Comparison between the use of thermal and hydrothermal time in weed emergence predictive models

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Background

– Weed emergence patterns (early 1960’s)

– Periodicity tables (early 1980’s)

– Increase in the use of Modeling in weed science (1990’s)

– Development of empirical methods for predicting weed emergence from the long-term weed emergence records and the associated meteorological data

Background cont'

<u>Factors influencing weed emergence</u>

- Temperature regulates both the dormancy and germination progress of many weed species
- Water availability is also a key factor affecting seed dormancy and germination timing
- **<u>Development of Thermal time models</u>**
- Use of thermal time above a base temperature
- **<u>Development of Hydrothermal time models</u>**
- Combination of thermal time above a base temperature and hydro time above a base water potential

Objectives

- Develop models based on thermal and hydrothermal time to predict emergence of *Amaranthus retroflexus* and *Chenopodium album*
- Evaluate the models developed
- Compare between the thermal and hydrothermal model

Experimental Information

- Emergence data from 2 experimental fields in Padova and another 2 in Pisa, grown with maize in 2007-08

- 2 sowing dates of maize were used for each location (early-sowing, late-March, and traditional-sowing, late-April)

- No herbicide application

- 33 fixed quadrats (30 cm*30 cm=0,09 m^2 each quadrat) / each field

- Seedlings counted twice a week and removed by hands

Soil Temperature and Soil Water Potential

- Temperature was monitored in both years using three thermocouples buried 2,5 cm deep and connected to a data logger

- Time domain reflectometry (TDR) was used to measure moisture content. TDR probes were placed at a depth of 5 cm

- T_b and Ψ_b for each species were determined in the lab using the methodology described in Masin *et al*. 2005

- Daily weather data was obtained by the local weather station

Data analysis

- Estimation of thermal time (GDD) using T_b of 5 ^oC for both spp. and T_b specific for each spp./location
- Estimation of hydrothermal time (SGDD) using T_b and Ψ_b specific for each spp./location
- Estimation of daily accumulation of GDD and SGDD
- Estimation of cumulative weed emergence, as a function of GDD and SGDD, with the Gompertz model
- Evaluation of models with the use of model efficiency index (EF) and mean bias error (MBE%)

Thermal time (Growing Degree Days)

$$GDD = \frac{T_{min} + T_{max}}{2} - T_b$$

where T_{max} is maximum daily air temperature, T_{min} is minimum daily air temperature and T_b is base temperature.

Hydrothermal time (Soil Growing Degree Days)

$$SGDD_i = n * \max(Ts_i - T_b, 0) + SGDD_{i-1}$$

Where n = 0 when $\Psi_i \leq \Psi_b$, n = 1 when $\Psi_i > \Psi_b$, Ts_i is the average daily soil temperature.

Prediction of Cumulative Emergence as a function of the Gompertz model using thermal or hydrothermal time

$$\text{CE} = b + ((a - b) * \exp(-\exp(-c * (\ln(\text{GDD or SGDD} + 0.0000001) - \ln(d)))))$$

CE is the cumulative emergence, *a* is the upper asymptote, *b* is the lower asymptote, *c* is the slope, and *d* is the point of inflexion.

Data were fitted using the Non Linear Regression module of Statistica 7.0

Model Evaluation

Model efficiency index (EF):

$$EF = \frac{\sum_{i=1}^{n}(O_i - \overline{O})^2 - \sum_{i=1}^{n}(P_i - O_i)^2}{\sum_{i=1}^{n}(O_i - \overline{O})^2}$$

P_i is the predicted value, O_i the observed value, and $\bar{O}$ the mean of observed values.

An EF value of 1 would mean that the model produced exact predictions.

Model Evaluation cont’

Mean bias error (MBE%):

