Is adaptation of crop management practices sufficient for arable crops to cope with climate change?

Magali Willaume, Anthony Vermue, Inès Irrazi, Philippe Debaeke, Jacques-Eric Bergez, Julie Constantin

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Title:

Is adaptation of crop management practices sufficient for arable crops to cope with climate change?

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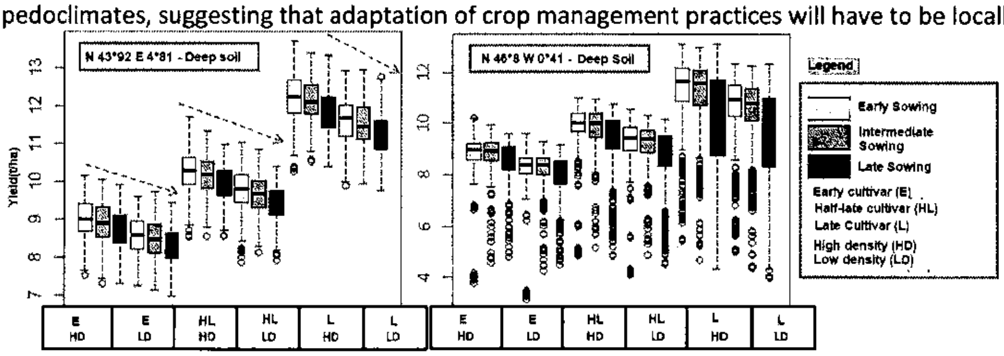
Abstract: (Your abstract must use **Normal style** and must fit in this box. Your abstract should be no longer than 300 words. The box will 'expand' over 2 pages as you add text/diagrams into it.)

Climate-change scenarios predict increased water scarcity for agriculture in irrigated regions. To design and assess arable cropping system adaptations to more frequent droughts, soil-crop models are useful and efficient. Here we explore and assess performances of a large range of interacting crop management practices that are likely to induce changes in crop water use.

The soil crop model STICS (Brisson et al., 2003) was used to simulate the impacts of management practices for 4 crops (maize, spring pea, winter wheat, sunflower) in 10 contrasted French pedoclimatic conditions under climate change. Climate scenarios (2006-2050) are based on the RCP 8.5 (Moss et al., 2010). Two to 3 levels for each tested crop management practice (irrigation calendar and level, sowing date and density, cultivar earliness, N fertilization, management of harvest residues, previous crop) were chosen, and all combinations were simulated using the simulation platform RECORD (Bergez et al., 2013). Interventions dates were annually adapted to fit climatic conditions using decision rules. Output variables range from yield to water fluxes, stress indices and greenhouse gases emissions (GHG).

To this day, only simulation on maize has been analyzed. All tested crop management practices have significant impact on yield. Irrigation management is the strongest driver, explaining between 60 and 86% of variation depending on pedoclimate. Other important drivers are cultivar earliness and sowing conditions in interaction. Water fluxes (drainage, evapotranspiration) and GHG emissions are also driven by residue management. Interventions dates become earlier along the considered period. However, no other significant trend over time was found on STICS outputs for maize. Management effects depend on pedoclimates, suggesting that adaptation of crop management practices will have to be locally specified.



Simulated yields in fully irrigated conditions for 2 pedoclimates according to sowing date, cultivar earliness and sowing density

Acknowledgements to the metaprogramme AAFCC (INRA), Climate-CAFE project and Eric Casellas for simulation support.

References

Bergez et al. (2013). Environmental Modelling and Software, 39: 39-43,
Brisson N., Gary C., Justes E. et al. (2003). European Journal of Agronomy, 18: 309–332.
Moss R.H., Edmonds J.A., Hibbard K.A. et al (2010) Nature 463:747–756.

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Context and objective

- This work is part of the project Climate-CAFE ("**Climate**Change **A**daptability of cropping and **F**arming systems for **E**urope") that aims at assessing the « adaptive capacity » to climate change of European arable cropping and farming systems, through the simulation of innovative strategies co-designed with actors.
- In France, Climate-change scenarios mainly predict increased water scarcity and thermal stress for agriculture.
- To design and assess arable cropping system adaptations to more frequent droughts, soil-crop models are useful and efficient.
- Here we explore and assess performances of a **large range of interacting crop management practices** that are likely to induce changes in crop water use and yields performances.

