First estimation and validation of a new model to predict dry matter loss based on temperature changes

I. A meta-analysis study

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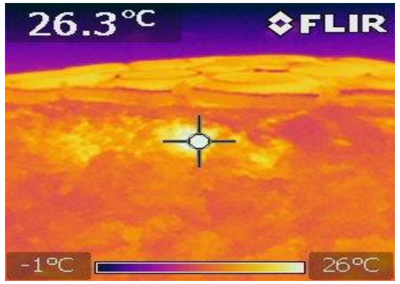
Presentation outline

- Introduction
- Material & Method
- Results & Discussion
- Conclusion

Temperature increase during aerobic exposure of silage

(McDonald et al., 1991)

Visible **yeast** and **mold growth**
Increase in **temperature**



Heat and **pH rises**

(Ashbell and Weinberg, 1992)

Corresponding **real-time** dry matter (**DM**) **loss** during continued aerobic exposure is **difficult** to **establish**.

Model

- Sensitivity
- Over/Under estimating
- Practicality

?

"The **objective** of this meta-analysis study was to establish the regression **correlation** between **DM loss** and **increased temperature** after **24 hours** of **aerobic exposure**"

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New model for DM loss prediction – function of recorded temperature in the silage

A literature review (Obs.= 9) on the **DM loss** after **24 hours aerobic challenge** was used as the basis for this meta-analysis study.

- **Different silages** (corn, alfalfa, and grass at DM ranging from 15-35%),
- **Temperature** and **DM loss measured**,
- DM loss (%) and temperature (°C) end points after 24 hours were plotted and submitted to a regression analysis (SAS institute),
- As a reference method a stepwise assessment of DM loss (McDonald et al. 1991) was compared with the new model.
- Two others linear equations were generated and compared to the new model.

$$\text{DM loss (\%)} = 0.49 * T\,(^{\circ}\text{C}) - 9.73$$

Obs. 1 from Wilkinson and Hall (1965); Obs. 2 from Henderson et al. (1979); Obs. 3 and 4 from Schukkling and Overvest (1980); Obs. 5 and 6 from Honig and Woolford (1980); Obs. 7 and 8 from Honig (1980); Obs. 9 from Rees (1982).

Existing models overview vs. new model

Items	Step logic approach (McDonald et al., 1991)	EQ 1 (Linear regression based on 18 study from Henderson, 1979)	EQ 2 (Linear regression based on 12 observations)	New model (Pires et al., 2018) (9 observations)
Temperature	ΔT to ambient	ΔT to ambient	T max during AS	T max during AS
Aerobic stability (AS)		9 days	24 hours **up to several days**	After **24 hours**
Estimate DM losses	0-3-10-15% ΔT= 0; 0 ≤ ΔT ≤1; 1 ≤ ΔT ≤5 or ΔT≥5	More precise (Overestimate)	Underestimate	Close to DM losses measured
Equation		DM loss (%)= ΔT*0.62+1.05	DM loss (%)= T_{max} *0.14-1.78	DM loss (%) = 0.49 * T-9.73
	Fit well when **T ambient is stable** e.g. mini silo trial • No influence of T ambient • T ambient is stable even during AS		No **controlled T ambient** and **AS duration**	More general and practical