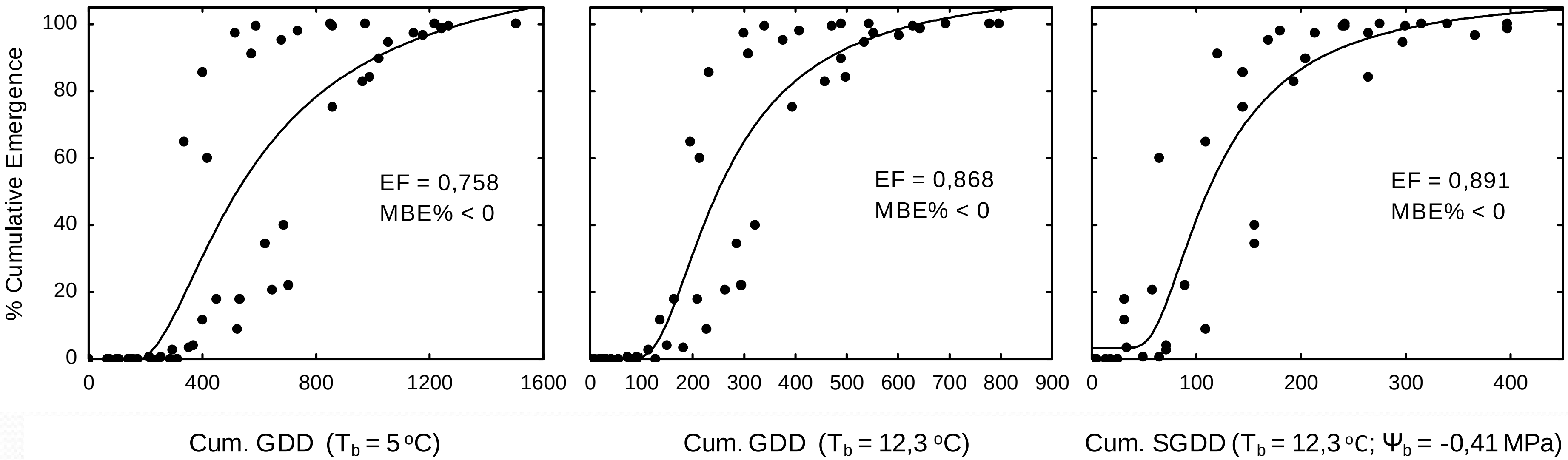
$$MBE\% = \frac{100}{N * R} \sum_{i=1}^{n} (P_i - O_i)$$

N is the number of observations and *R* the range of observed values.

A negative MBE% occurs when the model underestimates the observed values.

Results

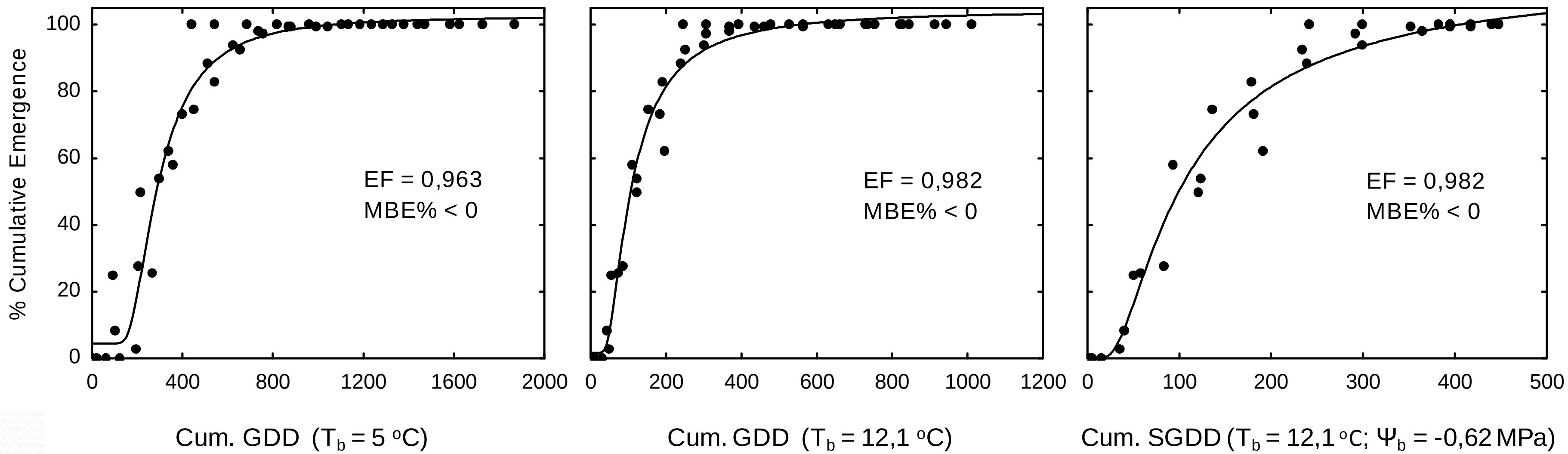
Amaranthus retroflexus emergence in Padova



- Highest EF obtained by hydrothermal model
- MBE% underestimation near 0 in all cases

Results cont'

