PHENOLOGICAL MONITORING AND MODELLING IN LIGURIA IN THE CONTEXT OF PROTERINA C PROJECT

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Summary
The phenological behavior of crops and natural vegetation is a key element for those who are called to manage a territory making rational decisions regarding environmental protection, agriculture, public health, etc.).
More specifically, phenological models are useful to drive the technical choices of farmers and thus are relevant tools for agro-meteorologists and technical assistants. This work describes the activities performed by the agrometeorological center of the Liguria Region (CAAR) in the context of the research project PROTERINA C.

Keywords: Normal Heat Hours, Phenological models, Iphen, Viburnum tinus.

Introduction

Brainchild of Reaumur in 1740, thermal based mathematical models are useful tools for evaluating the phenological behavior of plants. The basic element of this approach is the idea that the phenological rhythms (time of appearance of phases, such as budding, flowering and ripening) are governed by a PHysiological Clock (PHC) based on mechanisms ruled by hormones and driven by a lot of environmental variables (solar radiation, temperature, soil water and nutrient level and so on). At present the PHC is impossible to modelize in a mechanistic way and consequently a thermal clock is usually adopted as substitute.
The phenological monitoring activities carried out in Liguria under the project PROTERINA C were specifically referred to the following species (with the observational data set alongside each one):
Fruit trees:
– Olea europea L. (Olive) - 1999-2010;
– Vitis vinifera L. (Grapevine) - 1999-2010.
Ornamental shrubs:
– Genista monosperma L. - 2010-2011;
– Viburnum tinus macrophilla - 2010-2011.
Pest:
– Bactrocera oleae Gmelin, 1790 (Olive fruit fly) - 2006-2010.
The choice of those species has been justified by their economical relevance for the Liguria region and by their behavior strongly affected by climatic variability.
Phenological observations have been sided by measurements of physical variables collected by a network of six stations devoted to monitoring activities for ornamental shrubs in the context of PROTERINA C and supplemented with data from the operational meteorological network of the Liguria region.
The phenological models are based on a response curve that weighs the phenological effect of hours spent at a given temperature (Normal Heat Hours approach).
The models have been calibrated and validated to produce useful tools to support the operational activities of the agrometeorological service.
This paper describes the meteorological and phenological monitoring activities carried out on viburnum (Viburnum tinus L. ssp macrophilla), a plant mainly devoted to the production of cut shoots with flowers and fruits.

Material e Methods

Phenological observations on viburnum have been carried out on sites of the Imperia an Savona provinces listed in table 1.
Phenological observations by dr. Di Battista and dr. Aicardi have been carried out on the period from October 2010 to December 2011. Measurements were recorded on phenological sheets following the BBCH standard.
In July 2011 we have introduced a new encoding of the vegetative stages of Viburnum, in order to introduce a 3-digit encoding useful to better describe the foliation rhythm (Meier, 2001). The trans-coding between the codes in use until June 2011 and the following ones has been applied to the data in order to align them in view of mathematical modeling. To obtain representative meteorological data Davis electronic weather stations have been installed in phenological observation fields.
The reference phenological models for vegetative and reproductive phases have been produced by applying the techni-

Tab.1 - Monitoring sites.

site	cron	height	ctivation	compiled cards
San Remo	SIRF	115	Sept 2010	25
Latte	VLAT	108	Sept 2010	24
Costino	CSTO	231	Sept 2010	66
Gaiado	GIDO	393	Sept 2010	65
Riangrosso	RIAG	236	Sept 2010	67

Tab.2 - Models obtained on data gathered at San Remo (SIRF).

BBCH phases	Indep. Var.	Dep. Var.	Model	R2
vegetatives	NHH	BBCH	**BBCH = $3.280490299 \cdot 10^{-10}$ NHH^3 - $2.519700637 \cdot 10^{-6}$ NHH^2 + $7.018618406 \cdot 10^{-3}$ NHH + 102.0584795**	0.95
reproductives	NHH	fase BBCH	**BBCH = $-4.392336782 \cdot 10^{-9}$ NHH^3 + $6.244734493 \cdot 10^{-5}$ NHH^2 - $2.846579351 \cdot 10^{-1}$ NHH + 479.4914504**	0.98

Tab.3 - Validation of the vegetative model.

Data		average MAE	R2
origin	Period		
VLAT	04-11-2010 - 30-11-2011	8.3	087
RIAG	12-05-2011 - 15-12-2011	2.9	0.98
GIDO	12-05-2011 - 15-12-2011	3.2	0.96
CSTO	19-05-2011 - 15-12-2011	2.5	0.94

Tab.4 - Validation of the reproductive model.

Dati		average MAE	R2
origin	Period		
VLAT	04-11-2010 - 30-11-2011	2.6	0.62
RIAG	22-09-2010 - 15-12-2011	4.5	0.69
GIDO	22-09-2010 - 15-12-2011	6.00	0.42
CSTO	22-09-2010 - 15-12-2011	4.41	0.76

que of the Normal Heat Hours, NHH, according to which the test species cumulates n NHH, with n in the range 0 and 1 (extremes included) for each hour spent at a given temperature (Failla *et al.*, 2008).
The NHH cumulated for the period of operation of the network of automatic stations of PROTERINA C (July 2010-February 2012) have been calculated working on the half-hourly data produced by the reference meteorological stations. For the period before July 2010 or in case of missing data (whose presence was quite reduced) the data have been rebuilt from the data of the automatic network of Liguria region, applying an Inverse Distance Weighted Average IDWA method with weight inversely proportional to the square of the distance, applied on data previously homogenized for the height (Shepard, 1968). The IDWA method has been adopted to rebuilt maximum and minimum daily temperature whose were used to produce hourly temperatures by means of the algorithm of Parton e Logan (1988).
NHH calculus was carried out adopting a response curve given by a beta function (Wang e Engel, 1998) parameterized with 6, 25 and 35°C respectively as minimum, optimal and maximum cardinal temperatures (Failla *et al.*, 2008).
Viburnum is a perennial shrub and its annual cycle started conventionally April the 1th. Since this date and until the 30 march of the next year the development of new shoots, new inflorescences and fruits has been modeled taking into account the following rules:
1. thermal resources useful for the current year are calculated since January the 1th of the year itself because plant organs are exposed to the external environment even before the start of the annual cycle
2. measurements that exceed the limit of the reference year but belongs to it (e.g. observations of april 2011 related to sprouts of 2010) have been attributed to the reference year (e.g. 2010).
In general, phenological observations have provided two incomplete yearly cycles (October 2010 - March 2011 and April 2011 - December 2011).

Results and discussion

Phenological models for Viburnum calibrated on data collected at San Remo – Istituto Regionale per la Floricoltura (SIRF) are reported in Table 2 where 3th degree polynomials have been adopted to correlate NHH to BBCH. Results of validation carried out on data collected at other sites are shown in Tables 3 and 4.
It should be noted that models for Viburnum vegetative and reproductive phenological behavior, even if built on a very reduced time period, show an interesting descriptive power that bodes well on the predictive skills of NHH-based models, once a dataset with a sufficient number of years (at least 4-5) will be gathered.

Referencs

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