Is crop model DAISY able to simulate drought stress?

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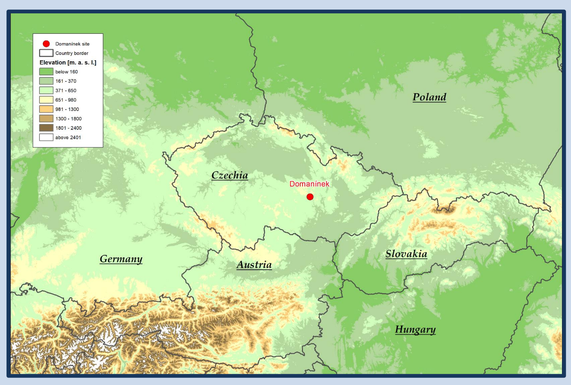
Aim

The main aim of this study was evaluate a drought stress effect on winter wheat and spring barley in 2020 and 2021 and using crop growth model DAISY simulate the response of these crops to the climatic conditions expected in the future, in this case drought stress.

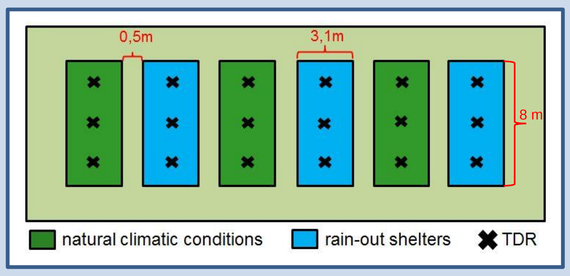
Materials and methods

The field experiment with rain-out shelters was established in Bohemian-Moravian highlands (Domanínek experimental station, 49°31'42"N, 16°14'13"E, altitude 560 m). The soil type is cambisol.



Field experiment with rain-out shelters

Dates of installation and deinstallation (harvest) of rain-out shelters in the					
growing season		2019/2020		2020/2021	
crop		winter wheat	spring barley	winter wheat	spring barley
sowing		4th October	8th April	6th October	12th April
harvest		13th August	20th August	13th August	18th August
sowing - harvest	ø temperature	7.5 °C	14.1 °C	6.4 °C	13.9 °C
	precipitation	567.8 mm	452.2 mm	616.3 mm	408.9 mm
rain-out shelters installation		14th May	3rd June	24th May	11th June
reduction of precipitation		360.8 mm	355.6 mm	300.1 mm	285.5 mm



The field experiment was conducted with the winter wheat and spring barley. The monitored parameters were development, grain yields and soil moisture on two growth seasons (2019/2020 and 2020/2021) for two experimental variants with three repetitions in each crops. The first variant was natural climatic conditions; the second variant was drought stress induced using the mobile rain-out shelters made of corrugated clear polycarbonate material and installed in the crop canopy from spring to harvest.

The ability of crop growth model DAISY to simulate drought stress represented by conditions from rain-out shelters response was tested.

Observed and measured parameters such as soil water content dynamics and grain yields were compared with modelled data.

Measured / observed data —*algorithms*→ **Crop growth model DAISY (4.1)** → **Outputs**

- **management**
- **soil data**
- **crop data**
- **meteorological data**
  - *a) natural climatic conditions*
  - *b) conditions from rain-out shelters*

Crop growth model DAISY (4.1)

- yield formation depending on **partitioning during reproductive stages**
- method to calculate water dynamics: **the numerical solution of Richards' equation**

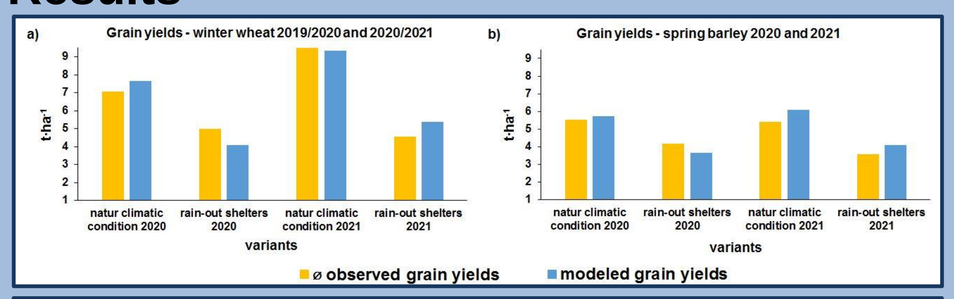
Outputs

- **grain yield**
  - *a) natural climatic conditions*
  - *b) conditions from rain-out shelters*
- **soil water content**
  - *a) natural climatic conditions*
  - *b) conditions from rain-out shelters*