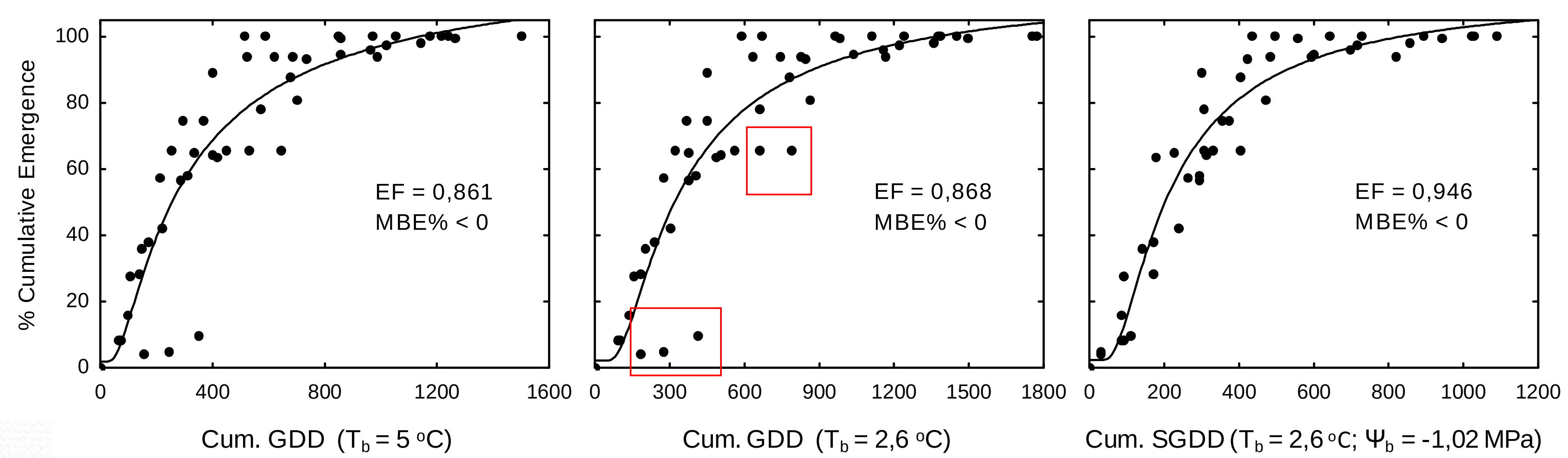
Amaranthus retroflexus emergence in Pisa



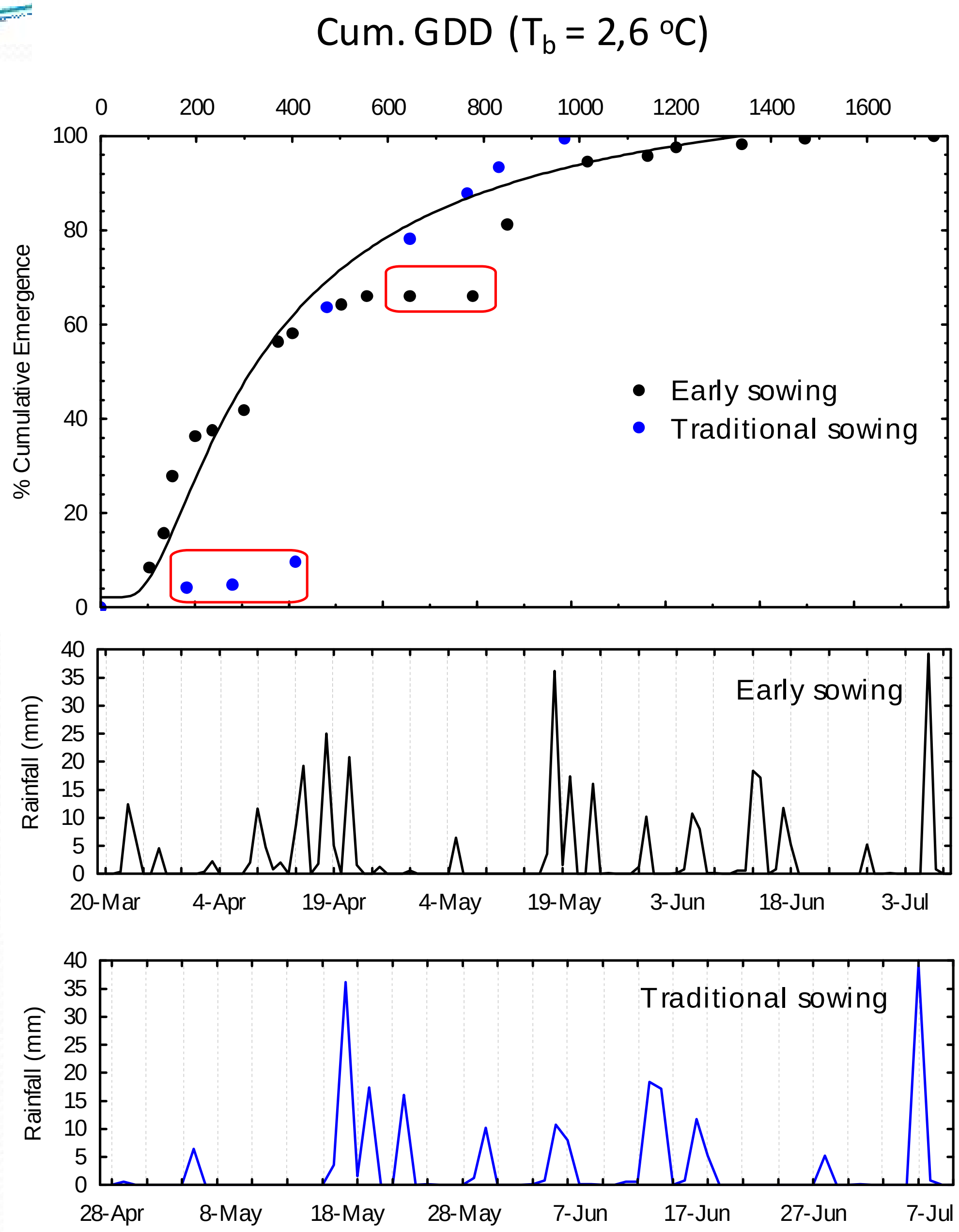
- High EF in all cases
- MBE% underestimation near 0 in all cases
- In thermal models T_b of 12,1 °C resulted in slightly higher EF
- High water potential in Pisa gave similar EF between models

