Simulation of crop productivity in Seyhan Plain under changing global climate using the SWAP model

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1. Introduction

Global climate changes caused by natural processes are major and important environmental issues. Climate change will have major impact on water resources and irrigated agriculture that is perhaps the most sensitive and vulnerable.

The effect of climate change on the crop productivity is investigated by the experimental method using a growth chamber or by the numerical method using a crop model.

The objective of this report is to estimate the crop parameters for maize in the crop model, which is integrated into the SWAP model, using the field maize data in 2003 at Adana. Then, the impact of temperature rise on crop growth is simulated by the SWAP model.

2. Material

Maize filed experiments were conducted in 2003 at commercial filed located 40km south from Adana, Turkey to obtain crop data which are required for the crop growth in the SWAP model. Maize (*Pioneer31G98*) was used for the experiments. Filed experiments were conducted two cropping seasons. That is, first crop, which planting was 6 April and harvest was 10 September, and second crop, which planting was 19 June and harvest was 8 November.

3. Results of filed experiments

Fig.1 shows the dry root weight profile for first and second crop maize. As shown in this figure, dry root weight decreased with the soil depth, and maximum root depth of first and second crop was 100cm depth and 80cm depth, respectively. Then, dry root weight

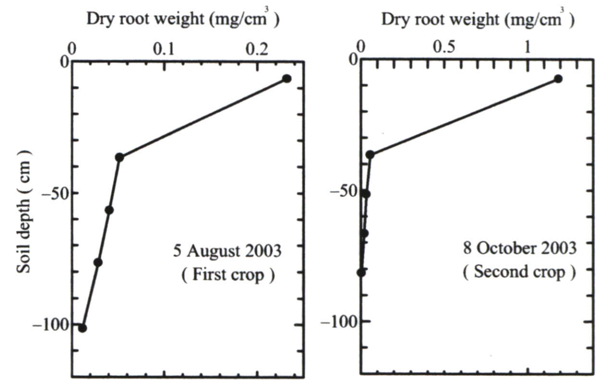

Fig.1 Dry root weight profile for Maize

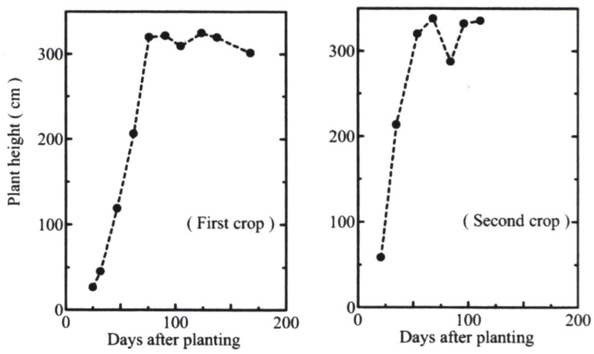

Fig.2 Temporal variation of plant height

concentrated in the range from ground surface to 40cm depth.

Fig.2 shows the temporal variation of plant height for first and second crop maize. As shown in this figure, maximum plant height of first crop maize was about 320cm before and after 100days from planting. On the other hand, in the case of second crop maize, it was about 340cm before and after 75days from planting.

Fig.3 shows the temporal variation of LAI for first and second crop maize. Both LAI values increased to the range from 6 to 6.5. However, the increase rate of LAI in second crop maize was larger than

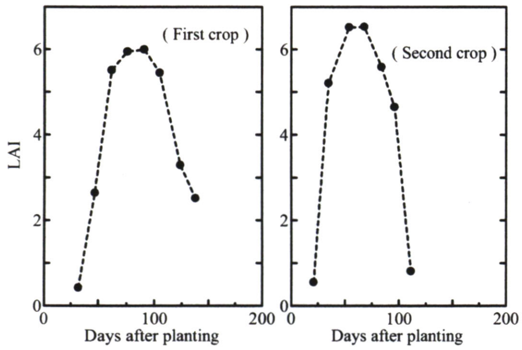

Fig.3 Temporal variation of LAI

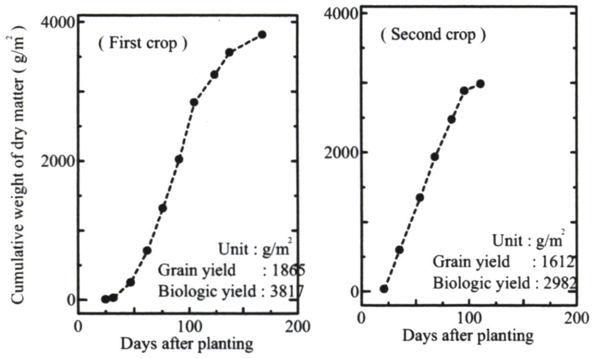

Fig.4 Cumulative dry matter weight

one in first crop maize.

