The effect of desiccated soils on transpiration in spring wheat subject to elevated temperature and CO_2 concentration

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1. INTRSUCTION

The dry matter production (DMP) for a 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 it is expected that the WUE/WUE_0 scarcely changes with soil desiccation and is similar among cultivars but the T/T_0 is severely suppressed by soil desiccation (Tanner and Sinclair, 1983). Hence the response of T/T_0 to soil desiccation is one of the most important factors deciding the DMP. The DMP_0 is a potential productivity under well irrigated condition. The DMP_0 is expected to be estimated from a simulation model (Nakagawa and Horie 1997).

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). Hence T/T_0 is the important factor to estimate the suppression of DMP_0 under soil desiccated conditions.

However, it is unknown the effect of soil water deficit on T/T_0 in spring wheat of Turkey subject to elevated temperature and CO_2 concentration.

2. MATERIALS and METHODS

Plant materials

Adana99 of one of the dominant cultivar from Mediterranean area, Adana, Turky was grown in pots under glass house. Seedling soil for rice including fertilizer of 0.28 g of N, 0.33 g of P_2O_5 and 0.3 g K_2O per l (Green soil, Izumo Green Co.) was put into pots. Pot volume was 1.5 or 8 l. One or two plants were grown in a pot.

Soil desiccation treatments

(1) Vegetative stage

In 2003 and 2004 plants were growth cabinet of Tottori Dryland Research Center after one week naturalization at the late vegetative stage from natural light glasshouse (Fig. 1- A&B). Temperature in ambient chamber was 20/15 °C, day time vapor deficit 11.9 g m^{-3} and CO_2 concentration 414±20 µmol l^{-1} and in an elevated chamber temperature 24/19 °C, day time vapor deficit17.4 g m^{-3} and CO_2 concentration 589±27 µmol l^{-1}. Watering was stopped for two weeks.

In 2005 plants were grown in temperature and CO_2 controlled chambers. The camber was covered with clear plastic film (Six-Light, Taiyo-Kogyo Co. Tokyo) and a temperature exchange fan and heater with a controller (Fig 1.-C). Temperature and CO_2 were controlled by several degrees higher than outside ambient and 600-700 µmol mol^{-1}, respectively. Watering was terminated from the late vegetative stage for three weeks. Two chambers were used as replications.

(2) Reproductive stage

In 2006 plants grown in 8 l pot was used. Watering was withheld from the flowering stage to maturity in non temperature controlled glasshouse in ambient CO_2 concentration.

In both stages soil surface was covered with clear plastic beads to protect soil evaporation and pot weight was measured every day to estimate transpiration rate and soil water contents.

FTSW was calculated from the equation.

$$FTSW=SWa/SWmax \quad (1)$$

where SWa is the actual water weight per pot and

SW0max is the available soil water weight per pot. SWmax is decided by the difference between soil water weight at the field capacity and at the permanent wilting point. The filed capacity is soil water weight at soil water potential of -0.03 MPa and the wilting point at -1.5 MPa (Kramer and Boyer, 1995). The soil moisture characteristic curve was decided for the soils with the thermocouple pshychrometer methods (Boyer, 1995).

3. RESULTS and DISCUSSION

Transpiration rate decreased with a decrease of FTSW and there was a curve liner relationship between T/T_0 and FTSW in both growth stage experiments (Fig. 1).

In the vegetative stage experiment the relationship under ambient and elevated conditions was similar within same experiment (Fig.1). However, precisely the curve should differ among experiments. Under climate change conditions plants suffer higher temperature and CO_2 concentrations from emergence and hence the plant may adapt to the environment. From the results the long term experiment in a chamber would be reliable because the plants have been elevated conditions since emergence (Fig.1-C).

Actually wheat in the Mediterranean zone sometime suffers from terminal drought, that is, the soil desiccation during the grain-filling period (Turner, 1997). Drought response during the grain-filling period is the most important performance in wheat in Adana areas (personal communication by Dr. Genc). When watering was withheld from pots at flowering, T/T_0 decreased with a decrease of FTSW similar to that at vegetative stage (Fig. 1-D). The result did not include the effect of elevated condition but the response of T/T_0 to FTSW in the reproductive stage should not differ between ambient and elevated conditions due to that in the vegetative stage.

The results suggest that under elevated temperature and CO_2 conditions in the future the response of T/T_0 to FTSW would be similar to that under ambient conditions and therefore the response curve should be available for sub-model to estimate the suppression of estimated biomass production by soil desiccation.

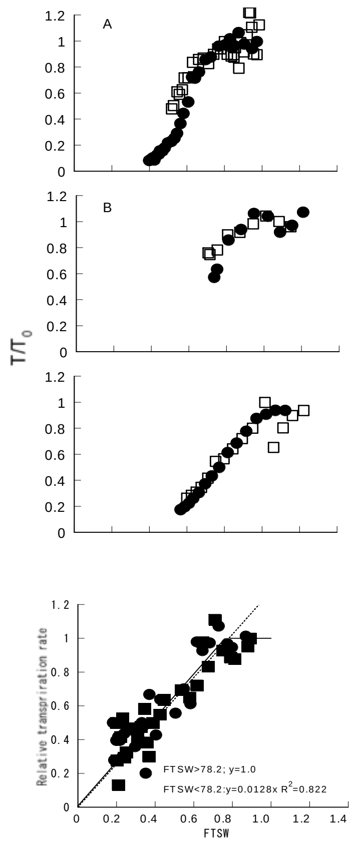

Fig.1. Transpiration ratio (T/T_0) and FTSW in Adana99 under ambient (■) and elevated (□) temperature and CO_2 concentration during vegetative (A-C) and reproductive (D) stage. From A to C each point indicates average of three observations and for D an individual plant. The equation in D was used for a model.

4. REFERENCES

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