Model Development and Assessments for Estimation of Crop Production under the Future Climate Changes

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Three dominant environmental factors affecting crop production in the Mediterranean climate areas are expected under future climate changes. The first factor is elevated temperature, the second is elevation of CO_2 concentration and the third is soil water deficit. Assessments for the effects on crop production require estimation model incorporating physiological responses and processes. In the report we have developed conventional models and assessed the reliability by the comparison between estimated and calculated yield in wheat about the past data in Adana rain fed area in Turkey.

Model concept

Potential biomass production rate (BPR_P) is estimated from a model calculated from air temperature, day length and solar radiation (Nakagawa et al. 1997). Model parameters were decided by filed experiments during 2003 and 2005 in Adana Trukey and partially in Ishikawa Japan about one of the dominant cultivar, Adana 99 in the Mediterranean zone of Turkey. Meteorological data of every day are input into the model and the data are accumulated. Soil water deficit is evaluated by suppression factor (SF). The SF is an empirical equation of fraction transpirable soil water (FTSW) (Ray and Sinclair 1998).

$$SF = f(FTSW) \qquad (2)$$

The equation was decided by pot experiments. Biomass production rate (BPR) is indicated as

$$BPR = BPR_P \times SF \qquad (2)$$

Grain yield (Y) is calculated from BPR ×HI after the start of flowering where HI is a fraction of harvest index.

$$Y = \sum(BPR \times HI) \qquad (3)$$

Model parameters in BPR_P have been decided in now ambient conditions. Therefore, the model may not be immediately adopted to the future changed climate conditions. Therefore, we will introduce the effects of elevated CO_2 on radiation use efficiency into the model while the effect is estimated from the past results. FS seems to be similar between ambient and elevated temperature and CO_2 conditions from the growth cabinet experiments (Kobata et al. 2005) and hence we use similar FS in both conditions

Results and Discussion

FTSW of each day during average wheat growing season in Adana was calculated from rain fall, evapotranspiration and transpirable soil water contents. The evapotranspiration was calculated from meteorological data and crop coefficient (FAO 2005) for average growth period in Adana. Transpiable soil water contents was for the soil depth of 90 cm in the field measurement in 2005. Water over field capacity was considered as overflowed or infiltrated water and eliminated from soil water balance. Calculated FTSW indicated that

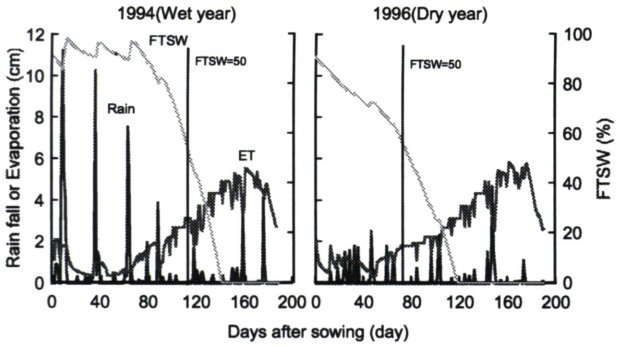

Fig.1. Rainfall, evapotranspiration and estimated FTSW in wet year (1994) and dry year (1996) in Adana.

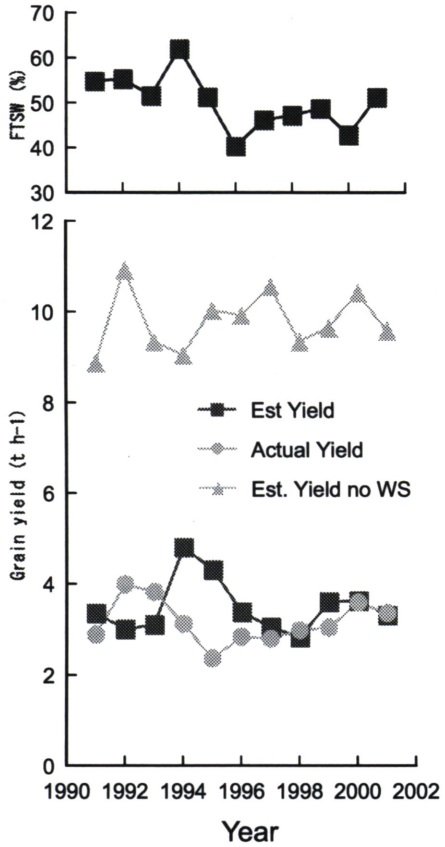

Fig.2. Actual grain yield (t h^{-1}), estimated FTSW and estimated grain yield of wheat from 1991 to 2001 in Adana.

wet and desiccated years appeared during the term (Fig. 1). However the decrease of FTSW seems to be severe because it attained zero at anthesis in most cases.

Actual grain yield indicated the maximum in 1992 and after the minimum in 1995 it increased to 2000 (Fig. 2). FTSW was higher between 1991 and 1994 than other years after the terms. Estimated potential grain yield was in a range between 9 and 11 t h^{-1}. Estimated gain yield was similar levels to actual one but partially it was higher.

Some differences between estimated by our simulation model and actual data in wheat yield were observed. One of the differences seems to be resulted from estimated FTSW that was under estimated. FTSW at anthesis was near zero (Fig. 1) and hence dry matter production during the grain filling period was scarcely reflected to grain yield. It is unusual. We should improve FTSW calculation procedure particularly for water over field capacity. Moreover data quality and simulation processes should be checked and revised.

After the revisions future effects on wheat grain yield by climate change could be estimate. Soil water seems to be a key factor in variation of grain yield in the Mediterranean area.

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