Results cont'

Chenopodium album emergence in Padova



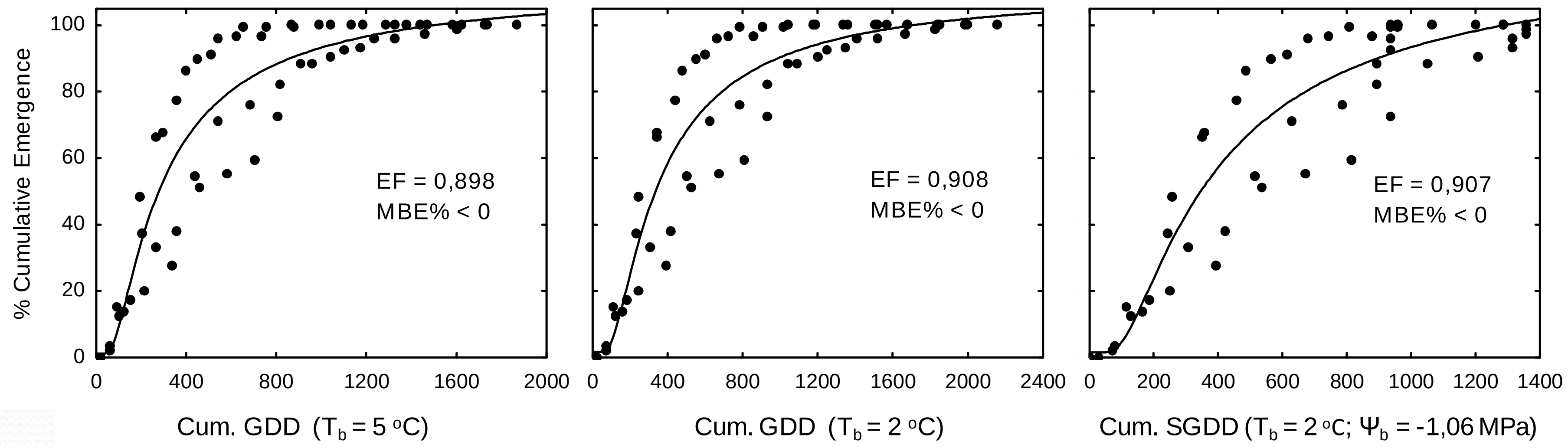
- MBE% underestimation near 0 in all cases
- In thermal models T_b of 2,6 ºC resulted in slightly higher EF
- Highest EF and better fit of data obtained by hydrothermal model



C. album cum. emergence under early and traditional sowing in Padova 2008

Results cont’