Fig.4 shows the cumulative dry matter weight for first and second crop maize. In the case of first crop maize, grain and biologic yield after 170 days from planting were 1865 and 3817 g/m^2, respectively. Then, in the case of second crop maize, grain and biologic yield after 110 days from planting were 1612 and 2982 g/m^2.

4. Parameterization of cop growth model in the SWAP model

SWAP is a computer model that simulates transport of water, solutes and heat in variably saturated soils. The problem is designed for integrated modeling of the Soil-Water- Atmosphere-Plant system.

The SWAP model contains three crop growth routines. That is, a detail model, the same model attuned to simulate grass model and a simple model. Input parameters for a simple crop model are simple crop growth data, such as LAI, crop height and rooting depth etc. A simple crop model mainly simulates the water balance in crop cycle, but it cannot simulate the crop growth. On the other hand, a detailed crop model can simulate the crop growth, but detailed information in the phonological stage of crop is needed. In this report, a detailed crop model

Table.1 Main crop parameters in a detailed crop model

*Temperature sum for the development rate of the crop. *Crop height for the potential evapotranspiration *LAI and maximum relative increase of LAI for the initial growth *Initial rooting depth and maximum rooting depth for the root growth *Partitioning of the produced structural plant material to the different plant organs	I
*Assimilation *Maintenance respiration *Death rate *Crop water use	II

is used in order to simulate the crop growth with climate changes.

Table.1 lists the main crop parameters in a detailed crop model. Parameters of □part are determined from the measured first and second crop maize data. On the other hand, parameters of □part , which are not obtained from the filed data, are estimated in order to fit the measured cumulative dry matter weight curve.

Maize growth was simulated with the SWAP model using the crop parameters, which were estimated from field data as described above, and the observed climate data in 2003 at Adana.

Fig.5 shows the comparison of observed and simulated values for cumulative weight of dry matter. As shown in this figure, simulated dry matter weight accorded substantially with the observed data. However, there was a difference between observed and simulated cumulative weight of dry matter curve. In the case of first crop maize, simulated dry matter weight values in the initial development stage were larger than the observed data. On the other hand, in the case of second crop maize, the observed data were reproduced approximately by the simulated values. It was considered that the difference between observed and simulated values as shown in the first crop maize was caused by the setting of the specific leaf area of a crop, which determined the maximum increase of leaf area index, and the initial crop weight. From now on, we are going to conduct more detailed examination of crop parameters to solve this problem.

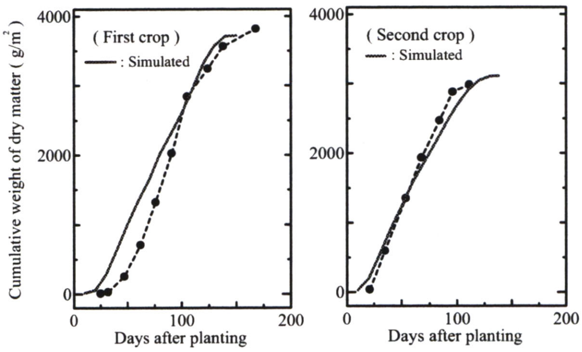

Fig.5 Comparison of observed and simulated values for cumulative weight of dry matter

5. The impact of temperature rise on the maize growth.

To investigate the impact of climate change on the first and second maize growth, crop growth was simulated by the SWAP model using the crop parameters obtained from the filed data in 2003 and the predicted daily climate data near Adana in 1981-2010 and 2040-2060 with the MRI model of Meteorological Research Institute.

