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Global analysis of variability in thermal stress thresholds for common wheat: potential underestimate of risk due to uncertainty

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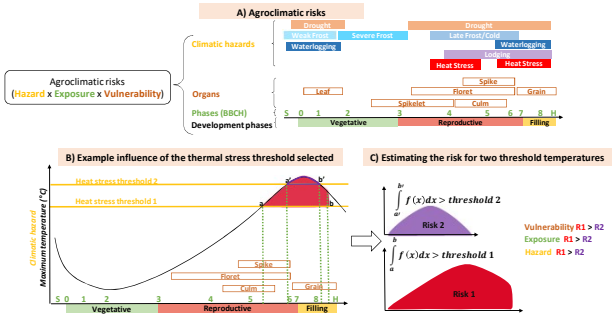
Context

A large number of studies have examined the impact of climate change on wheat production, in particular using an indicator-based approach. This approach requires the establishment of a threshold characteristic of the agro-climatic risk to be represented. The aim of this work is to analyse the variability of the thresholds available in the literature and their inconsistencies, to assess the causes and to determine the impact of this variability on the characterisation of an agroclimatic risk..



Conceptual diagram illustrating the influence of the threshold temperature chosen for estimating the agro-climatic risk for common wheat.

Method

- Global analysis of the literature
- Heat stress thresholds for common wheat.
- Grouping by phenophases, Classification according to 1) Geographical origin, 2) Type of wheat, 3) Type of process targeted.
- Analysis of the impact of classification on changes in the standard deviation of thresholds, a marker of consistency.
- Analysis of the uncertainty of thresholds on the characterisation of agroclimatic risk.

Data

- 134 scientific references
- 1135 stress thresholds
- 6 thermal stress indicators: minimum lethal (LTn), minimum (Tn), optimum (Topt), hot nights (HNT), maximum (Tx) and maximum lethal (LTx).
- phenophases (+ sowing and photosynthesis).
- 3 classes: geographical origin, type of wheat, type of process targeted.

Analysis of the potential causes of variability and inconsistencies in stress thresholds

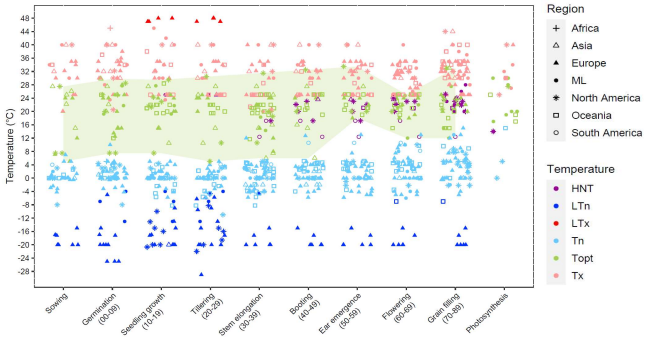


Fig 1: Variability of stress thresholds and thermal optimum during the life cycle of wheat.

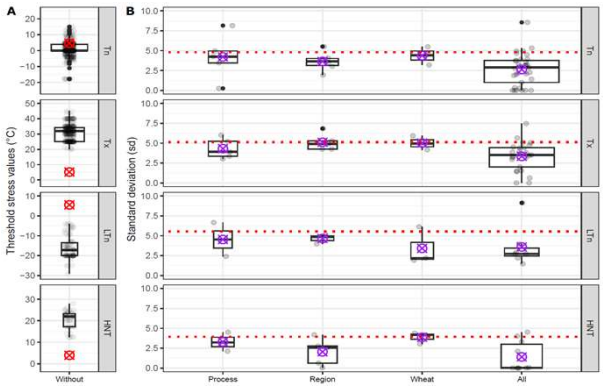


Fig 2: Impact of threshold classification on standard deviation (consistency marker).

What influence on the heat stress risk ?

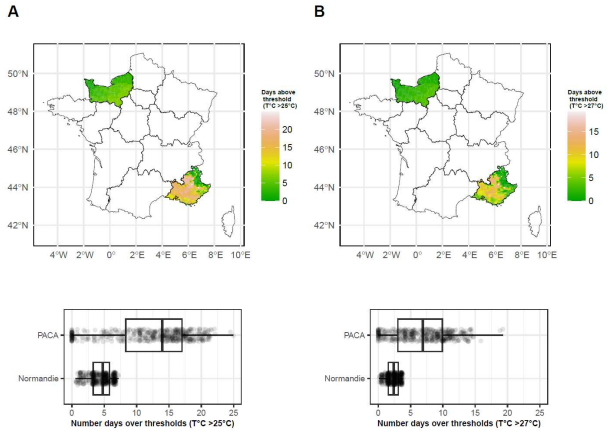


Fig 4: Spatial evolution of the number of days above two different stress thresholds for the same risk of scalding during the wheat filling phase.

Conclusions

- There is considerable variability (several degrees), for the same stress and the same phenological phase, within the thresholds derived from the literature (Figures 1).
- It is important to better select the stress thresholds, so that they are characteristic of our situation and the subject to be analysed. In particular, the geographical area, the type of wheat (winter or spring), and the process targeted have a significant impact on the value of the stress threshold (Fig.2).
- For the same risk, in this case scalding during the grain filling phase in wheat, a difference of two degrees in the choice of threshold (25°C vs 27°C) results in an underestimation of the risk of around 46% (Fig.4).
- The consistency of thresholds is essential, whether in the field of modelling or impact studies, if we are to gain a better understanding of the agroclimatic risks that crops face and will face in the future in the context of climate change and the emergence of new varieties.

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