Chenopodium album emergence in Pisa

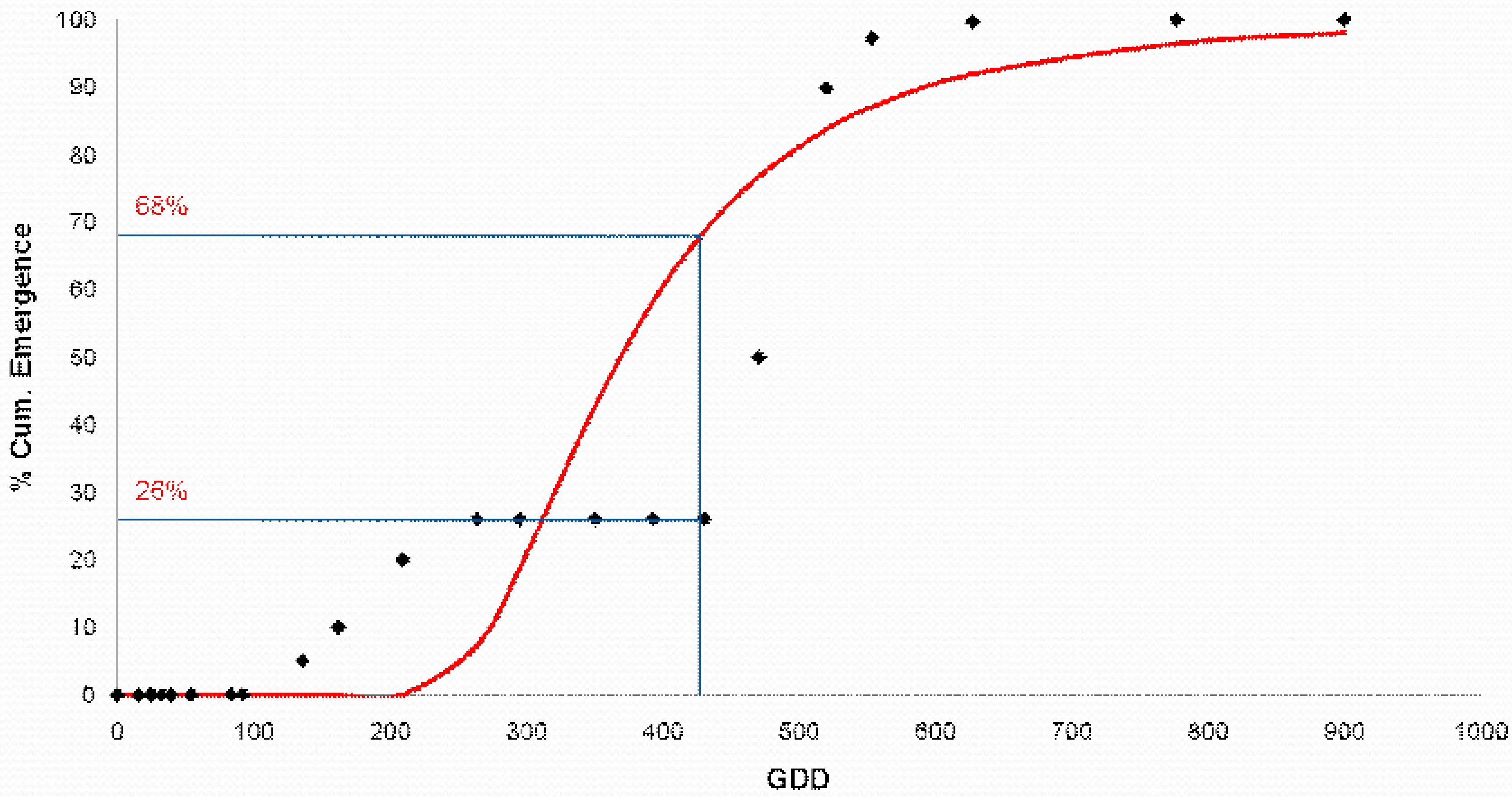


- High EF in all cases
- MBE% underestimation near 0 in all cases
- In thermal models T_b of 2 ºC resulted in slightly higher EF
- High water potential in Pisa gave similar EF between models

Conclusions

- Thermal time model using species specific T_b more efficient for both species than the general thermal model (T_b of 5 ^oC)
- Hydrothermal time model more efficient for emergence prediction of both species in sites under drier conditions
- It is important to underline that errors in the T_b and Ψ_b used in weed emergence predictive models determine inaccurate estimation
- Low soil water potential during drier periods reduces model reliability when used to time weed management

Example of false prediction for weed control



Thank you
for the attention