modextreme

agriculture facing extreme climatic events

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2nd Annual Meeting

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Cassandra
models for change

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Cold-induced spikelet sterility

- Rice is very sensitive to cold stress during **reproductive phase**: yield losses up to 30-40% in temperate growing areas (e.g., Northern Italy, North Japan, South Australia)
- Low temperatures cause structural and functional abnormalities in reproductive organs leading to **fertilization failure and premature abortion of seeds** (Thakur et al., 2010)
- Two moments of maximum susceptibility:
  - **Booting stage (microsporogenesis)**

    (e.g., Oliver et al., 2005; Gothandam et al., 2007; Imin et al., 2004; Sakata et al., 2014)
  - **Around flowering**

    (e.g., De Cruz et al., 2006; Sanchez et al., 2014)

(From Sakata et al., 2014)





How it can be modelled?

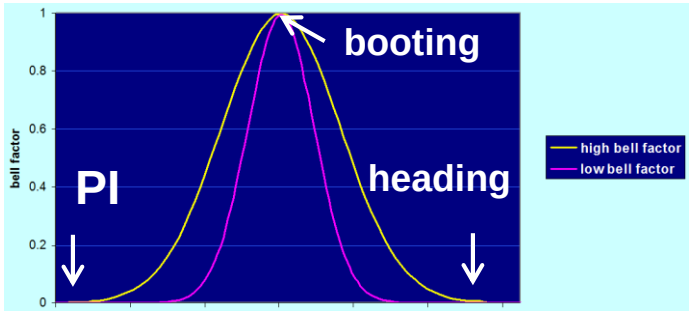
- **WARM approach**: only pre-flowering stress is considered

From panicle initiation to heading

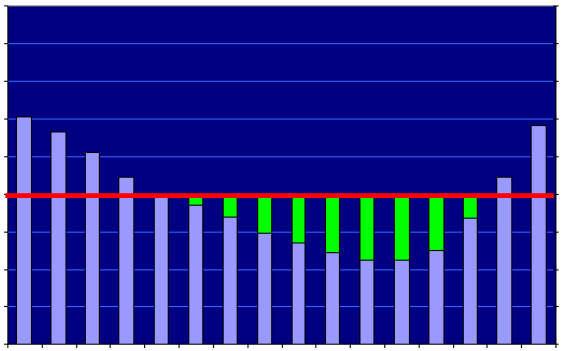
$$1.6 < DVS < 1.9 \cap T_T > T_{i,h}$$

$$Sterility_F = \begin{cases} \sum_{i=d_{1.6}}^{d_{1.9}} \left\{ bellF_i \cdot \sum_{h=i}^{24} \left(T_{TC} - T_{i,h} \right) \right\} \\ 1 \\ elsewhere \end{cases}$$

$$bellF_i = \frac{\delta}{\gamma\sqrt{2\pi}} \cdot \exp\left[\frac{\left(DVS_i - 1.8 \right)^2}{2\gamma^2} \right]$$



Threshold temperature








How it can be modelled?

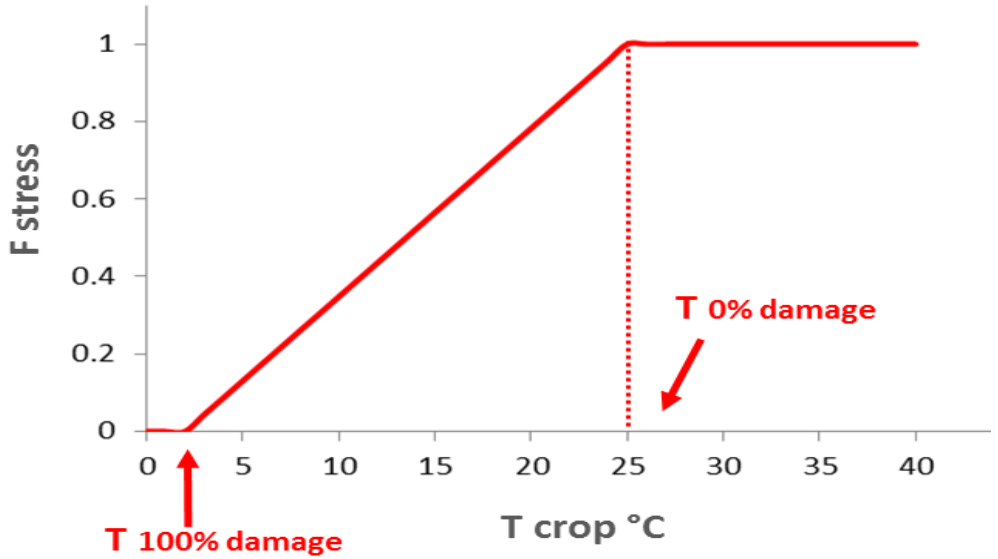
- **MODEXTREME component:** only the stress around anthesis is taken into account

