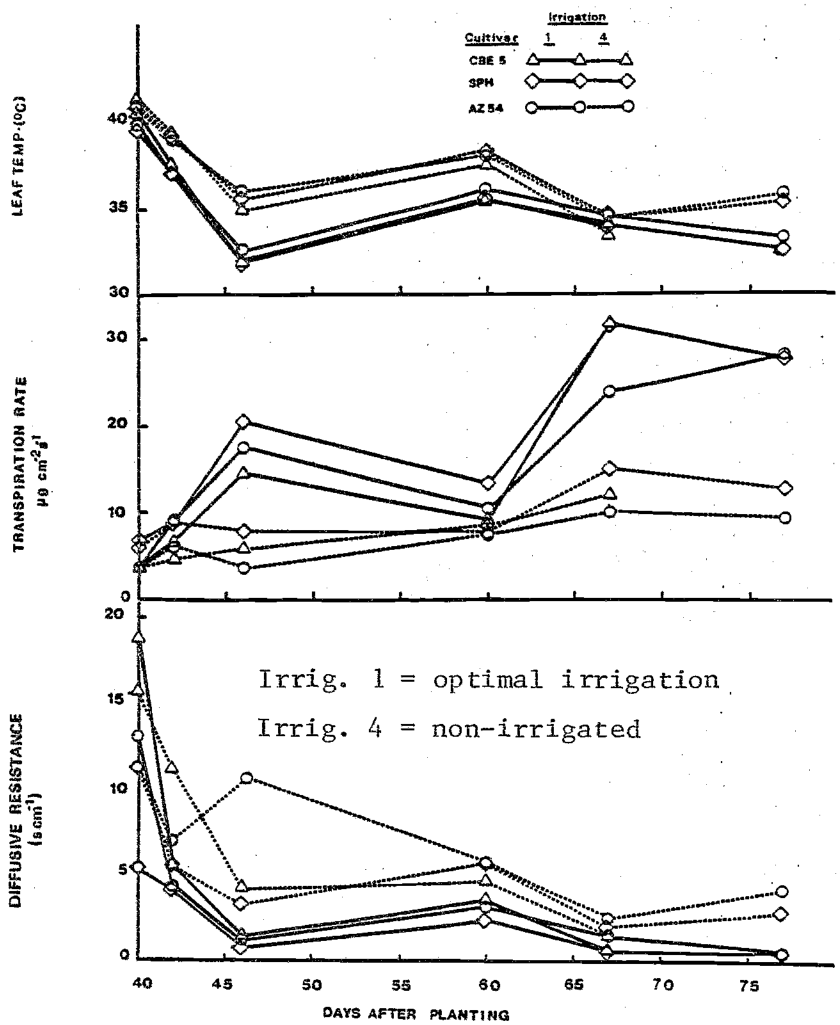

Fig. 1. Stomatal diffusive resistance, transpiration rate, and leaf temperature of California Blackeye #5 (CBE 5), Speckle Purple Hull (SPH), and AZ-54 cowpeas over the 1984 growing season.