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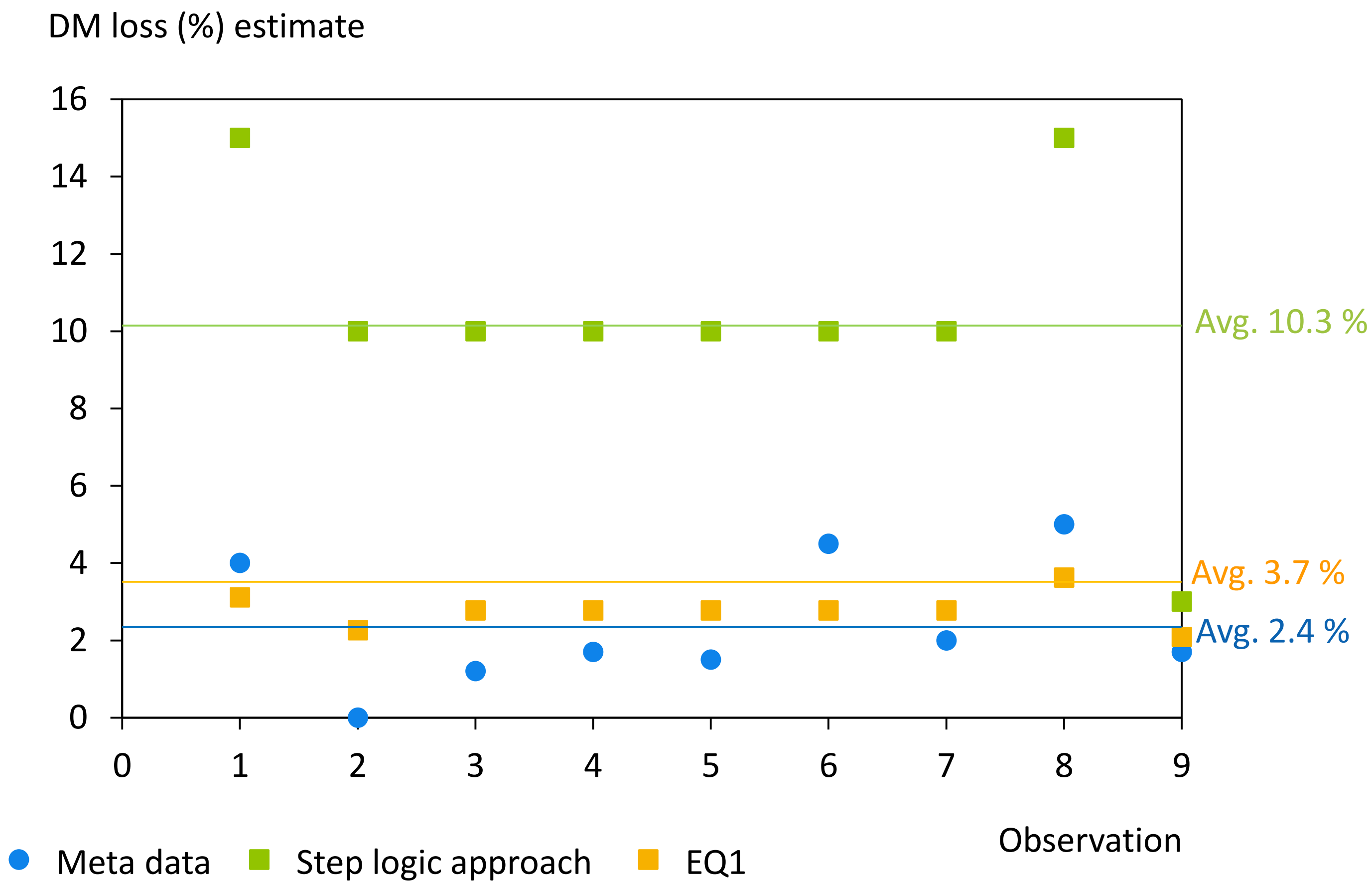
