SIMULATIONS ON DIFFERENT GRAPEVINE CULTIVARS WITH THE IVINE CROP GROWTH MODEL

SIMULAZIONI SU DIVERSE VARIETA' DI UVA CON IL MODELLO DI CRESCITA IVINE

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Abstract
The crop growth model IVINE (Italian Vineyard Integrated Numerical model for Estimating physiological values) was developed to simulate grapevine phenological and physiological processes and it was originally optimized only for cv. Nebbiolo. The IVINE model requires a set of meteorological data as boundary conditions, moreover informations about the vineyard and the cultivar are also required as input data. The main model outputs are: the timing of phenological stages, the leaf development, the yield, the berry sugar concentration and the predawn leaf water potential.
Recently IVINE model has been calibrated and validated also on different grapevine varieties (cv. Barbera, cv. Merlot). We will present here the results of these preliminary simulations of grapevine growth processes executed using datasets assembled in the frame of MACSUR2 project.

Parole chiave
modello di crescita, vite, taratura
Keywords
crop model, grapevine, calibration

Introduction

Meteorology, climate, soil fertility and management practices are factors that influence the quality and productivity of grapevine, strongly dependent on environmental conditions.
For this reason oenology and viticulture have been object of many studies aimed to know the effects of different environmental conditions on yield and quality.
In this context, crop models are essential tools for investigating the effects of climate change on crop development and growth by means of the integration of existing knowledge of crop physiology relating to different environmental conditions.
Crop growth models are able to evaluate interactions between plant, environment and management strategies and provide an instrument to understand the complex plant processes as influenced by pedo-climatic and management conditions (Brisson et al., 1998, Brisson et al., 2003, Costa et al., 2015). Weather conditions are the input data that drive the crop models and they have a great effect on yield and other model outputs.
A crop growth model named IVINE (Italian Vineyards Integrated Numerical model for Estimating physiological values), has been developed since 2016 to simulate physiological and phenological vine conditions of Nebbiolo cv, since in Piedmont the most famous wines are derived by this kind of grape (Andreoli et al., 2019). Recently the IVINE model has been also calibrated on different grapevine varieties as Barbera cv. and Merlot cv. The paper is focused on the results of these preliminary simulations.

Materials and Methods

The IVINE model is a crop model developed to study the vine growth processes under different environmental conditions.
The model need as boundary conditions a set of weather data: air temperature, air relative humidity, solar global radiation, photosinthetically active radiation, soil temperature, soil water content, wind speed and direction, rainfall and leaf wetness.
Other data about vineyards and soil characteristics are required in input: geographic coordinates, soil hydrology, variety characteristics and vineyard management informations.
IVINE operates on a daily time step and simulates the evolution of variables of agronomic interest through daily accumulation.
The main model outputs are: the timing of the main phenological phases, the leaf development, the yield and the sugar concentration, and the predawn leaf water potential.

The input datasets used for simulations on Barbera and Merlot have been assembled in the frame of the MACSUR project (phase 2) (Brouwer and Köchy, 2017). Meteorological data for Barbera cv. have been taken in two vineyards located in Cocconato (45° 05' 20" N, 8° 02' 26" E, 311 m a.s.l.) and Fubine sites (44° 57' 49" N, 8° 25' 52" E, 210 m a.s.l.), in Piedmont region, from 2008 to 2010 season. Instead those for Merlot cv. the data have been taken in a vineyard located in Couhins (44.75° N, 0.56° W, 23 m a.s.l.) in France, for 2004 and 2005 seasons. The type of soil is silty clay loam in Cocconato, clay loam in Fubine and loam in Couhins.
The meteorological databases assembled in the vineyards stations have been used as input data for the run of the land surface model UTOPIA (University of TOrino model of land Process Interaction with Atmosphere) (Cassardo, 2015). IVINE input data of soil temperature and soil water content were taken from the output of UTOPIA model while others input data were directly taken from the meteorological datasets.
An intercomparison between simulated data and in-field measured data, phenological phase and some physiological variables, has been done, with the specific aim of calibrate and validate the model on Barbera and Merlot varieties.

