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WIND BARRIERS MOST BENEFICIAL AT INTERMEDIATE STRESS[1]

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ABSTRACT

A slat-fence wind barrier, installed midfield and oriented east-west, was used to investigate leaf-water potential and stomatal resistance of winter wheat (*Triticum aestivum* L.) as influenced by barrier-induced microclimate in a semiarid macroclimate. Leaf-water potential, stomatal resistance, and micrometeorological parameters indicated that shelter affected neither leaf-water potential nor stomatal resistance when stress was low. At intermediate stress, leaf-water potential was significantly higher in the sheltered area than in open field. Under high stress, leaf-water potentials of plants in the two areas did not differ significantly; however, stomatal resistance was higher in the open field than in the sheltered area.

Additional index words: **Leaf water potential, Stomatal resistance.**

WIND barriers have been used extensively to ameliorate the harsh climate of the Great Plains. Since the Great Plains Forestry Project (3) began, numerous experiments (4) have shown crop plant responses to barrier-induced microclimate. Frank and Willis (2) found that leaf-water potential (Ψ_l) of spring wheat in North Dakota was generally lower in exposed than in sheltered plots. Water relations and yields were more favorable when plants were grown in shelter rather than in exposed treatments. In the subhumid climate at Manhattan, Kansas, Skidmore et al. (5) found that when environmental conditions were conductive to water stress, winter wheat (*Triticum aestivum* L.) plants in a sheltered area had significantly lower stomatal diffusive resistance and tended to have higher leaf-water potential than those in an open field. When water stress was low, differences in stomatal diffusive resistance, leaf water potential, and photosynthesis rate between open field and shelter were generally not significant. However, much winter wheat is grown in regions more arid than Manhattan. Therefore, winter wheat response to barrier-induced microclimate in a semiarid macroclimate was investigated at Tribune, Kansas, where mean annual precipitation is 39 cm as compared with 84 cm at Manhattan.

MATERIALS AND METHODS

On the Tribune (Kansas) Branch Exp. Stn., a 2.4-m tall, 75-m long, 40% porous, slat-fence wind barrier was installed in an east-west orientation on March 14, 1973, on a field of fall-seeded, winter wheat ('Eagle'). Soil water contents were measured by gravimetric samplings at 0 to 8 and 8 to 23-cm depths. Water contents were measured by the neutron scattering method at 15-cm intervals from 30 to 150 cm. Soil water content was measured six times from March 14 until June 8, 1973, at six locations (2, 6, and 12 H) each time. The letter H represents distance equal to height of barrier (2.4 m).

Leaf-water potentials (Ψ_l) and leaf stomatal resistances (both surfaces) were measured with pressure bomb and stomatal resistance meter, respectively, on May 8 and 22 and on June 8 in the shelter and open-field. Each observation consisted of at least four repeated measurements. The plant growth stages for those sampling dates were; early boot, anthesis, and soft dough, respectively. Each observation consisted of at least four repeated measurements. On the same three dates at approximately 1-hour intervals between sunup and sundown, various meteorological parameters were measured at one location on the edge of the wheat field. Wet and dry bulb temperatures were measured with a sling psychrometer, and windspeed and direction with an anenometer and vane handheld 2 m high. The output from a net radiometer was recorded continuously on a potentiometric stripchart recorder. Meteorological data were used to calculate potential evaporation by the combination method. The combined effects of potential evaporation (evaporation demand) and water content in the root zone of the soil profile were used to determine relative severity of water stress of low, medium, and high for May 8, May 22, and June 8, respectively.

RESULTS

The May 8 Ψ_l (Fig. 1) was relatively high, with no difference between open field and shelter. The soil was well supplied with water (Fig. 2, typical of all six areas sampled for soil water) and evaporative demand was medium (Fig. 3). Two weeks later (May 22), with much less water in the soil profile and a lower evaporative demand, Ψ_l was high (stress was low) in early morning but by 0900 hours was —24 and —14 bars in the open field and shelter, respectively. The forenoon decline of Ψ_l of sheltered plants lagged by about 2 hours the Ψ_l decline of open-field plants, and after a midday minimum, Ψ_l of sheltered plants began to increase much sooner than that for open-field plants. The mean standard deviations of Ψ_l were 0.8, 1.6, and 1.1 bars for May 8, May 22, and June 8, respectively.

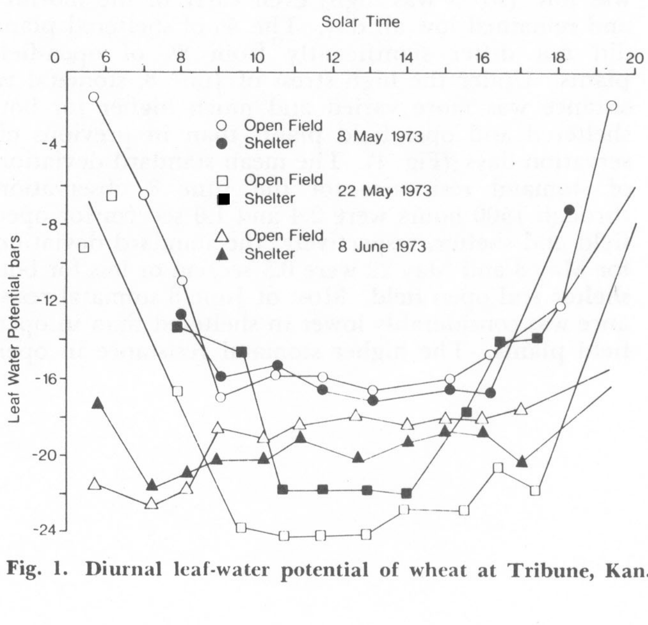

Fig. 1. Diurnal leaf-water potential of wheat at Tribune, Kan.