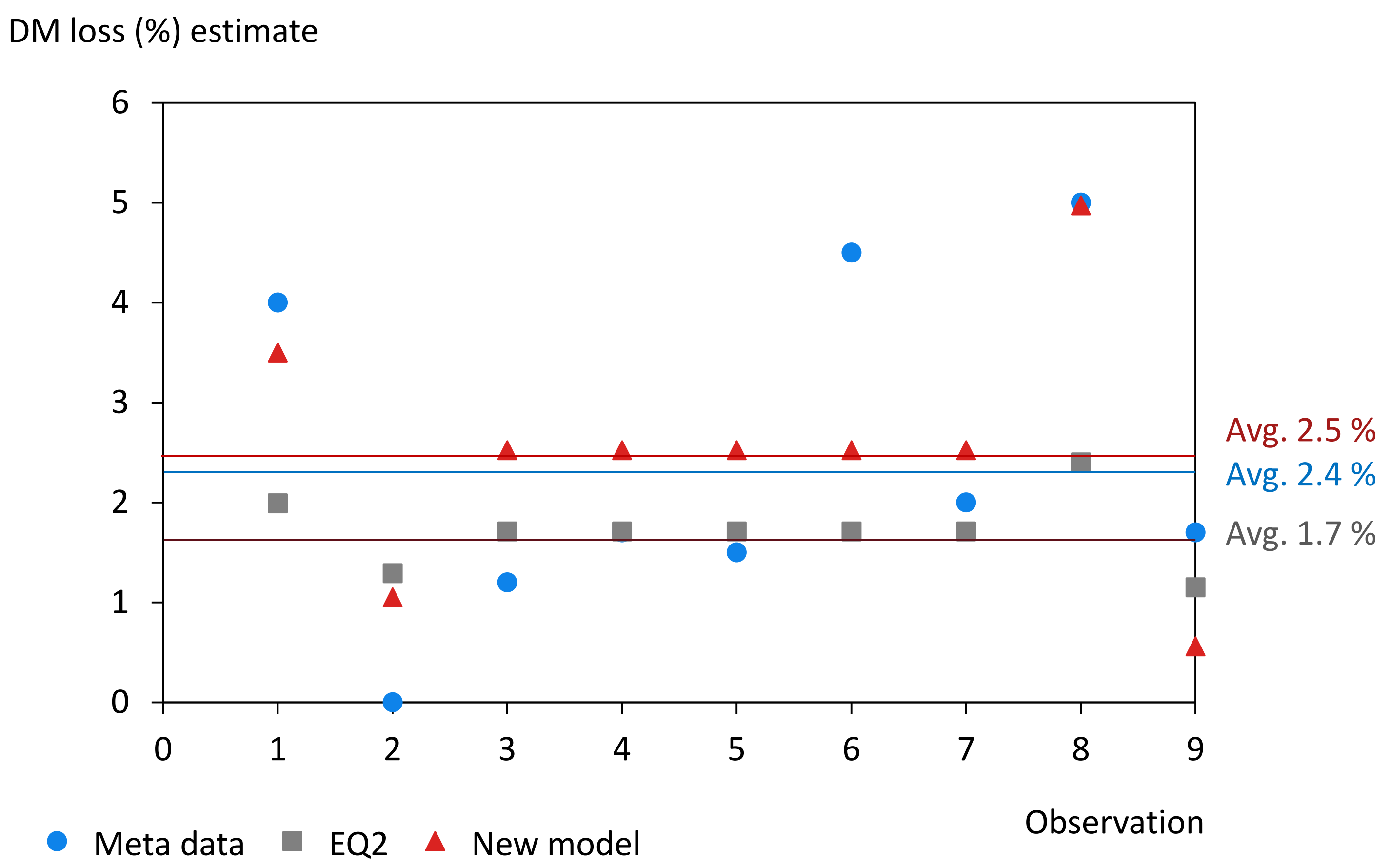
Predicted vs. observed (meta) DM loss (%). Two models based on Δ to ambient temperature