$$Fstress = \begin{cases} 0 & Tc \le T100 \\ \dfrac{(Tc - T100)}{(T0 - T100)} & T100 \le Tc \le T0 \\ 1 & Tc \ge T0 \end{cases}$$

Around flowering (DVS=2)

$$1.9 < DVS < 2.1$$

$$HIactual = (HIpotential \times Fstress)$$

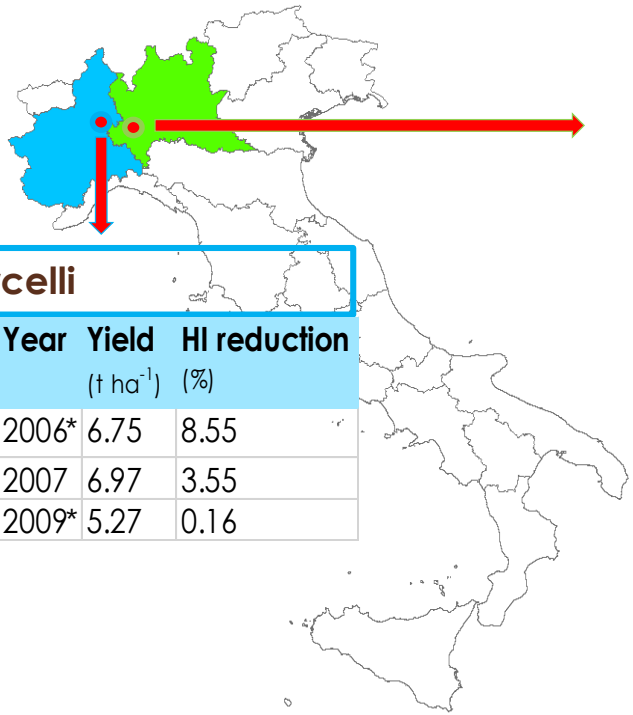







Field experiments

Data from Ente Nazionale Risi



Vercelli

Variety group	Variety name	Year	Yield (t ha^{-1})	HI reduction (%)
Japonica early	Loto	2006*	6.75	8.55
		2007	6.97	3.55
		2009*	5.27	0.16

Castello d'Agogna

Variety group	Variety name	Year	Yield (t ha^{-1})	HI reduction (%)
Japonica early	Loto	2004	5.66	0
Indica late	Thaibonnet	2004*	7.65	21.4
		2005	7.06	21.1
		2006	7.43	18.9
Indica medium	Gladio	2009*	8.64	12
		2011*	8.73	15.1

* Calibration dataset

WARM calibration:

- **Phenology** calibration (Tbase, Tmax, GDDem-fl, GDDfl-mat)
- **Growth** calibration (RUEmax, RipL0, SLAem, Topt, Tmax,..)



