BRIEFING / 3.5

July 2013

The impacts of future climate change on wheat yields in the Jordan River basin

Key findings

- The effects of decreased rainfall (average of 32 mm) for the predicted period were found to be insignificant on wheat yield.
- The decrease in the stress index (SI) and consequently, the decrease in wheat yields, was found to be significant.
- Evaporation reduction measures such as screening mesh or mulching may reduce evaporation considerably.
- The effect of mulching on wheat yield is pronounced only during dry years. The effect of mulching on increased drainage water is considerable, but its use is restricted to a limited area size.

Overview and Objectives

The impact of future climate change on wheat yields in the Jordan River basin was evaluated by comparing historical climate and wheat yield data with predicted data for a 30-year future period, the years 2070-2099, as calculated by a simplified bulk wheat model. Wheat is the main rain-fed agricultural crop in the Jordan River basin.
Aditionally, a simplified bulk wheat model was developed to calculate the annual Stress Index (SI) based on the daily-calculated ratio of potential to actual evapo-transpiration values. Finally, wheat grain yield (Kg/ha) was related to the seasonal SI and nitrogen application using a regression model calibrated by data from field trials.

Research Methods

Two main inputs are required for the wheat model:

I. Daily atmospheric parameters

Daily atmospheric parameters obtained by Global Climate Model ECHAM4 (Briefing 1.3) and regional model MM5 by IMK-IFU (18 Km), for the years 1961-1990 (control) and 2070-2099 (future).

II. The spatial distribution soils

The spatial distribution of soils within the Upper Jordan basin (1 km resolution supplied by Y. Salinger) and its main characterizations (particle size distribution, bulk density, water holding parameters.

Furthermore , the model has three components:

I. Atmosphere

The atmosphere, which determines the value of the potential evapotranspiration (PET) and rainfall input.

II. Soil

The soil, which determines plant growth rate, and actual evapotranspiration, based on the availability of water content within the soil.

III. Wheat plant

Wheat plant characteristics: root and canopy growth rate.

Daily totals of solar radiation, temperature, atmospheric vapor pressure and average daily horizontal windspeed were used to calculate the PET using the standard Penman-Monteith formulation for open water bodies.
The water fluxes taken into account within the developed model are rainfall, evaporation, transpiration, runoff and drainage. During a rainfall event, the soil layers are filled with water sequentially from top to bottom. The excess rainfall (above the water holding capacity of the soil profile at saturation) is assumed to run off the field. After the rainfall event, the amount of water above field capacity (FC) is assumed to drain to the layer below the root zone. The water that drains from the bottom layer is described as the drainage.
Root elongation rate (i.e. the maximum depth of a plant's roots), leaf area index (LAI), increase rate and transpiration rate are assumed to peak at FC (whole

profile) and decrease linearly if the soil water content is either higher (due to a lack of oxygen) or lower.

Grain yields are simulated for each soil type (assuming an average soil depth of 1 m) within each climatic grid cell using the daily meteorological inputs from the regional model, for the past (1961-1990) and future (2070-99) periods. The change in wheat yield is based on the difference between the thirty-year average values (Figure 1) as is the differences in drainage (Figure 2).

The model also tested the effect of mulching on wheat yields. In this case, part of the growing area was covered with mulch. The mulching contributed to the total water input by runoff, yet reduced the total growing area available for wheat.

Conclusions

The effects of decreased rainfall (average of 32 mm) for the predicted period were found to be insignificant on wheat yield, whereas the decrease in the stress index (SI) and consequently, the decrease in wheat yields, were found to be significant.

Evaporation reduction measures such as screening mesh or mulching may reduce evaporation considerably.

The effect of mulching on wheat yield is pronounced only during dry years. The effect of mulching on increased drainage water is considerable, but its use is restricted to a limited area size.

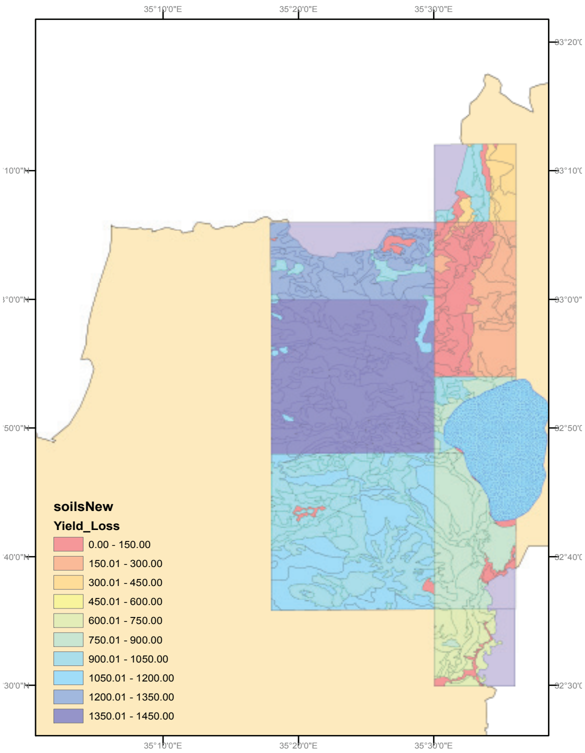

Figure 1: The annual future decrease in wheat yeilds (kg / ha) within the upper Jordan basin.

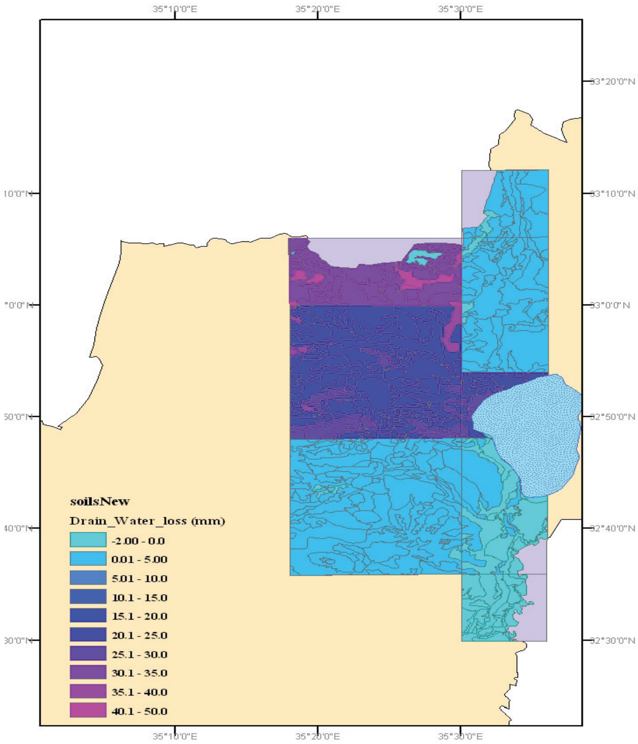

Figure 2: The annual future decrease in drainage (mm) within the upper Jordan basin.

References

Haiim, D., M. Schechter and P. Berliner (2008). "Assessing the Impact of Climate Change on Representative Field Crops in Israeli Agriculture: A Case Study of Wheat and Cotton." Climatic Change, 86 (4):425-440

GLOWA JR Briefings present relevant scientific results of the GLOWA Jordan River project concerning the effects of climate and global change in the Jordan River basin.

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