- The two models are over-estimating
- EQ 1 comes closer to observed DM losses (Meta data, overestimates DM loss by 1.32% on average).

Obs. 1 from Wilkinson and Hall (1965); Obs. 2 from Henderson et al. (1979); Obs. 3 and 4 from Schukkling and Overvest (1980); Obs. 5 and 6 from Honig and Woolford (1980); Obs. 7 and 8 from Honig (1980); Obs. 9 from Rees (1982).

Predicted vs. observed (meta) DM loss (%). Two models based on recorded temperature after 24 hours of aerobic stability.



- **EQ 2** is underestimating (by 0.69% points on average)
- **New model** naturally fits better to the Meta data (overestimates DM loss by 0.12% points on average)

Obs. 1 from Wilkinson and Hall (1965); Obs. 2 from Henderson et al. (1979); Obs. 3 and 4 from Schukkling and Overvest (1980); Obs. 5 and 6 from Honig and Woolford (1980); Obs. 7 and 8 from Honig (1980); Obs. 9 from Rees (1982).

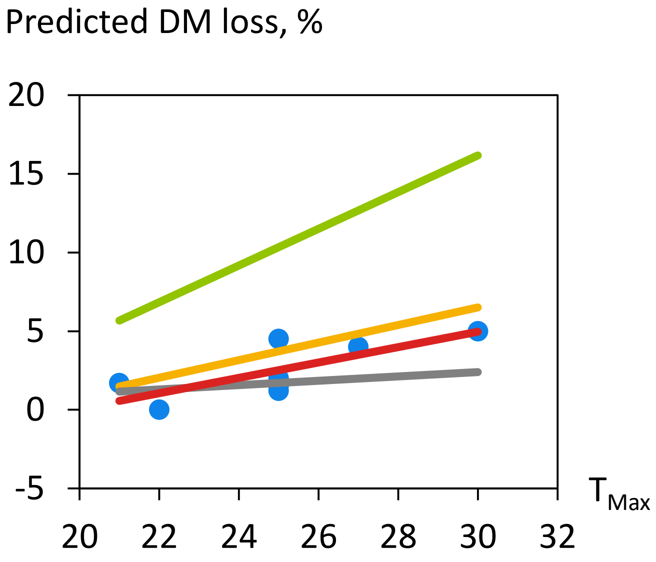
Recorded vs. Predicted DM loss with 4 different models

Trials Crops (structure) [fermentation time, days]	DM Loss (%) Recorded		DM Loss (%) Predicted							
			Step logic approach (McDonald et al., 1991)		EQ 1 (Linear regression based on 18 study from Henderson, 1979)		EQ 2 (Linear regression based on 11 observations)		New model (Pires et al., 2018) (9 observations)	
Treatment	C	SSFC	C	SSFC	C	SSFC	C	SSFC	C	SSFC
Maize (big bales) [120]	3.4	1.2	15	15	20.2	10.8	3.1	0.4	7.1	**-2.3**
Maize (mini silo) [90]	8.2	5.6	15	10	6.2	3.4	1.9	1.1	3.1	0.3
Grass/legume (mini silo) [90]	3.1	1.9	10	10	4	2	1.8	1.3	2.6	1
Maize (mini silo) [8]	3.8	2.6	15	15	5.9	5	2.3	2	4.3	3.5
Maize (mini silo) [16]	3.3	2.2	15	15	6.3	5.4	2.2	2.1	4.4	3.9
Maize (mini silo) [32]	2.9	1.8	15	15	7.1	5.2	2.5	2	5.1	3.3
Alfalfa (mini silo) [8]	10.8	5.7	15	10	11.4	4.1	3.4	1.8	8.2	2.8
Alfalfa (mini silo) [16]	7.5	4.9	15	10	7.9	3.4	2.7	1.6	5.7	2.2
Alfalfa (mini silo) [32]	7.3	5	10	3	7.1	4.1	2.4	1.7	4.9	2.5
Average	**5.6**	**3.4**	**13.9**	**11.4**	**8.5**	**4.8**	**2.5**	**1.6**	**5.0**	**1.9**

T_{Max} plot vs DM loss (recorded and predicted)

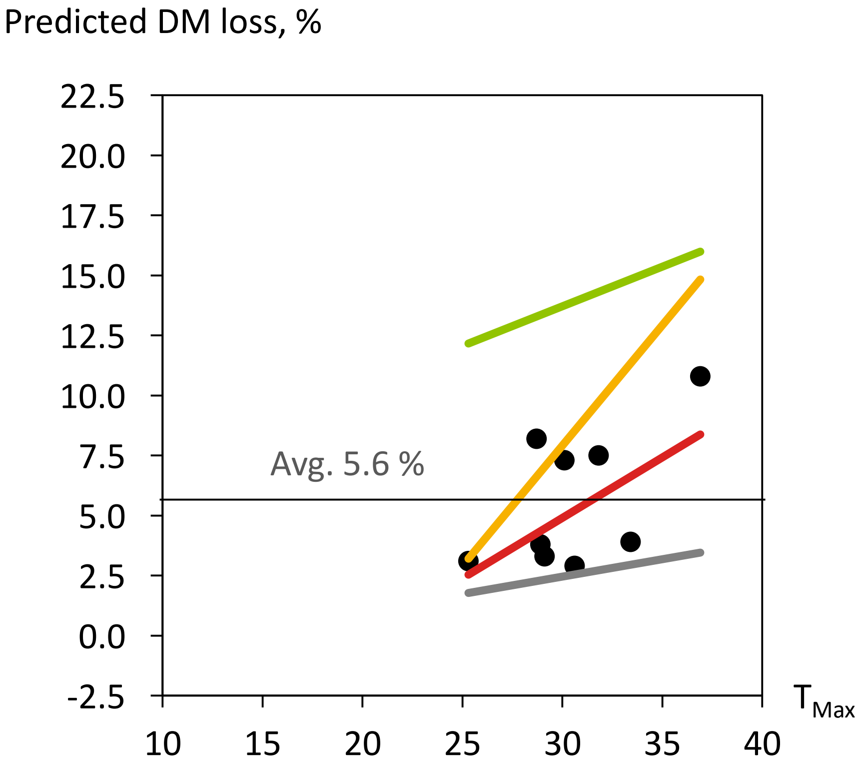
● Meta data ▬ Step logic approach ▬ EQ1 ▬ EQ2 ▬ New model