Results and Discussion

This section contains some preliminary results of the simulations performed on Barbera cv. since 2008 to 2010 season , in Cocconato and Fubine sites, and Merlot cv. in 2004 and 2005 seasons, in Couhins site. Moreover the results of the intercomparison between simulated and measured data are presented.
The main output variables analyzed are the phenological phases and the berry sugar concentration.

Tab. 1 – Intercomparison of simulated and measured BBCH stages in Cocconato site.
Tab. 1 – Confronto fra stadi BBCH simulati e misurati a Cocconato.

Phenological Stage	Year	Simulated Julian day	Simulated BBCH	Measured Julian day	Measured BBCH
Bud-break	2008	92	7	122	15
	2009	98		92	7
	2010	110		138	15
Flowering	2008	162	65	150	61
	2009	149		145	63
	2010	159		154	60
Fruit-set	2008	167	71	202	77
	2009	154		191	75
	2010	163		176	75
Beginning of ripening	2008	230	81	223	79
	2009	217		202	77
	2010	225		209	79
Veraison	2008	236	83	244	83
	2009	222			
	2010	232			

The phenological phases have been simulated in all three sites; the simulations return the dates in which a specific BBCH stage occurred (Tabs. 1,2,3); instead observations performed in the experimental sites report the BBCH stage achieved at the date of the survey. Sometimes the achieved stage was not in the list of those calculated by the model, making difficult a direct comparison.
Regarding the stage of harvest, the IVINE model simulates it when a specific concentration of berry sugar has been reached; the values are 26 °Bx for Barbera and 24 °Bx for Merlot (Cressano et al., 2008).
In Cocconato site is evident an anticipation of the Julian day of simulated fruit-set stage particularly during the 2008 and 2009 vegetative seasons, and of veraison stage during the 2008 season (Tab. 1).

Tab. 2 – Intercomparison of simulated and measured BBCH stages in Fubine site.
Tab. 2 – Confronto fra stadi BBCH simulati e misurati a Fubine.

Phenological Stage	Year	Simulated Julian day	Simulated BBCH	Measured Julian day	Measured BBCH
Bud-break	2008	91	7	120	16
	2009	97		105	12 – 13
	2010	109			
Flowering	2008	160	65	142	57
	2009	147		138	113 – 55
	2010	157			
Fruit-set	2008	165	71	171	71-73
	2009	152		159	73-75
	2010	161			
Beginning of ripening	2008	227	81	214	79
	2009	214		208	81
	2010	221			
Veraison	2008	233	83		
	2009	219		225	83
	2010	227			

Tab. 3 – Intercomparison of simulated and measured BBCH stages in Couhins site.
Tab. 3 – Confronto fra stadi BBCH simulati e misurati a Couhins.

Phenological Stage	Year	Simulated Julian day	Simulated BBCH	Measured Julian day	Measured BBCH
Bud-break	2004	108	7	114	7
	2005	104		108	7
Flowering	2004	160	65	157	65
	2005	153		152	65
Fruit-set	2004	163	71		
	2005	158			
Beginning of ripening	2004	230	81		
	2005	219			
Veraison	2004	233	83		83
	2005	222		220	83

Also in Fubine site there is a slight anticipation of Julian day of simulated stages of fruit-set (2008 season) and veraison (2009 season), and a delay of beginning of ripening simulated stage during 2008 and 2009 seasons (Tab. 2).
Regarding the simulations of phenological stages in Couhins site, a slight anticipation of bud-break simulated stage can be observed during the two analyzed seasons (Tab. 3); while for the other analyzed BBCH stages measured and simulated Julian days are quite close.
Regarding the berry sugar concentration, the trend simulated by the model is well reproduced during the whole season and in all three sites (Figs. 1,2,3).