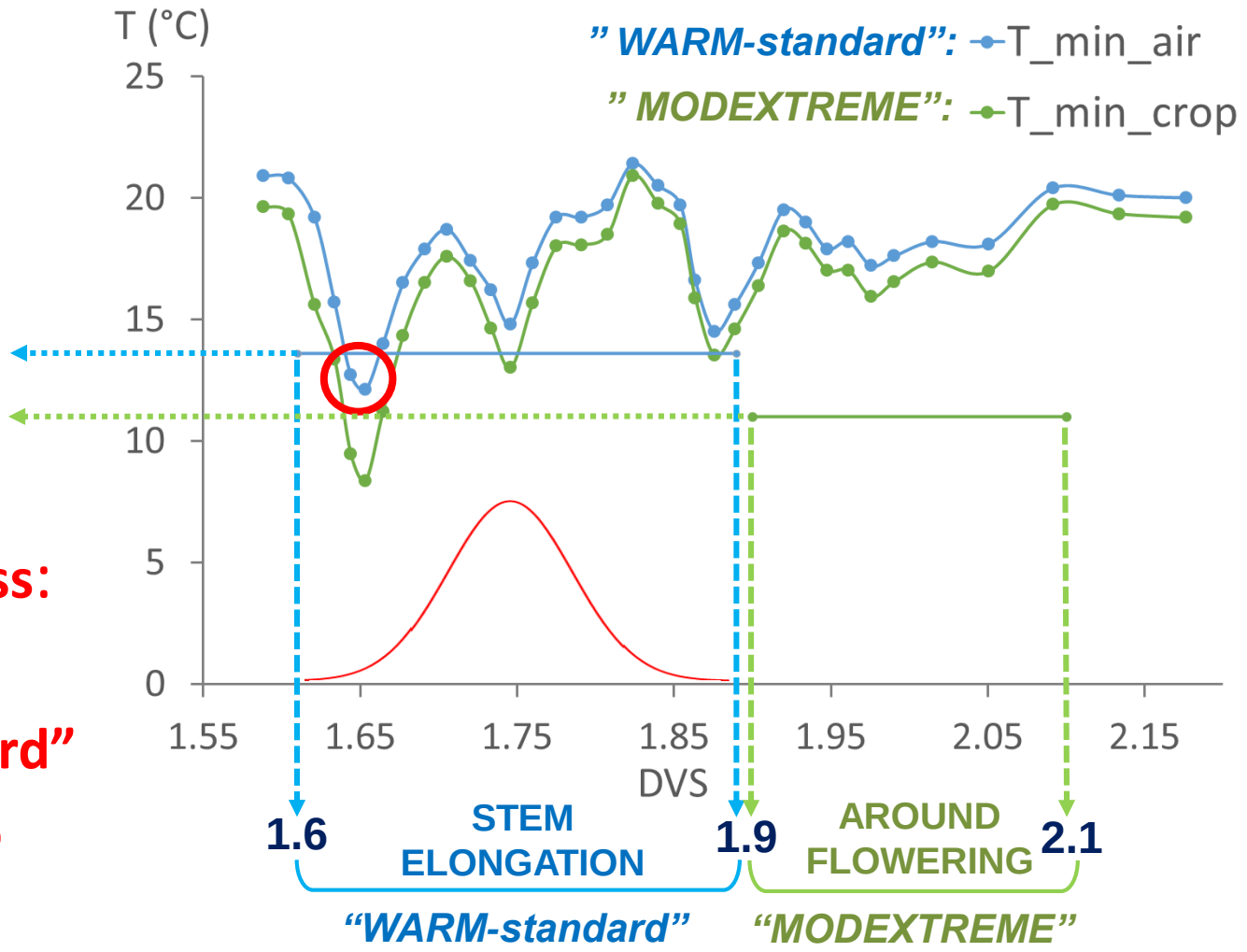



Sample results

Vercelli,

2009

Variety: Loto



Measured HI loss:

- 3 %

"WARM-standard"