● Untreated - Control ● SiloSolve®FC



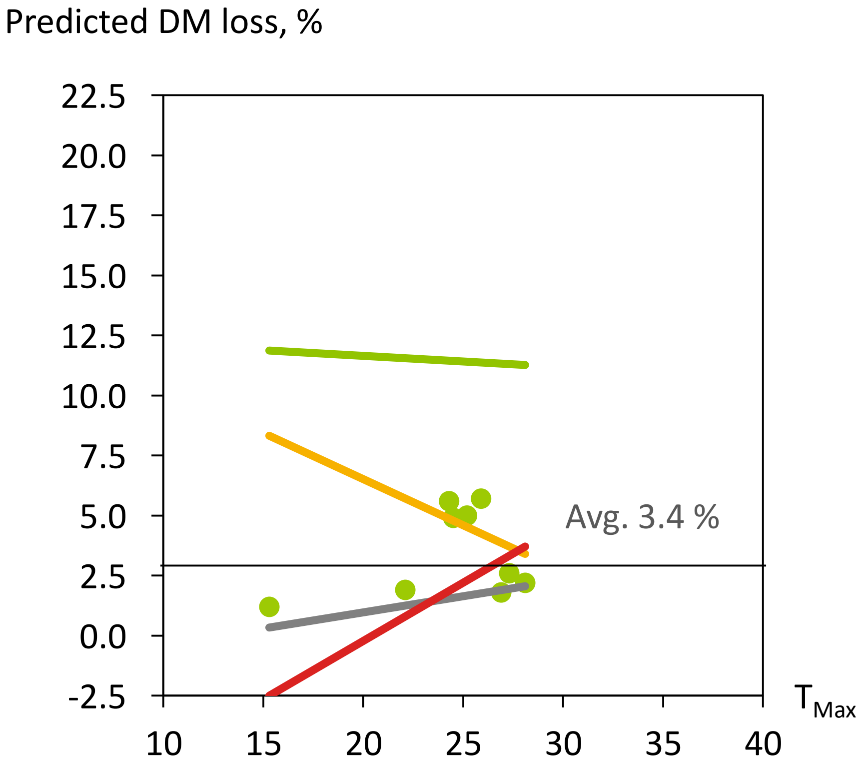
R^2=0.75 - R^2=0.96 - R^2=0.99 - R^2=0.99

Meta data and the different trends lines
(Different linear model)



