Effect of Soil Desiccation on Transpiration in Two Mediterranean Wheat Cultivars under the Elevated Temperature and CO_2 Conditions

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High temperature and elevated CO_2 concentration increased biomass production in soybean (Baker et al., 1989) while clear effects were not observed in rice (Kim et al., 1996). Soil water deficit inhibits the biomass production and result in yield reduction in most crops (Turner, 1997). However, the effect of soil desiccation on the crop production under elevated temperature and CO_2 conditions is clearly unknown. To estimate the effects on Mediterranean wheat cultivars, seedlings of two cultivars were grown under the ambient and elevated temperature and CO_2 conditions and the response of transpiration rate to soil desiccation was observed.

MATERIAL AND METHODS

Background of the research

The dry matter production (DMP) for one time interval is indicated by

$$DMP = WUE \times T/VD \quad (1)$$

where WUE is water use efficiency, T transpiration and VD vapor deficit (Tanner and Sinclair, 1983). When plants are well irrigated, DMP_0, WUE_0, and T_0/VD are given. The ratio of DMP to DMP_0 is

$$DMP/DMP_0=(WUE/WUE_0) \times (T/VD)/(T_0/VD)$$
$$=(WUE/WUE_0) \times (T/T_0) \quad (2)$$

$$DMP=DMP_0 \times (WUE/WUE_0) \times (T/T_0) \quad (3)$$

In diverse crop plants the WUE/WUE_0 scarcely changed with soil desiccation and was similar among cultivars but the T/T_0 was severely suppressed by soil desiccation (Tanner and Sinclair, 1983; Kobata et al., 1996). Hence the response of T/T_0 to soil desiccation is one of the most important factors deciding the DMP. The DMP_0 is considered as a potential productivity under well irrigated condition. Empirically there was a close curve liner relationship between normalized transpiration rate (T/T_0) and fraction of transpirable soil water (FTSW) in most crop species. The FTSW is ratio of soil water to transpirable soil water (Ray and Sinclair, 1998). In the

report percentage of field capacity was used as soil water condition because the lowest soil water content available for plants under −1.5MPa was not yet measured and hence FTSW was not calculated.

Plant Materials and Measurements

Seeds of two whet cultivars, Seri M82 (spring wheat) and Bezostaya1(winter wheat) were transplanted early December 2002 in 8 l pot containing mixture of Andosol and sand (volume ratio=1:1). They were grown for two months in a plastic covered house. 0.5 g of compound fertilizer including 14% of N, 17% of P and 13% of K was applied at the transplanting and irrigated.

Soil Desiccation Treatments

10 February 2003 at five leaf stage, pots were carried into tow growth chambers of an ambient chamber (temperature 20/15 ℃ and CO_2 concentration 360 μ mol l^{-1}) and an elevated chamber (temperature 24/19℃ and CO_2 concentration 600 μ mol l^{-1}). After one week, irrigation was stopped for half pots of each cultivar while remained pots was continuously irrigated. Pot surface was covered with plastic beads to protect soil evaporation. Four or three plants at the start and end of the treatments were harvested, dried in 80 ℃ oven for 48 h and weigh. Pot weight was measured with electric balance every day evening to estimate transpiration rate per day for three or four weeks.

RESULTS AND DISCUSSION

Soil water content (% of field capacity) decreased by stopping of irrigation from 100 to 50 or 60 % in both cultivars under the ambient and the elevated temperature and CO_2 concentration conditions (Fig. 1). In Seri M82 T/T_0 slightly decreased although in Bezostaya1 it was maintained till 60 % of field capacity regardless of the elevated treatments. There was not a clear difference in the response of T/T_0 to soil water contents between the ambient and elevated treatment plots. During the soil desiccated treatment WUE increased in both cultivars under the elevated treatments although soil desiccation did not clear affect the WUE. Because VD in the elevated treatment chamber was similar to that in ambient chamber, the increase of WUE did not seem to be cause by differences of air humidity. In the experiment, data of response of T/T_0 to lower soil water content (<50%) were not collected due to limitation of experimental period. The experimental term should be extended or smaller pot should be used to collect data under diverse soil water conditions.