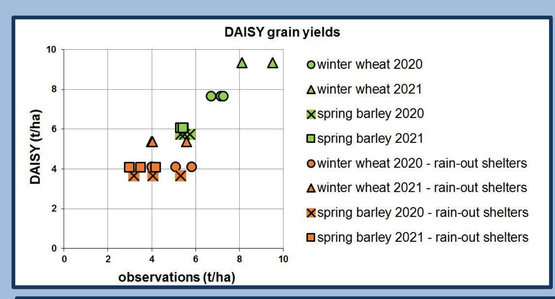
In each variant were sensors TDR to measure the soil water content placed vertically to monitor the soil water content from the surface to a depth of 30 cm.

Results

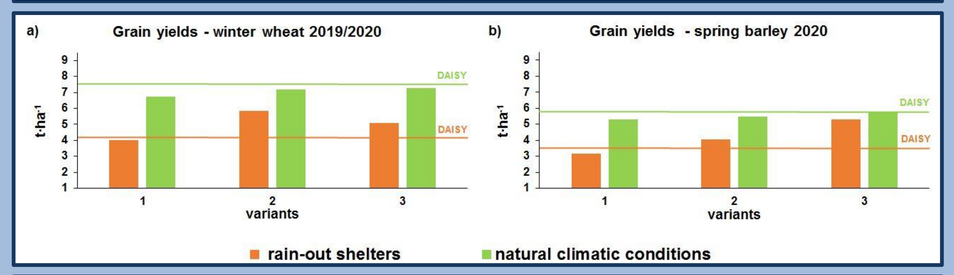
Yield



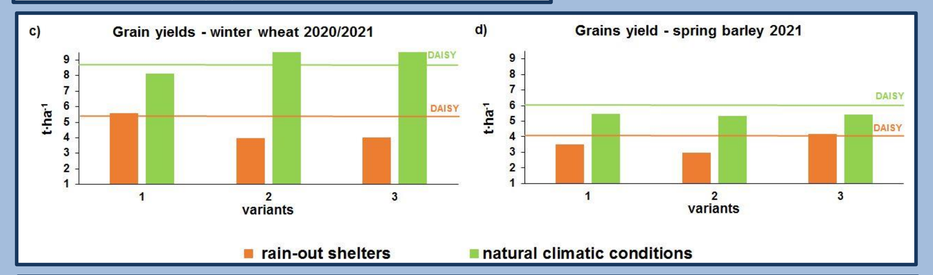
Comparison between average observed and modeled winter wheat (a) and spring barley (b) grain yields for 2020 and for 2021.



Comparison of the observed and modeled grain yields for winter wheat and spring barley using crop growth model DAISY.

