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Introduction

Agricultural production is substantially affected by variability in weather conditions and recently by climate change. For this reason, it is essential to understand how much meteorology and climate can influence crop productivity and quality. In the frame of a multiannual project, a numerical crop growth model, named VICMOTO, has been specifically developed in order to evaluate the effects of micrometeorological conditions on vine growth and grape quality. The numerical model simulates physiological and phenological vineyard conditions, allowing the knowledge of plant processes at the microscale and their responses to environmental forcing. The target of the project is the development of an advanced tool able to monitoring in real time the physiological and phenological vine processes, and to support the activity of decision-making, allowing a sustainable vineyard management. A specific advanced experimental campaign has been performed within a vineyard located in Langhe area (Piedmont, Italy), during the 2016 and 2017 vegetative seasons, by directly measuring phenological phases and some physiological variables, with the specific aim to calibrate and validate the numerical model. Here, the model will be described and the main results are presented.

Materials and methods

The measurements in vineyards were carried out during 2016 and 2017 on the Nebbiolo cultivar. The vineyard is located in Cerretta locality (Serralunga d'Alba, Piedmont region, 44°37.466'N 7°59.994'E, 322 m a.s.l.), owned by the 'Azienda Agricola Ettore Germano'. The instruments were installed in the three experimental plots identified with letters: A, B and C. Here we will comment the results referred to plot B.

A main station and a secondary wi-fi node (Pessel Instruments, Metos® Weather Station & Datalogger) were placed in the central plot (B) to measure solar radiation, wind direction and speed, precipitation, leaf wetness, air temperature and humidity, PAR, soil temperature and water potential at 20 and 50 cm of depth.

Other meteorological sensors were placed in each plot to measure air temperature and humidity (TinytagPlus2 TGP-4500, Gemini Data Loggers), and PAR (HOBO MicroStation H21-002 and S-LIA-M003, Onset Computer Corporation Ltd) into the bunches zone of the canopy, and soil temperature and water content (EM50 and 5TM, Decagon) at 20, 50 and 80 cm depths.

The crop growth model VICMOTO

(VIneyard Crop MOdel TOrino)

INPUT DATA (meteorological)
- Air temperature
- Air relative humidity
- Solar global radiation
- Photosynthetically active radiation
- Soil temperature
- Soil water potential
- Wind speed and direction
- Atmospheric pressure

INPUT DATA (others)
- Vineyards and soil characteristics
- Geography (latitude, longitude, slope, height)
- Soil hydrological parameters
- Plant density (plants/ha)
- Variety characteristics (clusters/plants, berries/cluster, °Brix maximum value, thermal thresholds)
- Vineyard management (Julian day and severity of trimming, Julian day and severity of cluster thinning)

VICMOTO

VICMOTO model is optimized for Nebbiolo variety. It is written in Fortran language

Physiological and phenological output
- Predawn leaf water potential
- Timing of the main phenological phases (dormancy break, budburst, flowering, fruit-set, beginning of ripening, veraison, harvest)
- Leaf development
- Yield
- Sugar concentration

Conclusions

The model VICMOTO shows good performances in simulating the phenological phases, the sugar accumulation, and the production per plant, while simulation of vine leaf area is less accurate. The two vegetative seasons of intercomparison were meteorologically different. VICMOTO also showed some variations, with the worse results in 2016. The algorithms related to vegetative development need to be improved. Besides, the calibration and validation of VICMOTO requires further measurements on different sites and years.

