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PROJECTION OF THE WATER REGIME PARAMETERS OF ZEMUN CHERNOZEM FOR WINTER WHEAT PRODUCTION BY THE END OF THE 21st CENTURY

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The aim of the research

This paper should answer the following question: Under the most aggressive scenario in greenhouse gas emissions and concentrations (RCP8.5), are we to expect better or worse conditions for the cultivation of winter wheat on the chernozem soil in the region of Zemun by the end of the 21st century?

Materials and methods

The CROPWAT 8.0 crop model was used for the projections of the water regime of chernozem soil under winter wheat crops in the region of Zemun. The projections were made for the period from 2021/2022 to 2099/2100. The following parameters were analysed: minimum, maximum and mean air temperature (Tmin, Tmax, Tmean), effective rainfall, potential winter wheat evapotranspiration (ETc), actual winter wheat evapotranspiration (ETa), winter wheat irrigation water requirements and yield reduction (in relation to the genetic potential). The near (2021/2022-2050/2051) and distant future (2070/2071-2099/2100) simulations were compared with the reference period (1970/1971-1999/2000) simulations. The simulations were created based on the model inputs consisting of climate, crop and soil parameters. In terms of climate data, the input comprised monthly values of reference evapotranspiration (ETo), calculated using the modified Hargreaves method, based on the projections of the daily values of minimum (Tmin) and maximum (Tmax) air temperature. The Tmin and Tmax projections, as well as the precipitation projections for the period from 2021/2022 to 2099/2100, were obtained using the results from the Nonhydrostatic Multi-Scale Model on the B grid (NMMB), which is a regional climate model with 8 km horizontal resolution).
Crop parameters were obtained from the FAO56. It was assumed that winter wheat was sown on October 16th, that the growing period lasted 260 days, and that harvest was performed on June 22nd. The soil was Chernozem on the Zemun loess terrace. It was assumed that the initial soil moisture (on the sowing day) was at the level of field capacity.

Results and discussion

Climate model simulations have indicated an increase of air temperature in the future (Figure 1)

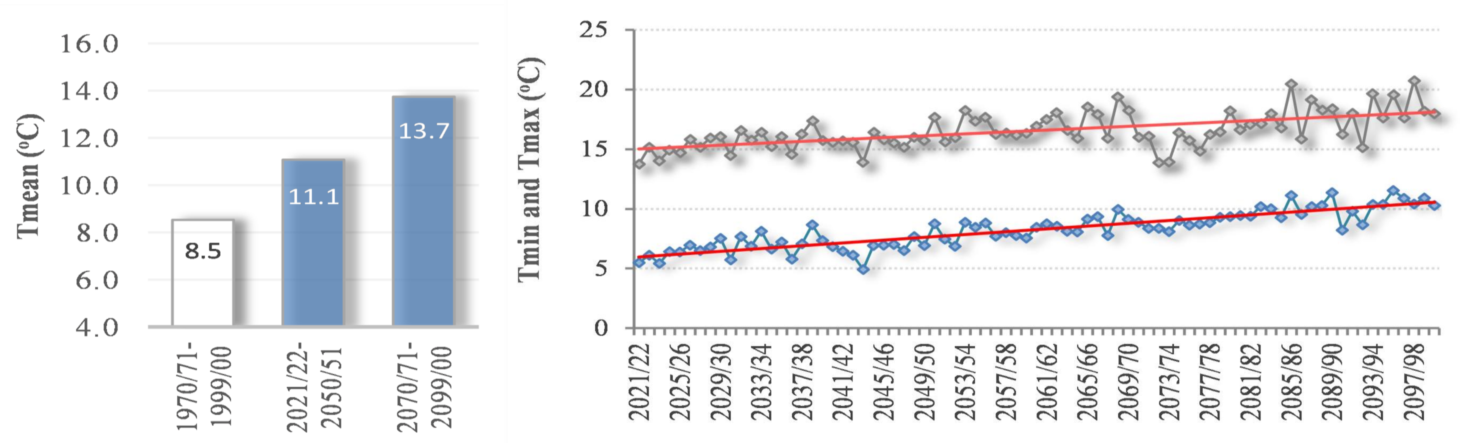

Figure 1. Left: Average mean air temperature (Tmean) in the reference period (1970/1971-1999/2000), in the near future (2021/2022-2050/2051) and in the distant future (2070/2071-2099/2100). Right: Simulation of the minimum and maximum air temperatures (Tmin and Tmax) during the entire observed period (2021/2022-2099/2100) and their upward trend.

