Modelling the impact of extreme events on phenology and fruit set in grapes

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In the last few years, the impact of climate change played an important role on the traditional wine-making regions resulting in shifts of phenology, yield and grape quality. In particular, grape growing distribution is expected to move towards new wine-making regions with climatic conditions more suitable for grape cultivation. More specifically, the increase in global average temperature is expected to have a great impact on the duration of the grape growth cycle. Moreover, the effect of heat stress during flowering showed a decrease in terms of grape yield.

For addressing the non-linearity of the interaction between mean climate and extreme events, the use of crop simulation models may play a fundamental role. On these premises, grape simulation model proposed by Bindi et al. (1997) has been implemented for a better estimation of grape yield. In particular, the four main processes simulated by Bindi et al. (1997) (i.e. phenology, leaf development, biomass accumulation and fruit growth) were improved through the introduction of chilling unit requirement and the effect of heat stress during bloom.

According to Bidabe (1965), the chilling requirement was used for a better estimation of bud-break date using an arithmetic progression of 10°C starting from a fixed days of the year until the dormancy break.

The effect of heat stress during bloom was accounted using data from literature describing the relationship between fruit set (%) and different temperature treatments (°C).

In this context, chilling unit requirement was calibrated and validated on ten grape varieties using data from the northern part of Italy. The calibration and validation showed a better accuracy for the model with chilling unit ($r=0.62$; RMSE=7.28; MSE=53) respect to the original one ($r=0.48$; RMSE=8.34; MSE=69.56).

Additionally, the formula of the temperature factor described by Farquhar et al. (1980) was used for defining the relationship between temperature and fruit set during bloom. Accordingly, three different temperature thresholds and the parameter (q) of the formula were calibrated showing the simulate trend statistically significant ($r = 0.69$; $p<0.05$).