References

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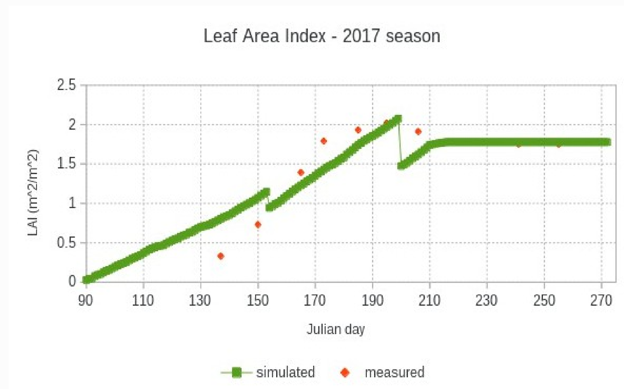
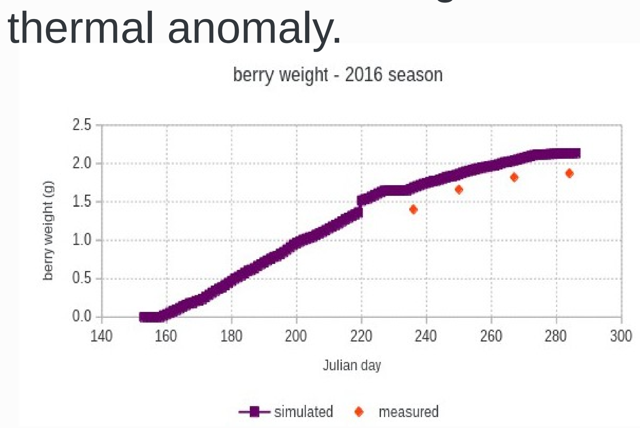
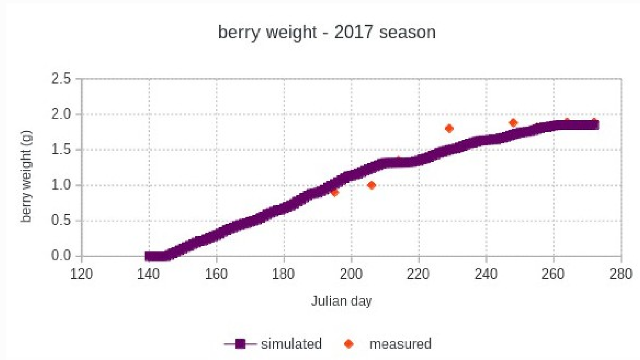
Results and discussion

A comparison between the data simulated by the model and the data collected during the field surveys has been performed in order to evaluate the model accuracy (experimental plot B).

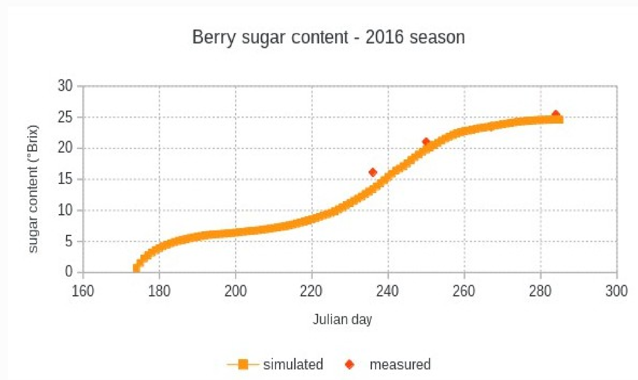


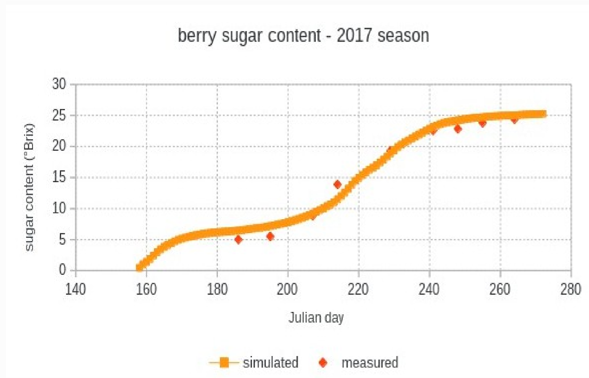
The simulated values of LAI were similar to the field observations in 2016 (except for the point at julian day 182), whereas in 2017 they were overestimated above all during the earlier period of the season, and underestimated since June. In 2017, from 18 April until 7 May (julian days: 108-127), a series of low values of the minimum temperatures was registered; this likely induced a thermal stress in the vines, that slowed down their vegetative growth. The model has not been able to diagnose the strong answer of the vines to this thermal anomaly.





The model was able to simulate the anticipation of the season 2017 with respect to 2016 by simulating the earlier berry development. The simulated values were quite similar to the measured ones in both years, even if in 2016 the values were a bit overestimated.





The values of sugar content simulated by VICMOTO resulted close to the observed ones in both years. The trend of sugar content in the berry was well reproduced in both years.

Phenological phase	year	Simulated (Julian day)	Measured (Julian day)	Measured stage
Bud-break BBCH7	2016	90	106	BBCH 15
	2017	82	80	BBCH 07
Flowering BBCH65	2016	159	159	BBCH 71
	2017	146	144	BBCH 65
Frut-set BBCH71	2016	164	159	BBCH 71
	2017	150	149	BBCH 69-71
Veraison BBCH84 °Brix ≥ 12	2016	234	224	BBCH 83
	2017	216	214	BBCH 85
Harvest °Brix ≥ 25	2016	300	284	25.7 °Brix
	2017	263	263	24.4 °Brix

Simulated and observed phenological phases were compared based on their respective occurrence (Julian days) in term of the achievement of an established BBCH stage

VICMOTO was able to well simulate the delay of 2016 season with respect to the 2017 one.

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