Simulations from the climate model have shown that in the future no major changes are to be expected (in the October-June period) in terms of precipitation quantity compared to the reference period (Figure 2).

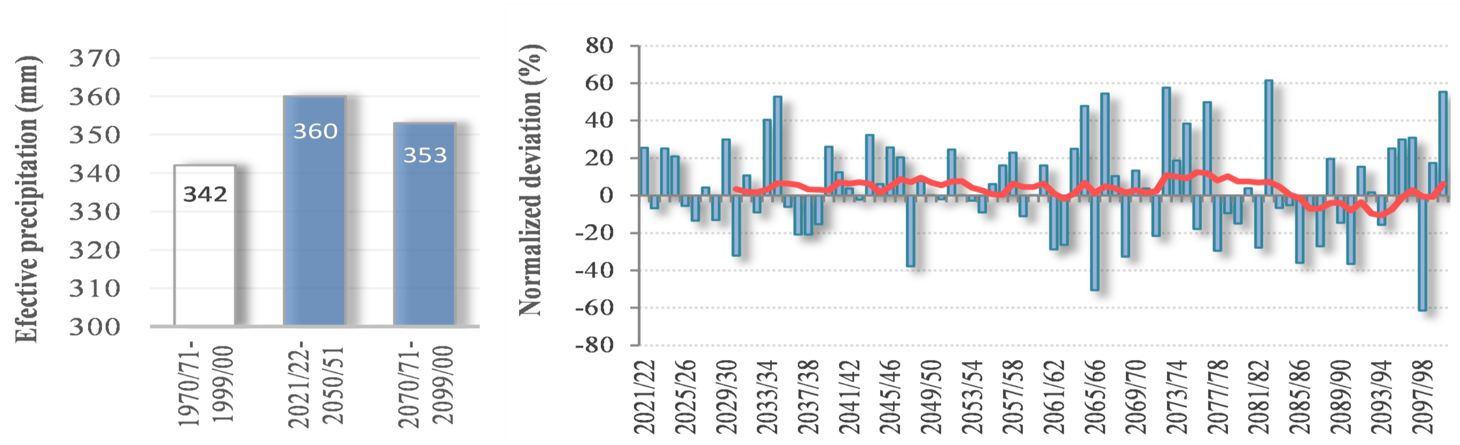

Figure 2. Left: Average value of effective precipitation in the reference period (1970/1971-1999/2000), in the near future (2021/2022-2050/2051) and in the distant future (2070/2071-2099/2100). Right: Time series of the normalised anomalies of projected effective precipitation (P_{eff}) during the winter wheat growing season 2021/2022-2099/2100 relative to the 1970/71–1999/2000 mean. The curve shows the moving average values for a 10-year period assigned to the last year of the period.

Simulations from the crop model have indicated an ETc increase of 4% in the near future and 3% in the distant future, relative to the reference period (Figure 3).