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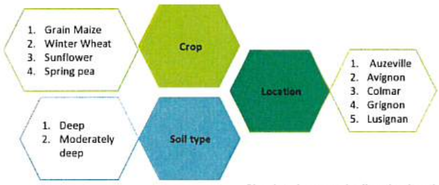
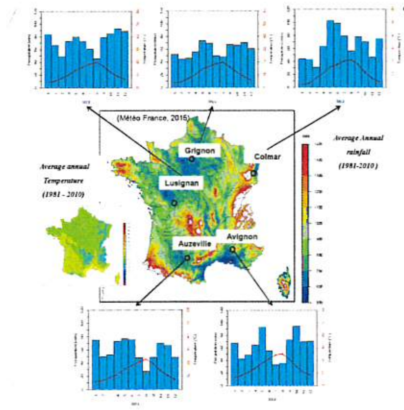
Material and Methods

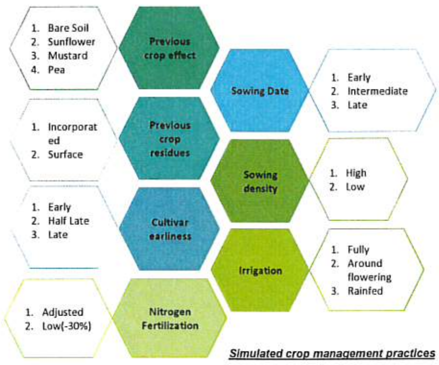
- We used the **soil-crop model STICS** (Brisson et al. 2003) to simulate effects of **Climate scenarios (2006-2050)** based on the RCP 8.5 (Moss et al., 2010).
- STICS simulates crop development and water, C and N fluxes with a daily time step according to soil, climate and crop management.
- Output of interest are **yield, water fluxes, stress indices** and greenhouse gases emissions (**GHG**).



Simulated agropedoclimatic situations



- **Interventions dates** (sowing, fertilization, irrigation start, harvest) **were annually adapted to fit climatic conditions** using decision rules.

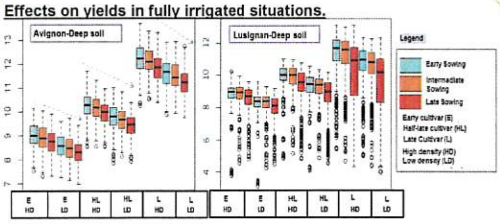


Simulated crop management practices

- All combinations (34560 * 44 years) were simulated using the simulation platform RECORD (Bergez et al., 2013).

Results

Effects on yields in fully irrigated situations.



Simulated yields in fully irrigated conditions for 2 pedoclimates according to sowing date, cultivar earliness and sowing density

→Practices effects **depend on location**

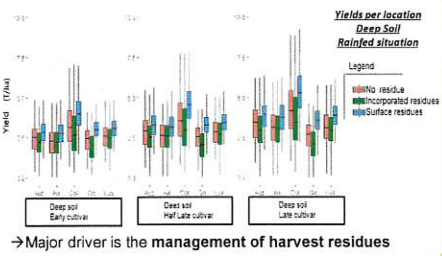
→Major drivers are : **Cultivar earliness >>Sowing conditions** (date, density) >> cultivar*sowing date interaction

→These practices are strongly linked -> **influence phenological stages**

→Tested Nitrogen fertilization range was non discriminant.

- To this day, only simulation on maize has been analyzed.
- All Intervention dates and phenological stages become **earlier** due to climate change.
- **All tested crop management practices have significant impacts on yield and water fluxes** (drainage, evapotranspiration)
- **Irrigation management is the strongest driver**, explaining between 60 and 86% of variation depending on soil –climate situation.

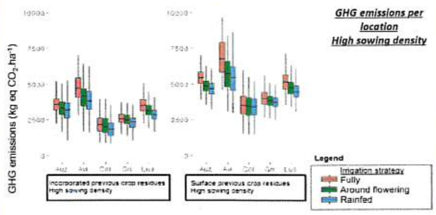
Effects on yields in rainfed situations



→Major driver is the **management of harvest residues**

→**Cultivar ealiness** comes second

Effects on GHG emissions



→ GHG emissions are mainly driven by **irrigation strategy** and **residue management**

Conclusions

- All tested crop management practices have **significant impact** on yields. But annual meteorological conditions remain crucial.
- **Irrigation strategy** influences greatly the effects of other management practices.
- Management effects also strongly depend on soil-climate context, suggesting that **adaptation of crop management practices will have to be locally specified.**

References:

Bergez et al. (2013). Environmental Modelling and Software, 39: 39-43,
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