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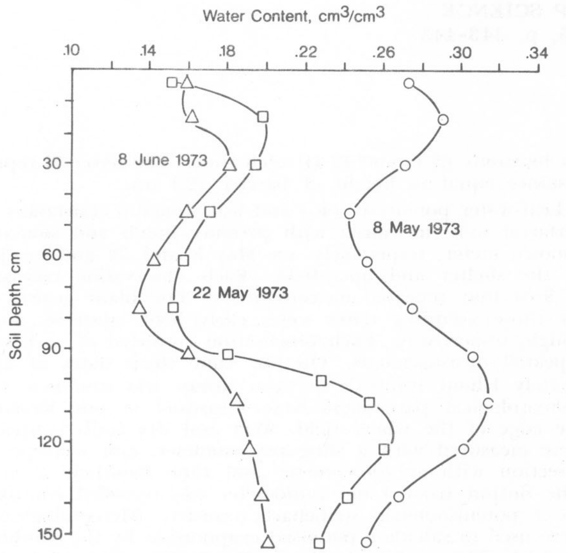

Fig. 2. Soil-water content as a function of depth and time.

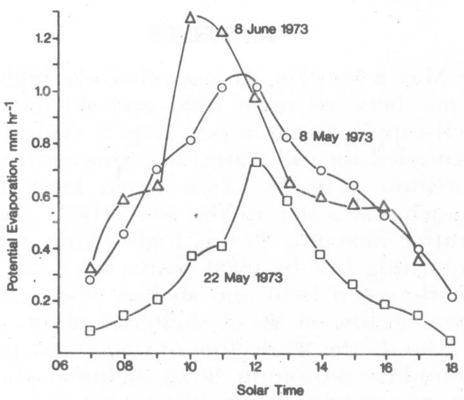

Fig. 3. Diurnal potential evaporation.

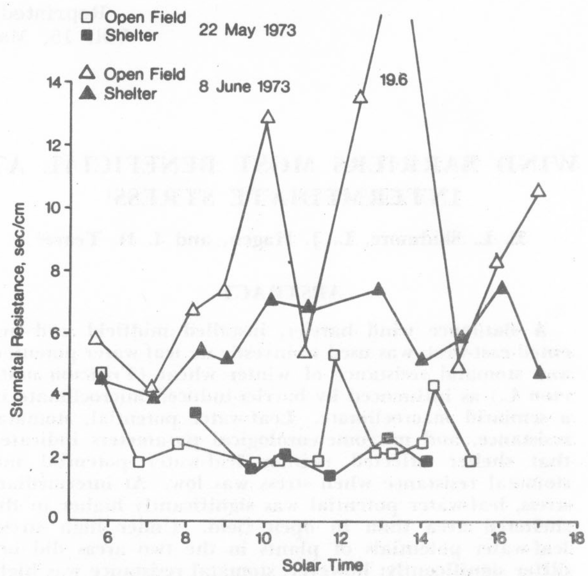

Fig. 4. Diurnal stomatal resistance. Mean stomatal resistances between 0800 and 1600 hours May 8 were 1.7 ± 0.4 and 1.8 ± 0.4 sec/cm for open field and shelter, respectively.

On June 8, a day of relatively high evaporative demand and low water content in the soil reservoir, Ψ_l was low (stress was high) even early in the morning and remained low all day. The Ψ_l of sheltered plants did not differ significantly from Ψ_l of open-field plants. Under the high stress of June 8, stomatal resistance was more varied and much higher for both sheltered and open-field plants than in previous observation days (Fig. 4). The mean standard deviations of stomatal resistance for the June 8 observations through 1500 hours were 2.4 and 1.6 sec/cm for open field and shelter, respectively; the standard deviations for May 8 and May 22 were 0.5 sec/cm or less for both shelter and open field. Most of June 8 stomatal resistance was considerably lower in sheltered than in open-field plants. The higher stomatal resistance in open-field plants reduced transpiration and enabled plants to better withstand the high stress.

These data indicate that shelter influences Ψ_l under medium stress, but not under low stress (low evaporative demand and high soil-water content) or high stress. As stress becomes more severe, differences in Ψ_l between shelter and open field plants disappear. Plants in both areas become stressed, which corresponds with findings by Frank et al. (1) that windbreak shelter benefited irrigated more than dryland soybeans (*Glycine max* L.). Dryland sheltered soybeans showed more vegetative growth earlier than exposed soybeans, but their early depletion of soil water severely restricted later growth.

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