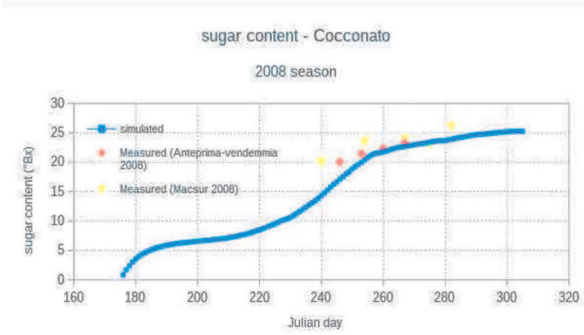

Fig. 1- Comparison between simulated and measured berry sugar content at Cocconato site, during the 2008 vegetative season for Barbera cv.
Fig. 1 – Confronto fra valori di concentrazione di zucchero degli acini simulati e misurati a Cocconato, nella stagione vegetativa 2008 per la varietà Barbera.

Fig. 1 shows the simulated values of berry sugar concentration in Cocconato site, compared with values measured during the MACSUR experimental campaign and with values measured in some reference vineyards in Piedmont region (Cressano 2008). The simulated berry sugar content resulted close to the in-field measured values in the final part of the season while in the central part it was underestimated.

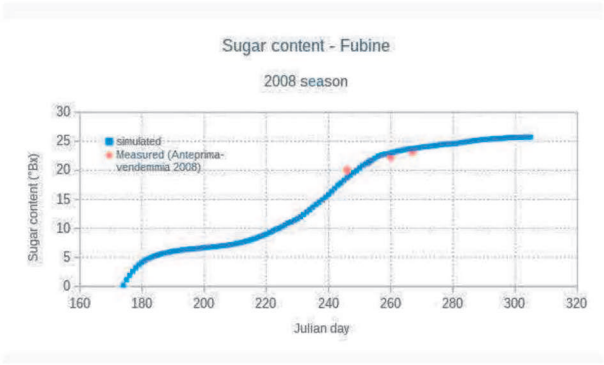

Fig. 2- Comparison between simulated and measured berry sugar content at Fubine site, during the 2008 vegetative season for Barbera cv.
Fig. 2 – Confronto fra valori di concentrazione di zucchero degli acini simulati e misurati a Fubine, nella stagione vegetativa 2008 per la varietà Barbera.

In Fubine site the comparison has been done between simulated values and measurements performed in the references vineyards in Piedmont region (Fig. 2) (Cressano 2008). Simulated and measured values resulted to be close and the trend was well reproduced.
In Fig. 3 are shown the results of the simulation of berry sugar content in Couhins site (France), where the two considered vegetative seasons have been compared. The graph clearly shows that the IVINE model was able to simulate the different evolution of sugar accumulation, depending on season meteorological conditions.

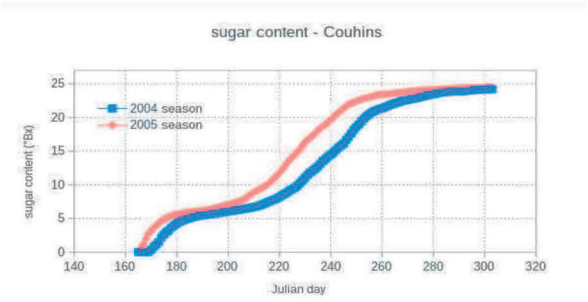

Fig. 3- Comparison between simulated berry sugar content during 2004 and 2005 vegetative seasons at Couhins site for Merlot cv.
Fig. 3 – Confronto fra i valori di concentrazione di zucchero dell'acino simulati durante le stagioni vegetative 2004 e 2005 a Couhins per la varietà Merlot.

Similar analyses carried out on other model outputs, as yield and leaf area index, are not shown in the present paper.

Conclusions

The crop growth model IVINE, originally developed for Nebbiolo variety, has been calibrated for Barbera cv and Merlot cv.

The results of some of the preliminary simulations and of some intercomparison between simulated and measured data have been here presented.

The IVINE model seemed able to represent the evolution of growth processes in these two varieties. Eventual other available measured data collected in different vegetative season or in different sites could improve the calibration of the model and allow an higher accuracy on model outputs.

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