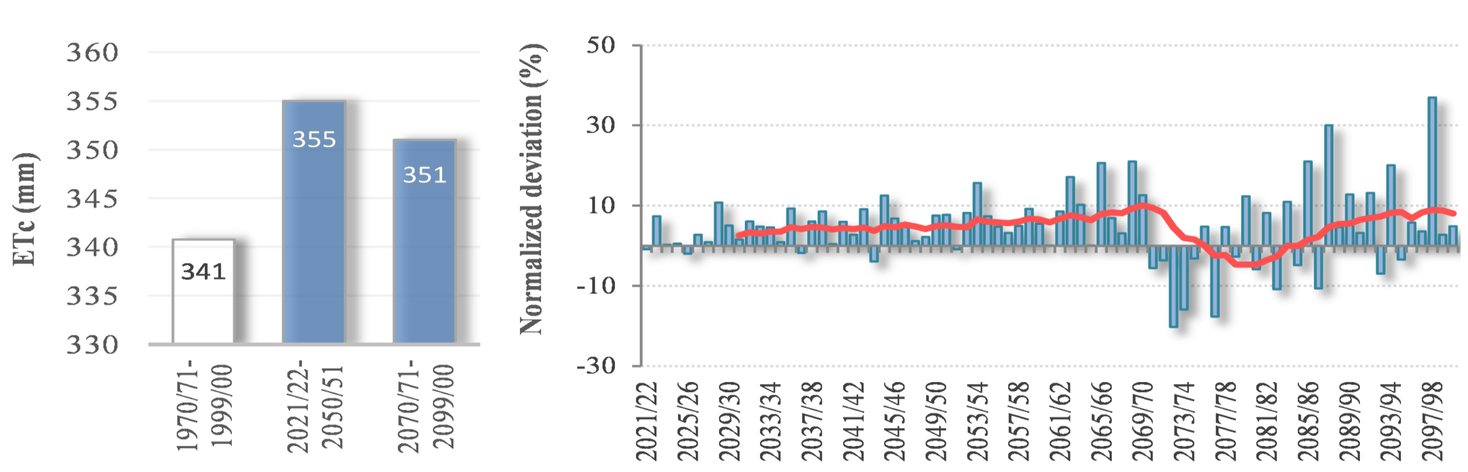

Figure 3. Left: Winter wheat potential evapotranspiration in the reference period (1970/1971-1999/2000), in the near future (2021/2022-2050/2051) and in the distant future (2070/2071-2099/2100). Right: Time series of the normalised anomalies of projected potential winter wheat evapotranspiration in the area of Zemun during 2021/2022-2099/2100, relative to the 1970/71–1999/2000 mean. The curve shows the moving average values for a 10-year period assigned to the last year of the period.

The simulations have shown that the winter wheat ETa will increase by 10% in the near future, and that it will be equilied to the reference period in the distant future (Figure 4)