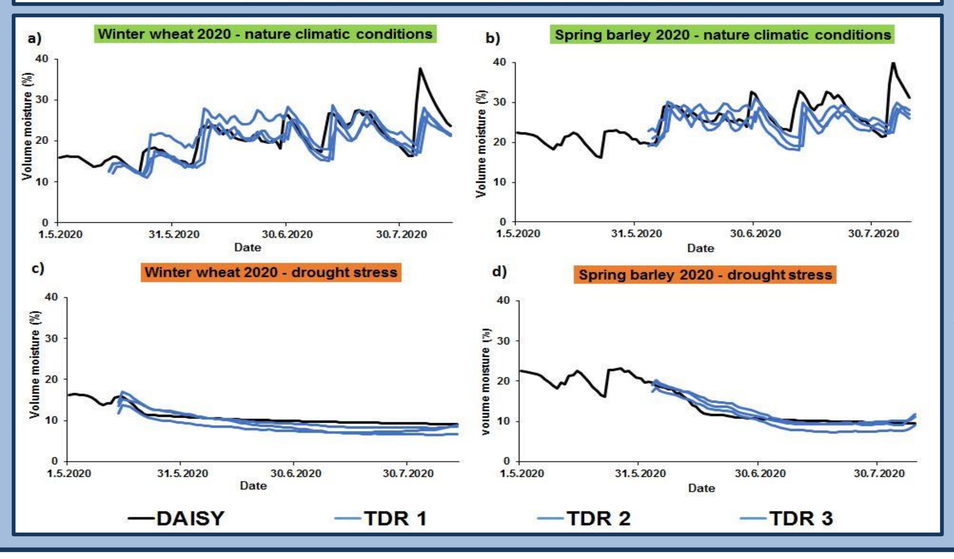


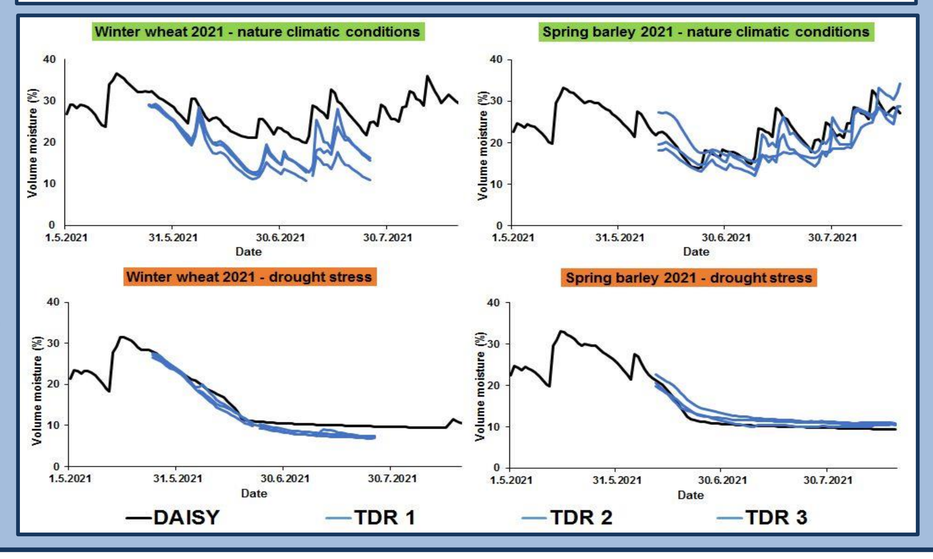
Comparison for variants between observed (columns) and modeled (lines) winter wheat (a, c) and spring barley (b, d) grain yields for 2020 and for 2021.



Soil water content dynamics

Comparisons between measured (by sensors TDR, under the rain-out shelters as drought stress and outside as natural climatic conditions) and simulated (DAISY) soil water content from 0.0 to 30 cm for winter wheat (a, c) and spring barley (b, d) for 2020 and for 2021.





Conclusion

- **A reduction of precipitation during the growing season by 360.8 mm and 300.1 mm for winter wheat 2020 and 2021 and a reduction of precipitation by 355.6 mm and 285.5 mm for spring barley 2020 and 2021, led to decrease in grain yields.**
- **Grain yield for winter wheat/spring barley decreased from 7.05 /5.51 t/ha (natural climatic conditions) to 4.98/4.18 t/ha (drought stress was induced using the rain-out shelters) in 2020 and from 9.48(4.74)/5.40(2.46)t/ha to 4.54/3.56 t/ha in 2021.**
- **The simulation grain yield for winter wheat/spring barley decreased from 7.65/5.74 t/ha (natural climatic conditions) to 4.10/3.66 t/ha (drought stress was induced using the rain-out shelters) in 2020 and from 9.35/6.07 t/ha to 5.37/4.07 t/ha in 2021.**
- **The crop growth model DAISY reproduced the drought stress for crop yields of winter wheat and spring barley to a certain extent and relatively satisfactorily simulated the soil water content dynamics.**

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