R^2=0.24 - R^2=0.465 - R^2=0.906 - R^2=0.981

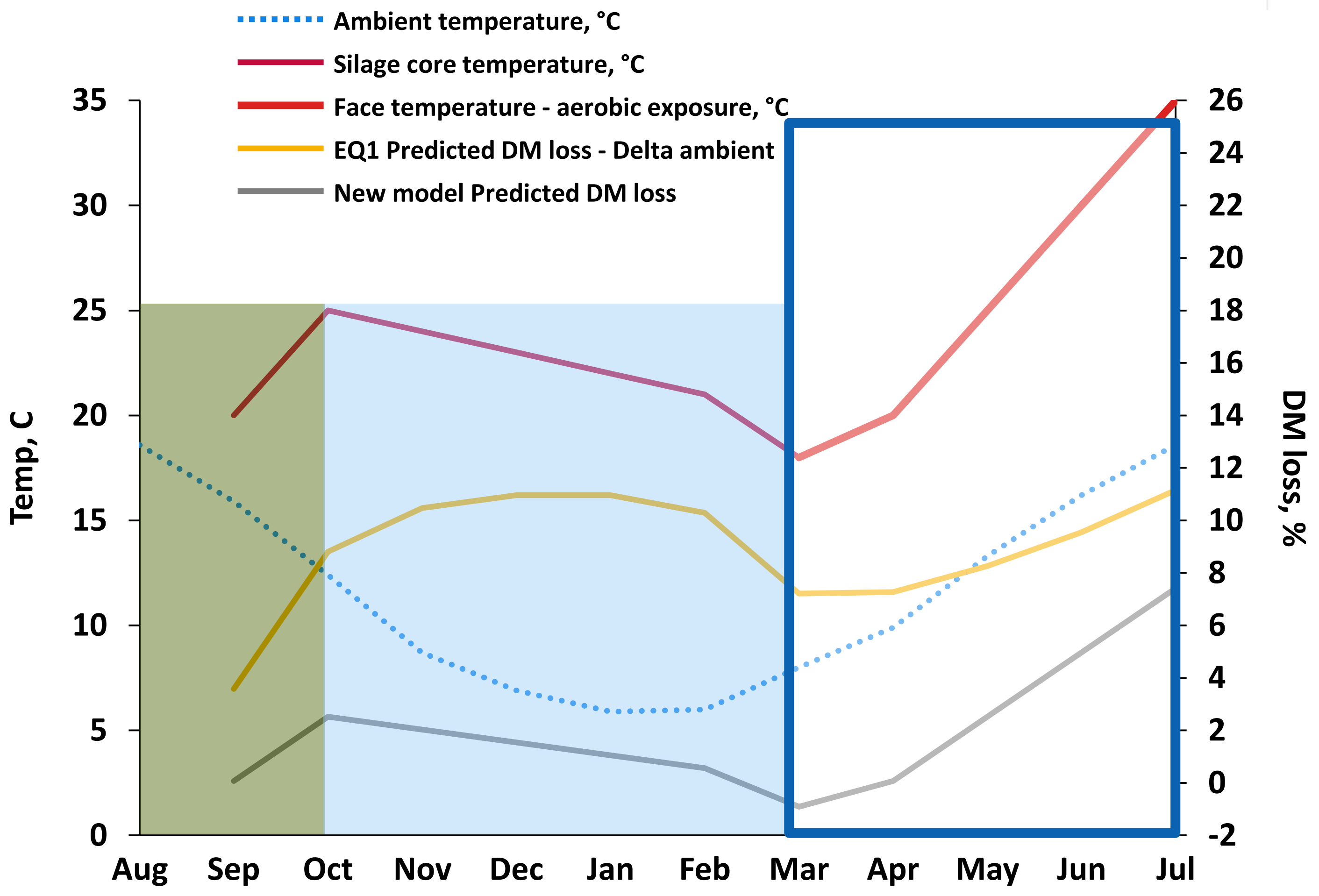
- ≥30°C → 6.5 DM losses
- Large variability



R^2=0.002 - R^2=0.359 - R^2=0.906 - R^2=0.911

- We reduce variability
- Lower temperature recorded
- Better fit when T is between 20-30 °C

Limitations of delta to ambient temperature models – from a practical point.



- Without ΔT to ambient:
More realistic DM loss estimation during fermentation - as well as feed out

- When opening the bunker – the "damp" of hot silage raises concern – but is only reflecting the T difference to ambient – not indicating silage heating due to spoilage.

5% DM losses due to fermentation Unavoidable (McDonald et al., 1991)

≤8% DM losses after AS deterioration

The new model – Practical tool for the farmers

- We confirm that a linear correlation exists with DM loss and recorded silage temperature (independent from the ambient T)

- More practical model and related to face management

- Using a IR camera gives producers an instant indication if they should change de-facing principles

- The model has been already validated in several studies
  - ✓ **WE-118**: First estimation and validation of a new model to predict dry matter loss based on temperature changes – II. Validation of maize mini silo and big scale silage
  - ✓ **WE-119**: First estimation and validation of a new model to predict dry matter loss based on temperature changes – III. Validation of model in a crop with low ensilability
  - ✓ **WE-120**: First estimation and validation of a new model to predict dry matter loss based on temperature changes – IV. Validation of model in a short fermentation regime

Thanks for your attention