EFFECTS OF TEMPERATURE AND SOLAR RADIATION ON GIANT REED (ARUNDO DONAX L.) DEVELOPMENT AND GROWTH
EFFETTI DELLA TEMPERATURA E DELLA RADIAZIONE SOLARE SULLO SVILUPPO E SULLA CRESCITA DELL'ARUNDO (ARUNDO DONAX L.)

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Abstract
Giant reed is one of the most promising energy lignocellulosic crops; nevertheless, giant reed needs further studies. In this work, by means of the ARMIDA model, the effects of temperature and solar radiation on giant reed development and growth are described. Our study shows that the temperature is the main variable that drives the crop early growth while it does not have strong impacts afterwards. Radiation Use Efficiency (RUE) has a discontinuous trend along the vegetative season: it is very high during the first phase and it drops from beginning of August on. Thus an earlier early growth lets giant reed to intercept more light in the high RUE period: this gives rise to higher yields.

Keywords: RUE, growth model, perennial biomass, energy crop.
Parole chiave: RUE, modello di crescita, biomasse perenni, coltura da energia.

Introduction
The necessity to decrease the dependence on fossil fuels is stated in the climate-energy packet 20-20-20 approved by EU. Herbaceous perennial crops such as giant reed (*Arundo donax* L.) is a promising crop from an economic and environmental point of view for the high yields and the low agronomic inputs. In this work, results of giant reed simulation by means of ARMIDA (ARundo and MIscanthus Development and Assimilation) model and comparisons between the three years 2009-2010-2011 data are shown.
Calibration and validation for giant reed are carried out, comparing simulation results to observed data collected in the experimental farm of CRA-CIN in Anzola dell'Emilia (Bologna).

Materials and Methods
ARMIDA (Volta *et al.*, 2012) model simulates the growth of perennial lignocellulosic crops and computes the potential yields. It is based on RUE, computed as the first derivative of the function that connects PAR (Photosynthetically Active Radiation) and the aboveground dry matter of the crop; for giant reed the experimental value is assumed 5.74 g MJ^{-1} (Ceotto *et al.*, 2013 *submitted*). Crop growth and phenological development in ARMIDA depends on degree days summation, where the base temperature is equal to 12.7°C, according to Graziani and Steinmaus, 2009.
Experimental data used for the simulations are collected for three years (2009-2010-2011) in Anzola dell'Emilia (Bologna). Meteorological data (air temperature and global radiation from which PAR is calculated) are collected from a station close to the experimental field.

Results and Discussion
In Tab. 1, we compared the observed and simulated days of emergence. The model matches very well to the observed data: the discrepancies go from 1 day to 8 days of difference.

Tab. 1 - Observed and simulated days of emergence.
Tab. 1 - Giorni di emergenza osservati e simulati.

Year	Observed	Simulated
2009	05/05	06/05
2010	10/05	02/05
2011	20/04	19/04

Remarkably, in 2011 giant reed emerged two weeks in advance with respect to the other years.
In Fig. 1, we plot aboveground dry matter during the three years of experiment; the first year (2009) is correctly simulated, 2010 presents two of the three summer data significantly lower than in simulation. Remarkably these discrepancies are due to the extreme heterogeneity of giant reed. In 2011, simulated data are coherent with observed data, excepted for the last sampling. Yields of 2011 are the highest (simulated: 56.2 Mg ha^{-1}, observed: 61.2 Mg ha^{-1}); yields of

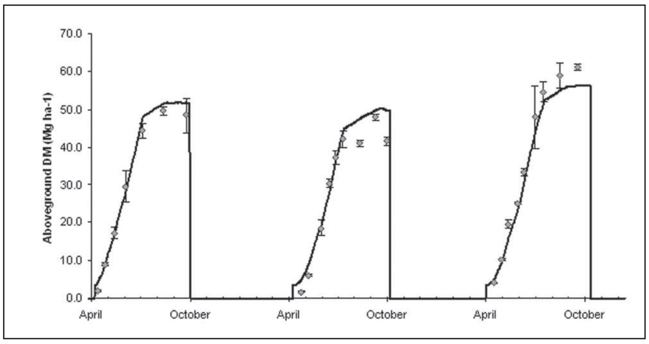

Fig. 1 - Aboveground dry matter during the three years experiments; observed data are compared with simulation outputs (solid line).
Fig. 1 - Sostanza secca epigea durante i tre anni di esperimento; i dati osservati sono confrontati con gli output di simulazione (linea continua).

