MODELLING CLIMATE CHANGE IMPACTS ON MAIZE AND WHEAT GROWTH AND DEVELOPMENT

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Introduction

Crop models are widely used for assessing climate change impacts on crop yields (Mearns *et al*., 1997; Semenov and Porter, 1995). This paper aims to estimate the effect of expected climate change on yields of maize and wheat in the most fertile area of the Czech Republic.

Methods

Crop models CERES-Maize and CERES-Wheat were used in this study to simulate crop growth in present and changed climate conditions. The contribution consists of two parts:

1) Parameterization and validation of CERES-Maize and CERES-Wheat growth models: The grain yields simulated by the two crop growth models with use of measured site-specific pedological, physiological, cultivation and meteorological data are compared with observed grain yields. The experimental site Zabcice is located in southern Moravia, the Czech Republic. Observational data from seventeen years were evaluated for maize, nineteen years for wheat.

2) Modelling crop yields for 2· CO_2 climate conditions + sensitivity analysis: The 99-year crop simulation experiments were run using synthetic weather series (precipitation - *PREC*, solar radiation - *SRAD* and extreme air temperatures *TMIN* and *TMAX*) synthesized by stochastic weather generator (WG) Met&Roll (Dubrovsky, 1997; Dubrovsky and Zalud, 1999) and other input data taken from the selected representative year. Parameters of the WG were derived from observed weather series and then modified in accordance with climate change scenario. The scenario related to doubled atmospheric CO_2 is based on ECHAM3/T42 GCM model (Nemesova *et al*., 1999). The sensitivity analysis is made to reveal the role of projected changes of individual weather characteristics and direct effect of increased CO_2 on potential and stressed yields.

Because of the brevity of this communication, the figures will be displayed here only for maize.

Results

validation: The results of the validation experiment are given in Fig. 1. It is seen that the simulated yields well fit the observed yields for most of the years. The slight systematic overestimation could be caused by the occurrence of the non-simulated factors, such as harvest losses, pest and diseases, or by the occurrence of extreme weather events. The failures of the simulation are assumed to be due to the human error (the observed yields were probably wrongly calculated in 1991) and occurrence of catastrophic floods (1981).

sensitivity analysis: The climate change scenario defines changes of the means and variability of the four daily weather characteristics used for crop simulation. Since individual changes were affected by different error, the sensitivity analysis was performed to estimate impact of changes in individual characteristics. For each sensitivity scenario, the 99-year simulation with synthetic series was run for potential and stressed (water and nutrients limited) simulations and $1\times CO_2$ and $2\times CO_2$ concentrations in the atmosphere. The results are shown in Fig. 2.

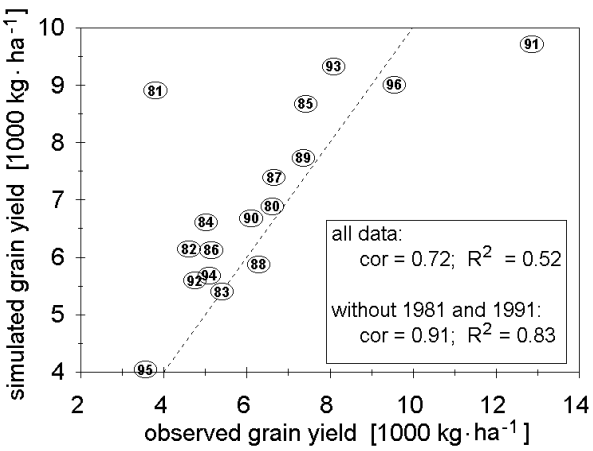

Fig. 1: Validation of the CERES-Maize model. cor is the correlation coefficient, R^2 is the coefficient of determination.

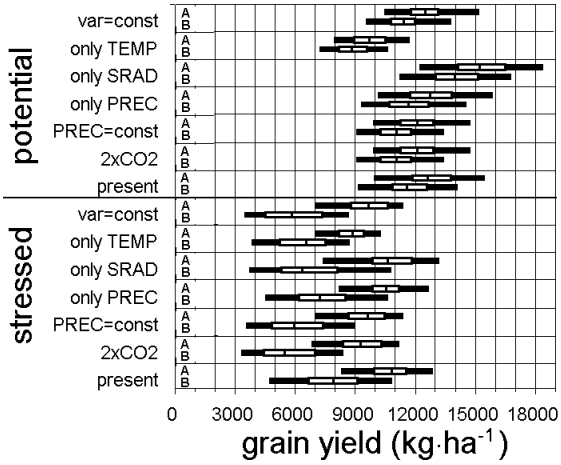

Fig. 2: Maize yield in changed climate conditions - sensitivity analysis. The bars represent quantiles (5^{th}, 25^{th}, median, 75^{th}, 95^{th}) from 99-year simulations. A and B relate to $1\times CO_2$ and $2\times CO_2$ in the atmosphere.

The set of scenarios used in the sensitivity analysis (Fig. 2) include:

- present — parameters of the WG are derived from observed series (1961-1990)
- 2×CO2 — parameters of the WG are modified according to GCM-based scenario
- PREC = const — same as "present" but the precipitation parameters are unmodified
- only PREC — only precipitation parameters are modified
- only SRAD — only solar radiation parameters are modified
- only TEMP — only temperature parameters are modified
- var = const — as "present" but variances of *SRAD*, *TMIN* and *TMAX* are unmodified

Conclusions

1. The validation tests show very good fit between observed and modelled yields for maize and only partly good fit for wheat.
2. The positive direct effect of doubled CO_2 will dominate over negative effect of changed weather conditions.
3. The potential yield of maize (wheat) will increase by about 5 % (17 %); the stressed yield will increase by 14 % (31%) in $2\times CO_2$ climate.
4. Surprisingly, the available water will not be the limiting factor for both crops.

Acknowledgement: The study was sponsored by Grant Agency of the Czech Republic, contract 521/97/P089.

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