gembloux agro bio tech

63rd Annual Meeting
EAAP 2012
August 27th - 31st, 2012

Bratislava, SLOVAKIA

Université de Liège

Assessing Heat Stress Effects on Production Traits of Holsteins in a Temperate Region

H. Hammami[1,2], J. Bormann[3], and N. Gengler[1,2]

[1] Animal Science Unit, University of Liège, Gembloux Agro-Bio Tech (GxABT), Gembloux, Belgium

[2] National Fund for Scientific Research (FNRS), Brussels, Belgium

[3] Administration of Agricultural Technical Services (ASTA), Luxembourg, Luxembourg

fnrs LA LIBERTÉ DE CHERCHER

ASTA Administration des Services Techniques de l'Agriculture

Temperature humidity index

- Climate change: extreme hot waves will be seen as a real threat
- Heat stress is influenced by the combination of ambient temperature (T_{db}), relative humidity (**RH**), solar radiation (**RAD**), wind speed (**WS**)
- Temperature humidity index (THI) Thom, 1959

$$TI_1 = (1.8 \times T_{db} + 32) - (0.55 - 0.0055 \times RH) \times (1.8 \times T_{db} - 26)$$ NRC,1971

  - Developed in empirical model
  - Ignore effects of environmental parameters (RAD & WS)
  - Biological (rectal temperature, sweatingé) and cow specific differences (breed, production...) are also ignored

New thermal indices

Thermal Indices (TI)	T_{db}	RH	RAD	WS	Biological effects & cow specific differences	Developed under range of T_{db}
Equivalent Temperature Index (Baeta et al., 1987)	✓	✓		✓	☺	16 to 41 °C
Environmental Stress Index (Moran et al., 2001)	✓	✓		✓	☺	22 to 45 °C
Adjusted THI (Mader et al., 2006)	✓	✓	✓	✓	☺ ☺	17 to 36 °C
Heat Load Index (Gaughan et al., 2008)	✓	✓		✓	☺ ☺	8 to 45 °C
Comprehensive Climate Index (Mader et al., 2010)	✓	✓	✓	✓	☺ ☺ ☺	-30 to 45 °C

New thermal indices

Thermal Indices (TI)	T_{db}	RH	RAD	WS	Biological effects & cow specificity differences
TI1: THI (NRC, 1971)	✓	✓			
TI2: Adjusted THI (Mader et al., 2006)	✓	✓	✓	✓	☺ ☺
TI3: Heat Load Index (Gaughan et al., 2008)	✓	✓		✓	☺ ☺
TI4: Equivalent temperature index (Baeta et al., 1987)	✓	✓		✓	☺
TI5: Environmental Stress Index (Moran et al., 2001)	✓	✓		✓	☺
TI6: Comprehensive Climate Index (Mader et al,, 2010)	✓	✓	✓	✓	☺ ☺ ☺

Temperature humidity indices

Apparent temperature indices

Objective

Evaluation of HS effects on production traits of Holsteins under a temperate environment using large field data and comprehensive TI indices as indicators of production traits losses

Data

- Historical performance data (2000-2011)
  - 230,192 TD milk, fat, and protein yields records
  - 23,963 cows
  - 604 herds
- Historical hourly meteorological data (2000-2011)
  - 14 Meteo stations
  - Tdb, RH, RAD, WS

Thermal indices

- **THI indices**
  - **TI_1**: THI (NRC, 1971)

    $THI = (1.8 \times T_{db} + 32) - (0.55 - 0.0055 \times RH) \times (1.8 \times T_{db} - 26)$
  - **TI_2**: Adjusted THI (Mader et al., 2006)

    $THI_{adj} = 4.51 + THI - (1.992 \times WS) + (0.0068 \times RAD)$
  - **TI_3**: Heat Load Index (Gaughan et al., 2008)

    $HLI = 8.62 + (0.38 \times RH) + (1.55 \times BG) - (0.5 \times WS) + e^{(2.4 - WS)}$ if BG> 25