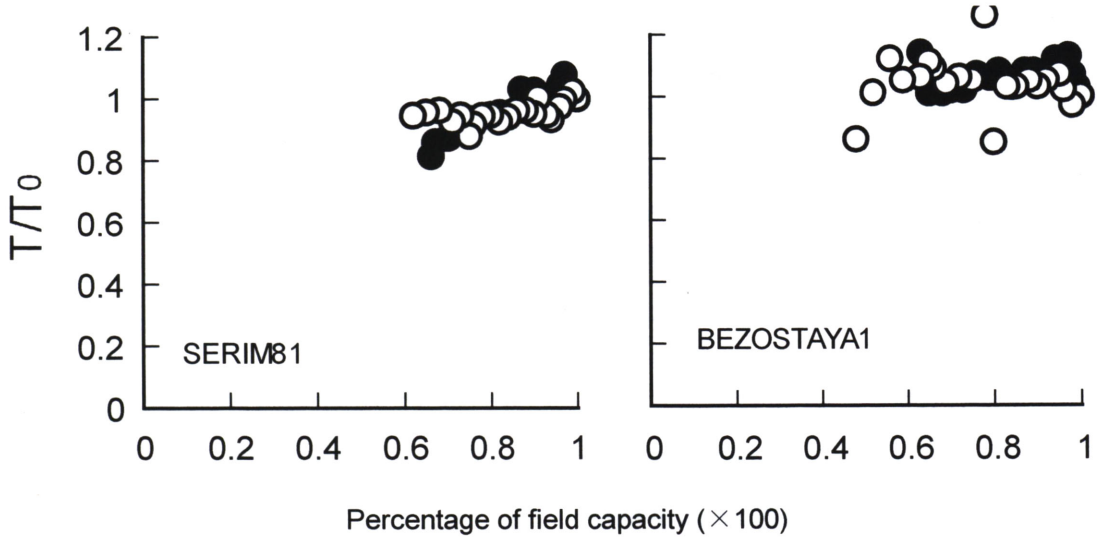

Fig. 1. Normalized transpiration rate (T/T_0) and soil water content (percentage of filed capacity) in two wheat cultivars under ambient and elevated temperature and CO_2 conditions when watering was stopped to seedling plants. Closed and open symbols indicated ambient and elevated temperature and CO_2 concentration treatment plants, respectively.

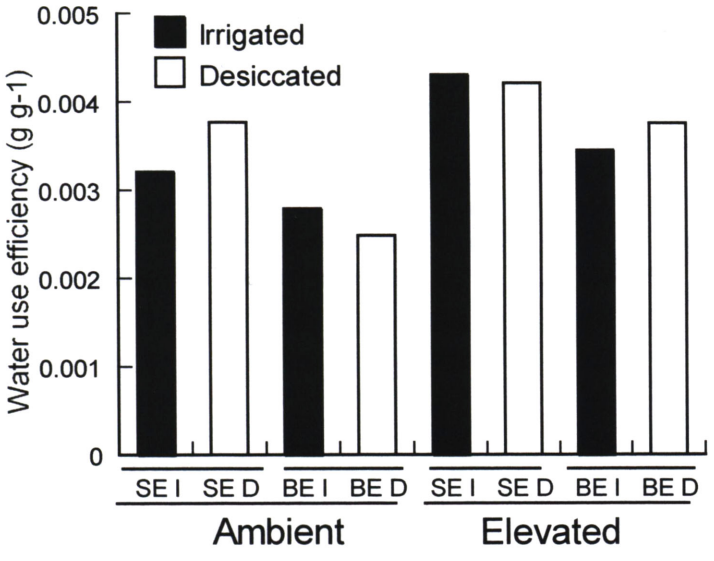

Fig. 2. Water use efficiency for 23 days in two wheat cultivars under ambient and elevated temperature and CO_2 conditions when water was withheld from seedling plants.

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