Modelling Memory: do crop models need to become nostalgic?

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Background

Increased frequency of stress events such as heat waves has been observed for the last decades. Based on the last IPCC report, they are expected to be more frequent, to last longer and to increase in intensity during the reproductive phase of economically important crops. Many recent studies pointed out induced memory effects of stressing events when plants are challenged several times with similar stresses throughout the crop season. These memory effects were shown to be potentially beneficial since the plants are 'primed' and thus more prepared to develop an earlier, more rapid, intense and/or sensitive response when the stress recurs [1]. Therefore, the new climatic patterns prompts to take into account stress memory into predictive crop modelling approaches so as to estimate the effects of repeated stresses and their consequences on crop yield, quality of harvested products. During the last decades**,** the use of crop models have been enlarged to climate change driven predictions [2]. While evidence for improving crop climate models and especially the temperature response functions in order to reduce uncertainty in yield simulations before any decision making in agriculture, no modelling studies have attempted to decipher and interpret simulation bias in the light of stress memory nor they focused on methodologies to take into account stress memory effects.

Aims

The objectives of the work is to (i) identify thermo-priming patterns that can explain alleviated crop responses to extreme stress events and (ii) better predict crop performances i.e. yield and grain/fruit quality criteria in this climatic context characterized by higher frequency of heat waves. We make the assumption that the effects of several successive stress events do not equal the sum of the effects of each events thus leading to unexpected crop responses to repeated stresses.

Materials and Methods

In this study we will use the ecophysiological model SuMoToRI to develop distinct approaches to take into account the memory effects of heat stress. This model was implemented in oilseed rape and used under a range of climatic scenario and management practices [3]. Although deleterious effects of high temperature on growth, yield and grain quality were observed [4], evidence for beneficial effects of repeated stresses throughout the spring period on protein content, acquisition tolerance to desiccation and seedling vigour were also observed (unpublished results).

Therefore, based on these prior experiments and newly acquired datasets, we will develop two distinct modelling approaches to identify and formalize thermo-priming patterns actions on crop performances: (i) a **mechanistic approach** aiming to define physiological responses rules to temperature sequences and (ii) a **statistical approach** based on Knowledge Discovery in Databases (KDD) which is the process of discovering knowledge from implicit information provided by datasets. In this method, prior hypotheses are excluded so as to explore without a priori assumptions. This data mining technique can be performed by either models emergence (e.g. classifiers, multiple linear models, neural network) or patterns extraction which describe relationships between the given variables [5].

Conclusion

This study aims at demonstrating the need to model the effects of stress memory especially with the new features of climate change so as to better predict crop performances. It will act as a proof of concept that crop models can be modified with efficient approaches whether they are mechanistic or statistics-oriented. The analysis of the memory of high temperature stresses could be extended to other stresses which are expected to be more frequent by the end of the century.

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