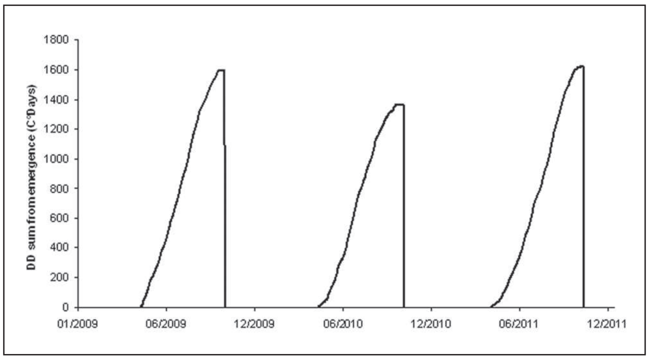

Fig. 2 - Degree days summation during the three years simulation.
Fig. 2 - Sommatoria gradi giorno durante i tre anni di simulazione.

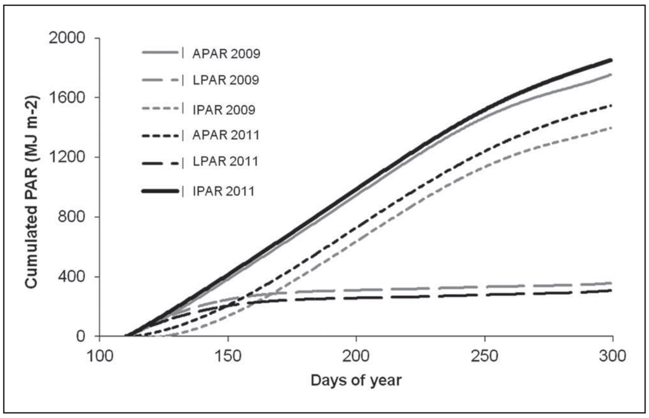

Fig. 3 - Cumulated PAR for the years 2009 (gray lines) and 2011 (black lines): incident PAR (solid lines) is the sum of absorbed PAR (short dashed lines) and lost PAR (long dashed lines).
Fig. 3 - PAR cumulata negli anni 2009 (linee grigie) e 2011 (linee nere): la PAR incidente (linee continue) è la somma della PAR assorbita (linee a tratto corto) con la PAR non utilizzata (linee a tratto lungo).

2009 (simulated: 51.5 Mg ha^{-1}, observed: 51.0 Mg ha^{-1}) and 2010 (simulated: 49.5 Mg ha^{-1}, observed: 49.1 Mg ha^{-1}) show akin values.

In Fig. 2, degree days summation during the three years simulation are shown. In 2009 and 2011, degree days summation reached 1600°CDays, whereas in 2010, summation just achieved 1400°CDays.

Since 2009 and 2011 showed similar degree days trends, we can conclude that this variable does not have strong influence on giant reed final yield. Thus, we analysed how radiation drives the crop growth.

In Fig. 3, the cumulated values (from April, 19) of incident PAR, absorbed PAR and lost PAR for the years 2009 and 2011 are shown.

From this plot, we observe that APAR 2009 is lower than that of 2011; this data along the high value of RUE explains the noticeable difference in yield during the years.

The LPAR of 2009 is higher than 2011 because of the delay in the crop emergence.

Conclusions

In this work we compared three years of observations of giant reed with simulations provided by the ARMIDA model. Giant reed showed distinct behaviours along the three years; simulations reproduce well the dry matter accumulation. Moreover ARMIDA is a helpful tool to understand the causes of yield discrepancies.

Indeed 2009 and 2011 show a very similar degree days accumulation but a substantial difference in biomass yields: this is due to the difference in PAR absorption.

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