Figs.6 and **7** show the variation of predicted

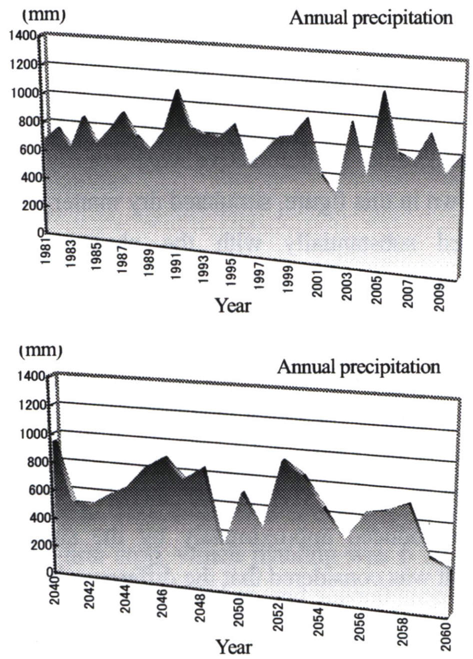

Fig.6 Predicted annual precipitation in 1981-2010 and 2040-2060

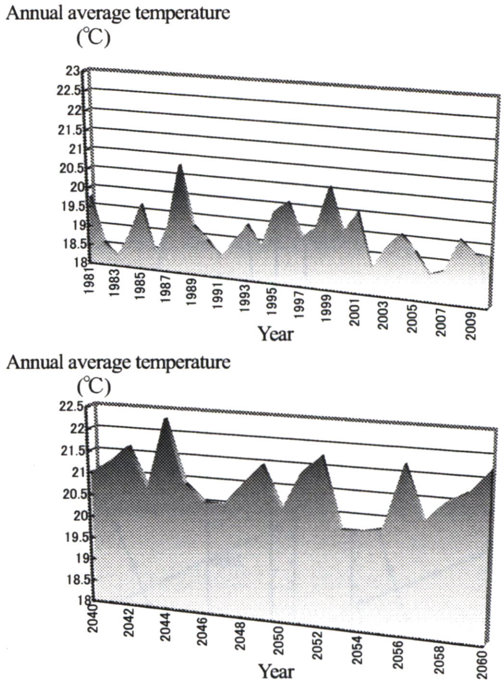

Fig.7 Predicted annual average temperature in 1981-2010 and 2040-2060

annual precipitation and average temperature and in 1981-2010 and 2040-2060. As shown in the figures, annual precipitation tended to decrease and averaged annual precipitation in 2040-2060 decreased by 18.1% as compared with one in 1981-2010. Then, annual average temperature tended to increase and averaged annual average temperature in 2040-2060 increased by 1.7 degree C as compared with one in 1981-2010.

Fig.8 shows the simulated average dry matter weight in 1981-2010 and in 2040-2060 for first and second maize. Temperature rise is mainly considered to influence the maize growth, because we assume no water stress in this simulation. As shown in this figure, average dry matter weight of first and second maize in 2040-2060 decreased by 11.7% and 14.9% as compared with those in 1981-2010. This drop of dry matter weight is mainly caused by the shortened crop growth due to temperature rise. In this simulation, crop growth of first and second maize decrease by 8% and 6%, respectively.

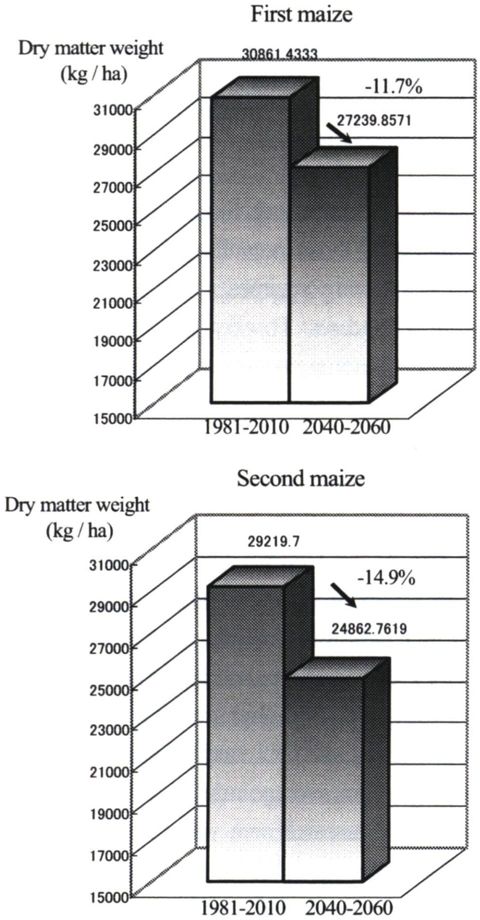

Fig.8 Comparison of averaged dry matter weight in 1981-2010 and 2040-2060.

6. Conclusions

In this report, crop parameters for maize were estimated from the filed data in Adana (2003) and comparison was made between observed and simulated cumulative weight of dry matter. Consequently, the simulated value in the initial development stage of first maize overestimated, however, the simulated value agreed substantially with the observed value in the case of second maize. Thus, it was necessary to estimate the crop parameters for maize using phenology data collected from the various experimental conditions.

Maize productivity with change climate was simulated by the SWAP model using the predicted climate data of MRI model. In this simulation, average dry matter weight in 2040- 2060 decreased by 11.7% and 14.9% for first and second maize as compared with one in 1981-2010, respectively. This decrease was mainly caused by the shortened crop growth due to temperature rise.