HI loss: - 0.3 %

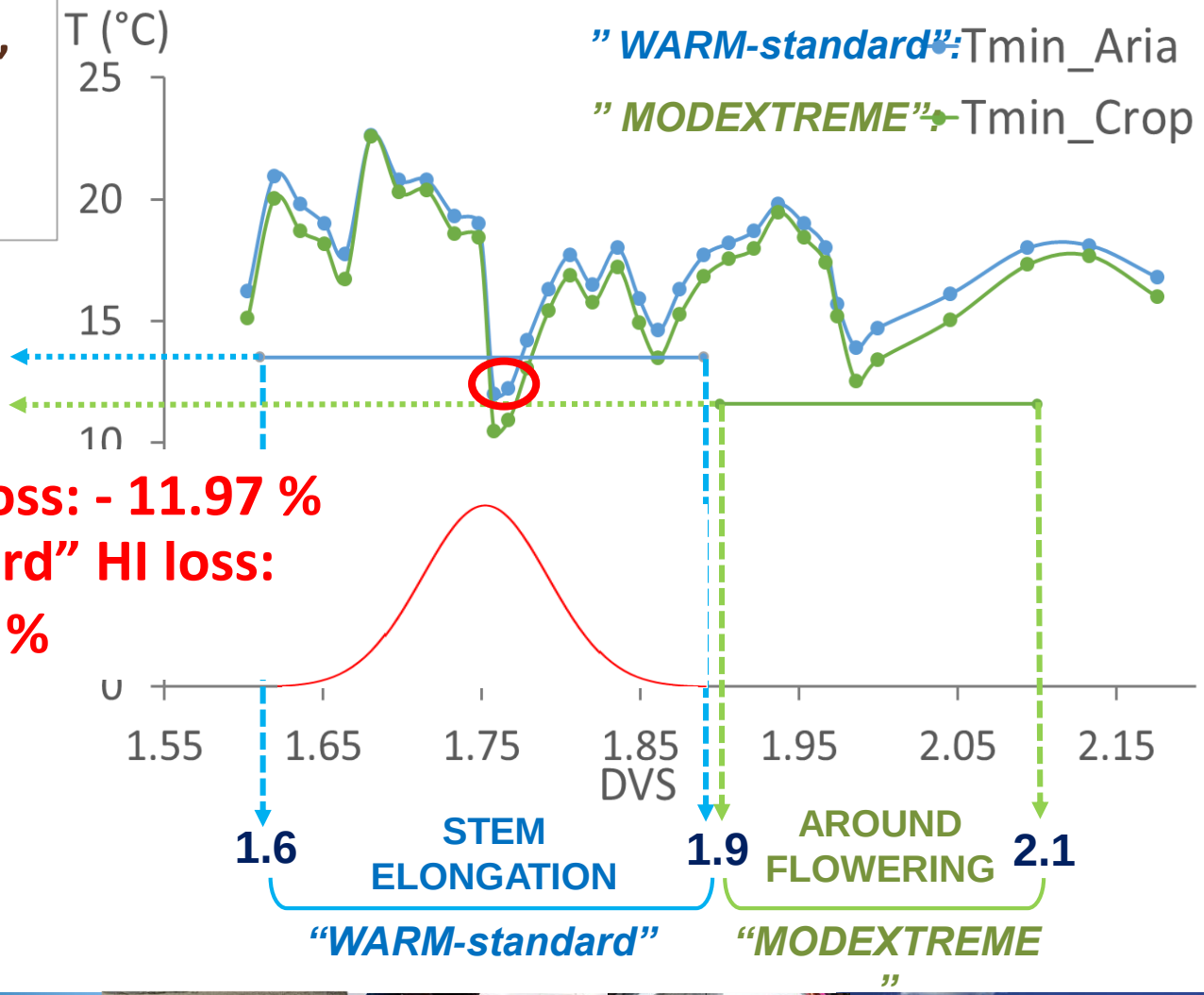





Sample results

Castello d'Agogna, 2009

Variety: Gladio



Measured HI loss: - 11.97 %

"WARM-standard" HI loss: - 8.16 %

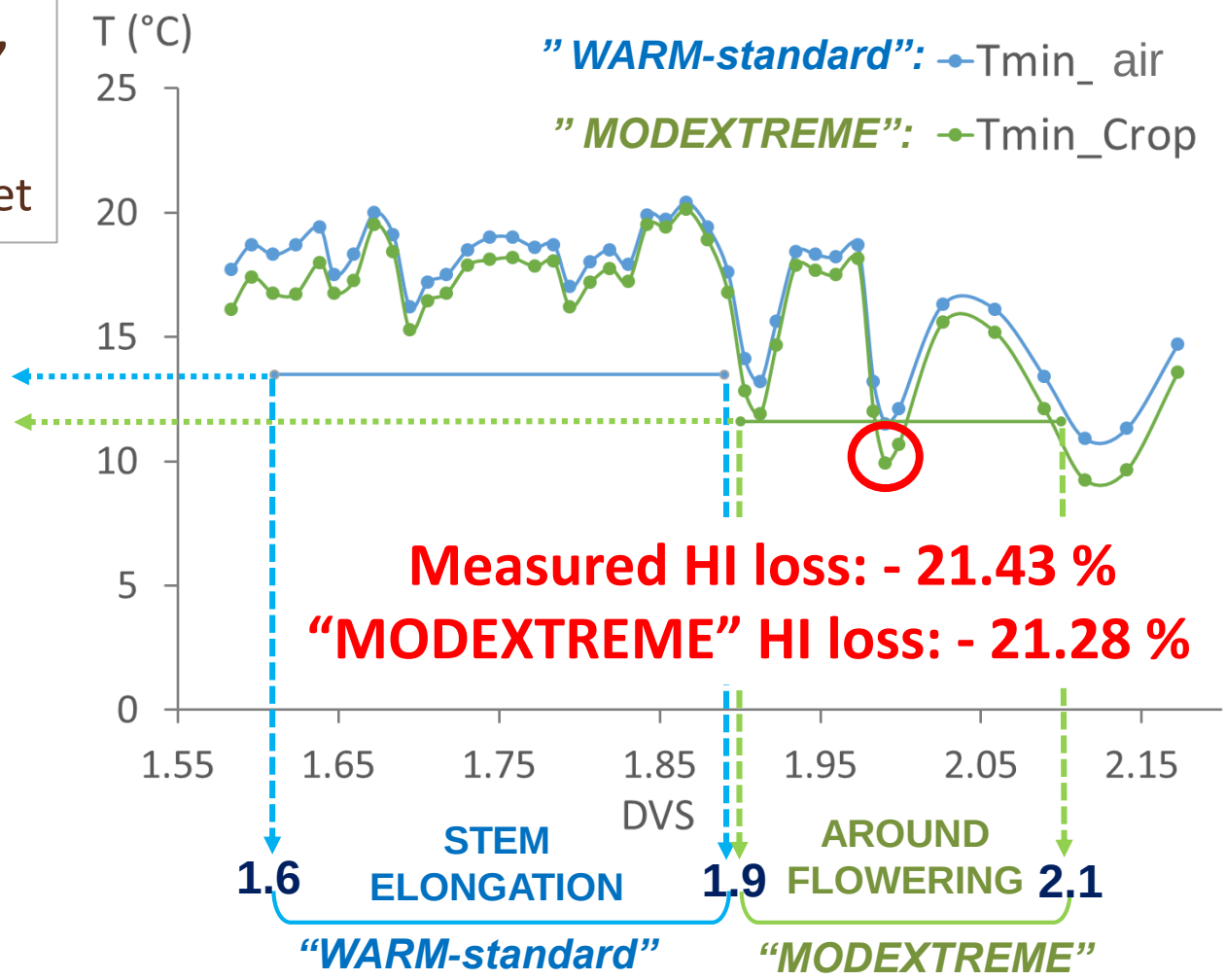





Sample results

Castello d'Agogna, 2004

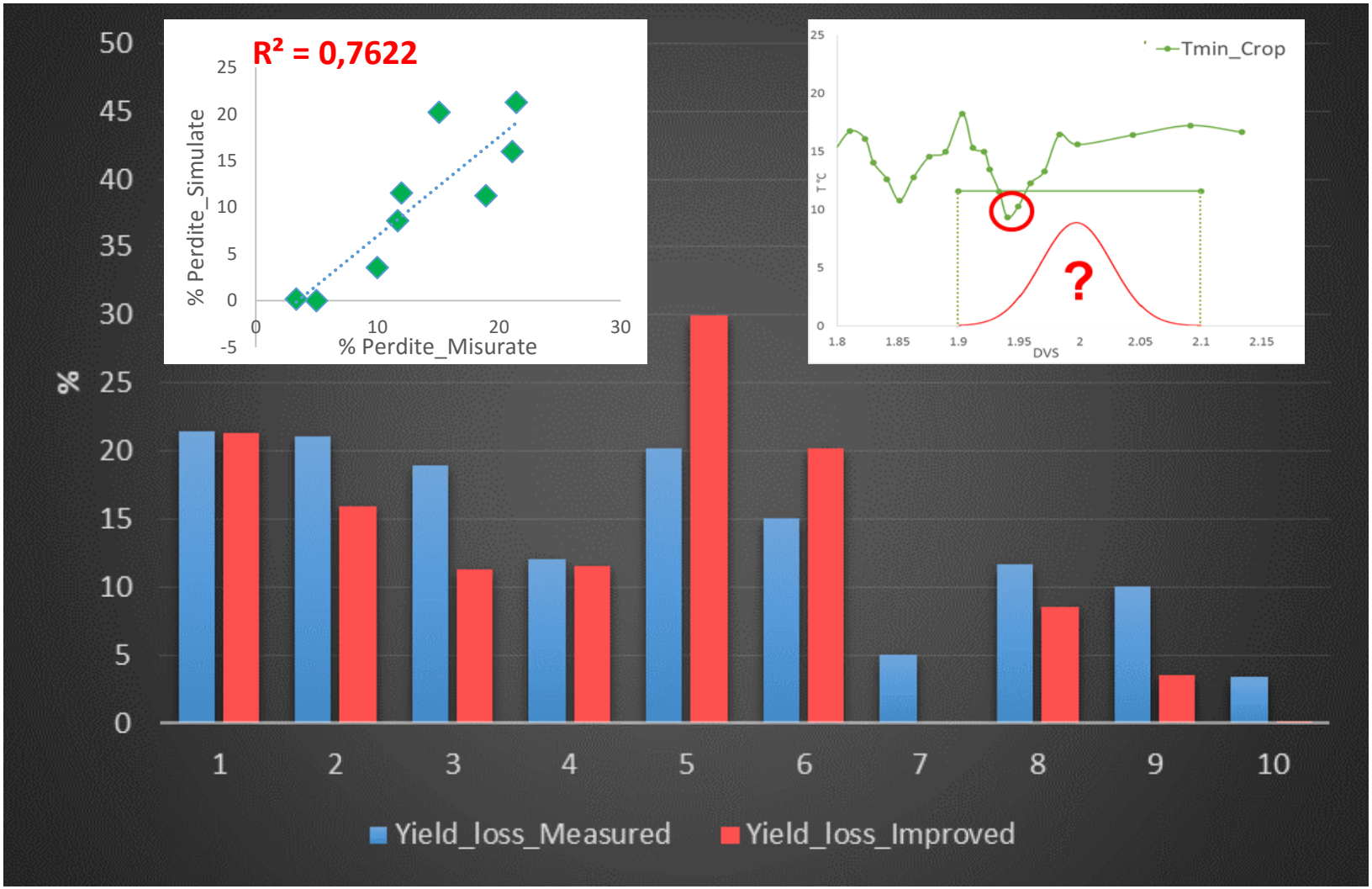
Variety: Thaibonnet








Results


R² = 0,7622
% Perdite_Simulate
% Perdite_Misurate
Tmin_Crop
T°C
DVS
?
%
Yield_loss_Measured
Yield_loss_Improved







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Conclusions & Perspectives

- Results can be considered as fully satisfactory
- The MODEXTREME component allowed to greatly improve the simulation of the impact of cold air irruption on rice yields
- Although carefully parameterized, the model likely overestimated the damage
  - A bell-shape function could allow reproducing the heterogeneity of occurrence of pollen germination/fertilization within spikelet/plant/field






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