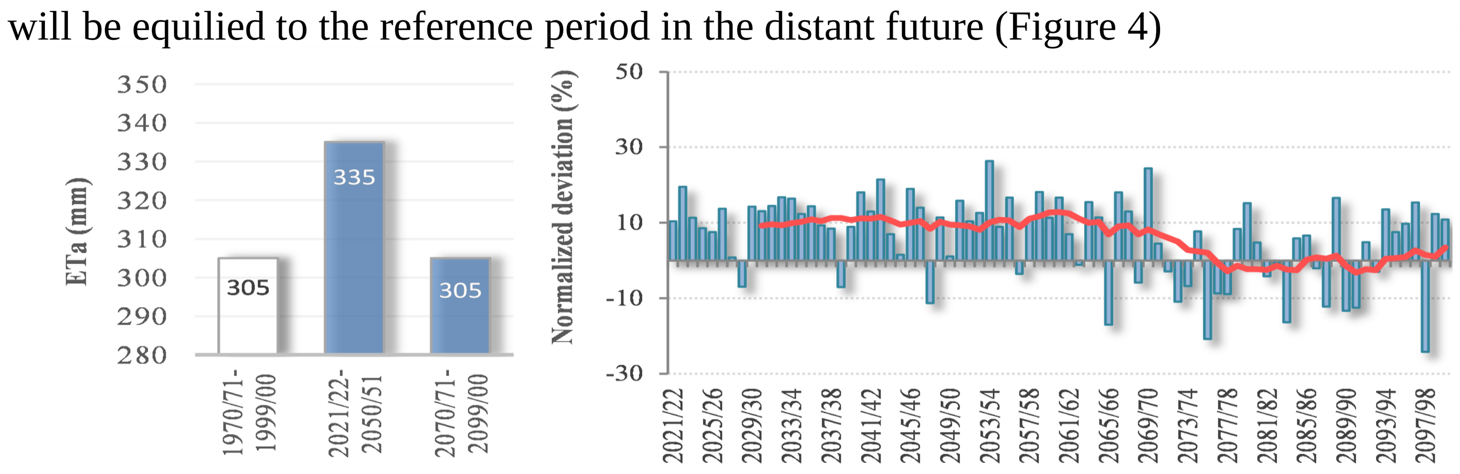

Figure 4. Left: Average winter wheat actual evapotranspiration (ETa) in the reference period (1970/1971-1999/2000), in the near future (2021/2022-2050/2051) and in the distant future (2070/2071-2099/2100). Right: Time series of the normalised anomalies of the projected winter wheat ETa in the area of Zemun during 2021/2022-2099/2100, relative to the 1970/71–1999/2000 mean. The curve shows the moving average values for a 10-year period assigned to the last year of the period.

The irrigation water requirements of winter wheat are 175 mm on average (1970/1971-1999/2000). The simulations have shown that irrigation water requirements will decrease (-7%) in the near future, and increase by 12% in the distant future, compared to the reference period (Figure 5)

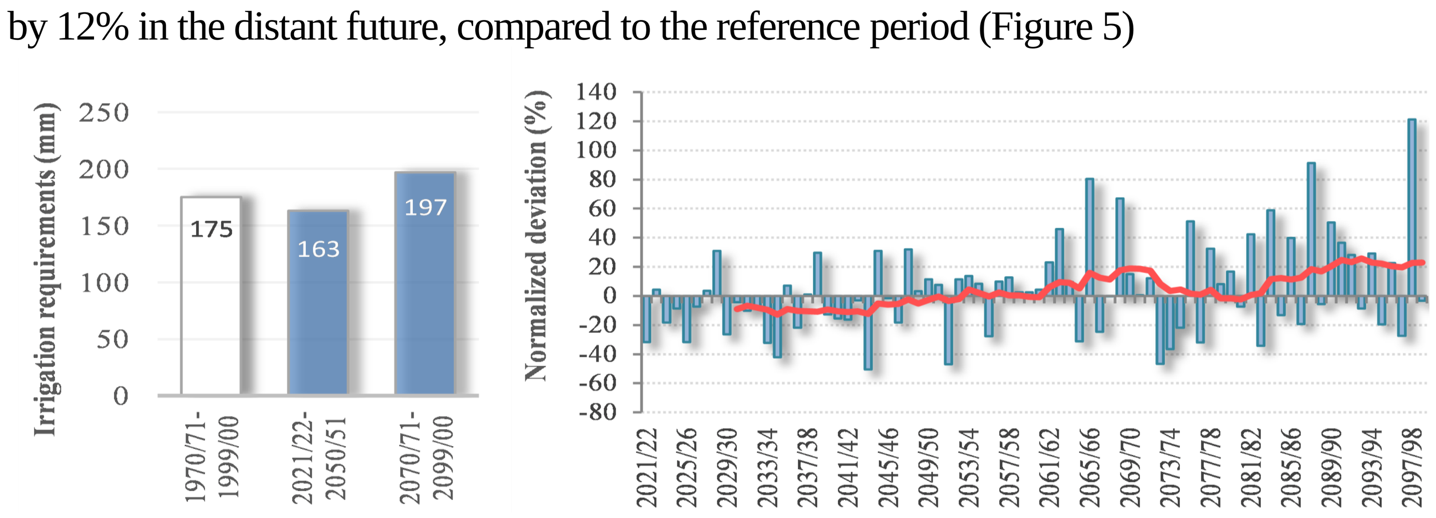

Figure 5. Left: Average irrigation water requirements in the reference period (1970/1971-1999/2000), in the near future (2021/2022-2050/2051) and in the distant future (2070/2071-2099/2100). Right: Normalised deviation of the projected winter wheat irrigation water requirements in the area of Zemun during 2021/2022-2099/2100, relative to the 1970/71–1999/2000 mean. The curve shows moving average values for a 10 year-period assigned to the last year of the period.

