

## **Simulating frost impact on crop production**

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A single event of frost may reduce crop yield and quality when minimum temperature is lower than critical damage temperature(s) of the relevant plant organ(s). Critical damage temperature of a tissue, with a percentage attached, is a parameter that represents the tissue temperature that inflicts a given percentage of damage to the tissue, when there is enough time for the freezing process to take place. However, critical damage temperatures are not fully representative of field conditions with air temperature measured in an appropriate shelter.

In this study, a detailed literature review of the critical temperatures for frost damage was done. Critical temperatures were subdivided into two types: i) LT1(0.0-1.0) – Critical damage temperature below which a fraction of the vegetative organs is lost to frost. For example, the fraction, may affect the state variable LAI; and ii) LT2(0.0-1.0) – Critical damage temperature below which a fraction of the reproductive organ or reproductive structure is lost to frost. For example, the fraction, may affect the state variable number of fruits, DM of fruits, or HI. The critical temperatures of a total of 25 crops and hundreds of cultivars were classified in relation to plant age/stage, acclimation status, dry/wet surface condition, and saved in a database. Therefore, all critical temperatures of crops relevant to Modextreme are now compiled.

Two response functions for frost damage, F1 and F2, are computed daily using LT1 and LT2 as parameters, respectively. The values of these parameters are selected in relation to phenological stage and whether the plants are acclimated or not. These response functions are aggregated and yield is ultimately simulated.

The detailed simulation approach is formalized and validation case-study is presented. Using a data set of apple flowers subjected to frost events, the simulation results are compared with actual data. The performance of the model was high what indicates that the approach may improve predictions of crop yield in areas subjected to frost damage.