# To what extent can ecoclimatic indicators assist crop performance predictions in oilseed rape upon repeated heat waves?

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Modelling is an obligate approach to predict crop yield under a wide range of environmental conditions. Simulations under different climatic scenarios can provide useful information to adapt management practices (i.e. earlier sowings, new cultivars, innovative fertilization strategies) in order to maintain, or even improve, crop performances under changing environments. Based on the last Intergovernmental Panel on Climate Change (IPCC) report, heat waves are expected to become more frequent, to last longer and to increase in intensity during the plant's reproductive phase, thus impacting the yield and quality of economically important crops such as oilseed rape (Magno et al., 2021). In our work, we aim to improve crop predictions by considering the effects of repeated heat waves into ecoclimatic indicators that can be used in statistical models. Our underlying hypothesis was that the plant's response to a stressing event might be modified if the plants were previously exposed to similar stresses.
Based on large datasets in oilseed rape (Corlouer et al., 2019), we developed statistical models to look for correlations between ecoclimatic indicators and the plant final performance variables (i.e. yield, oil and protein content). For this purpose, (i) we divided the plant cycle into four intervals after flowering, according to the physiological stages of development in oilseed rape; (ii) we scored the number of warm days (i.e. above 25°C and 30°C) in each interval for 26 combinations of location x year in France; (iii) we proposed several models that differed from the combination of ecoclimatic indicators; and eventually (iv) we selected the best fit predictive models of the final performance-related variables by using an automatic stepwise approach using the stepAIC function, as performed in Akmouche et al. (2019).
With this approach, we first observed that contrasting final performances were tightly related to the timing, frequency and intensity of high temperature events after flowering. In addition, specific combinations of these ecoclimatic indicators seems to be much more predictive of the final crop performances than a single cumulative indicator which reflects the sum of all stresses in the same period. These results support our prior assumption that the outcome of several successive stressful events is not equal to the sum of each individual effect. Our approach is a proof of concept of the need to consider stress memory (i.e. the capacity of plants to store and process information acquired during an initial exposure to stress) in predictive crop modelling approaches, so as to better estimate the effects of repeated stresses and their consequences on crop yield and quality of harvested products.

**Key words:** oilseed rape, heat stress, stress memory, crop modelling

Akmouche, Y., Cheneby, J., Lamboeuf, M., Elie, N., Laperche, A., Bertheloot, J., D'Hooghe, P., Trouverie, J., Avice, J.-C., Etienne, P., Brunel-Muguet, S., 2019. Do nitrogen- and sulphur-remobilization-related parameters measured at the onset of the reproductive stage provide early indicators to adjust N and S fertilization in oilseed rape (*Brassica napus* L.) grown under N- and/or S-limiting supplies? Planta 250, 2047–2062. https://doi.org/10.1007/s00425-019-03284-2

Corlouer, E., Gauffreteau, A., Bouchet, A.S., Bissuel-Bélaygue, C., Nesi, N., Laperche, A., 2019. Envirotypes based on seed yield limiting factors allow to tackle G × e interactions. Agronomy 9, 1–18. https://doi.org/10.3390/agronomy9120798

Magno Massuia de Almeida, L., Avice, J.C., Morvan-Bertrand, A., Wagner, M.H., González-Centeno, M.R., Teissedre, P.L., Bessoule, J.J., Le Guédard, M., Kim, T.H., Mollier, A., Brunel-Muguet, S., 2021. High temperature patterns at the onset of seed maturation determine seed yield and quality in oilseed rape (*Brassica napus* L.) in relation to sulphur nutrition. Environ. Exp. Bot. 185. https://doi.org/10.1016/j.envexpbot.2021.104400