The chernozem water regime under the natural rainfall regime has so far (2070/2071-2099/2100) caused an average reduction of winter wheat yield of 9.8% relative to the genetic yield potential. Simulations from the crop model have indicated that the soil water regime conditions will be more favourable in the near future, leading to a smaller yield reduction (5%), compared to the reference period (Figure 6). In the distant future, due to the prediction of a higher water deficit, yield reduction is expected to be larger (11.5%).

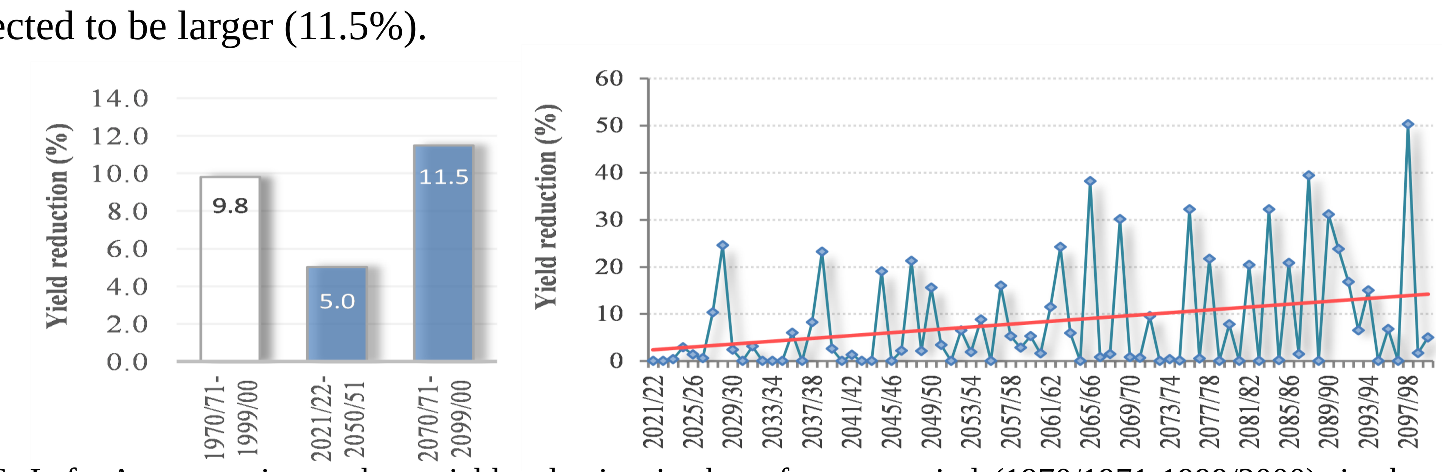

Figure 6. Left: Average winter wheat yield reduction in the reference period (1970/1971-1999/2000), in the near future (2021/2022-2050/2051) and in the distant future (2070/2071-2099/2100). Right: Simulation of the winter wheat yield reduction over the entire studied period (2021/2022 do 2099/2100) and its increasing trend.

Conclusion

The projected climate parameters (2021/22-2099/2100) based on the RCP8.5 greenhouse gas emission scenario, have shown that by the end of the 21st century in the region of Zemun air temperatures are expected to increase, while precipitation amounts are not expected to change significantly during the winter wheat growing season (October-June).
The CROPWAT model simulations have shown that the chernozem water regime conditions for the production of winter wheat are expected to be more favourable in the near future (2021/2022-2050/2051) and less favourable in the distant future (2070/2071-2099/2100), relative to the reference period (1971/1972-1999/2000).
In the near future it is expected that there will be an increase in the potential (ETc) and actual (ETa) evapotranspiration, and a decrease in irrigation water requirements and yield reduction, compared to the reference period.
In the distant future, ETc is expected to increase, ETa to remain unchanged and irrigation water requirements and yield reduction to increase, relative to the reference period.

Acknowledgement

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