    $HLI = 10.66 + (0.28 \times RH) + (1.3 \times BG) - WS$ if BG<=25
- **Apparent temperature indices**
  - **TI_4**: Equivalent Temperature Index (Baeta et al., 1987)

    $ETI = 27.88 - (0.45 \times T_{db}) + (0.010754 \times T_{db}^2) - (0.4905 \times RH) + (0.00088 \times RH^2)$
  - **TI_5**: Environmental Stress Index

    (Moran et al., 2001)

    $ESI = (0.63 \times T_{db}) - (0.03 \times RH) + (0.02 \times RAD) + 0.0045 \times (T_{db} \times RH) - 0.073 \times (0.1 + RAD)^{-1}$
  - **TI_6**: Comprehensive Climate Index (Mader et al., 2010)

    $CCI = RH_{adj} + WS_{adj} + RAD_{adj}$

Data

- Daily TI : average of hourly values over 24h
- The reference station was matched to each herd based on minimum distances (7.6 km)
- The mean of TI over the previous 3 days before each TD was designed as TI reference for the current TD

Thresholds identification:

- Random regression TD model (no effect of HS)

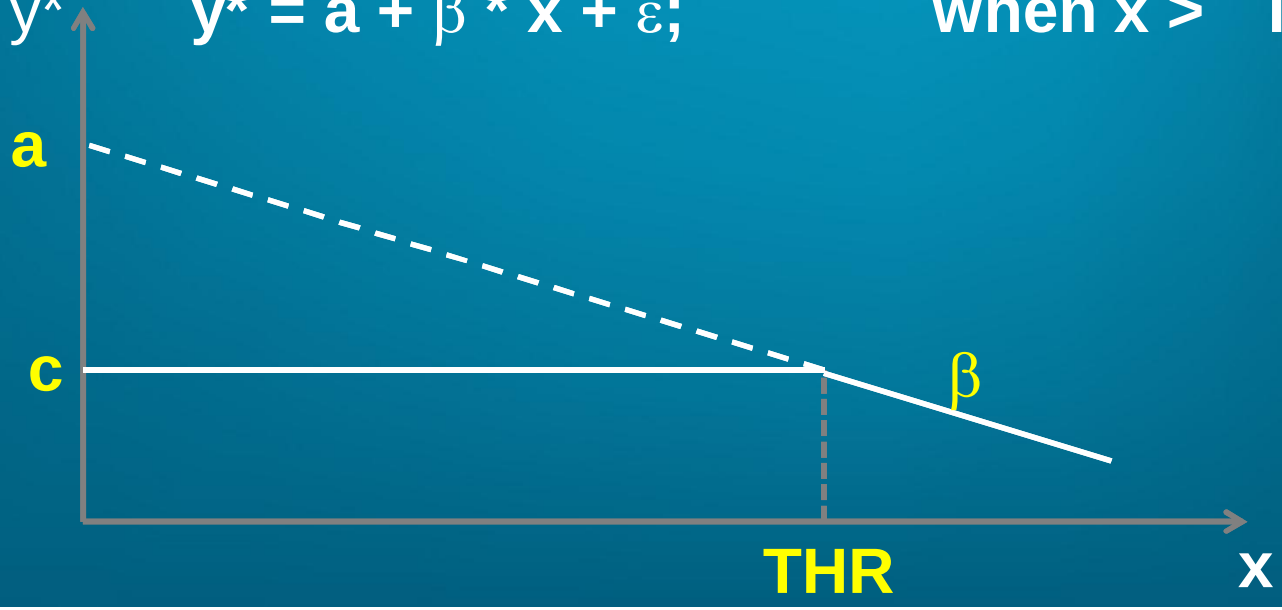
$$y = HTD + AGS + LS + \sum \phi a + \sum \phi p + \sum \phi h_{+} e$$ **Model 1**

- Broken line regression model **Model 2**

$$y^* = y \ddot{\imath} (HTD + AGS + LS)$$

$y^* = c + \varepsilon$; when x <= THR

$y^* = a + \beta * x + \varepsilon$; when x > THR



Production losses due to HS

- 1- Ability of TI to detect production losses

  RRTD model (with effect of HS)

$$y = HTD + AGS + LS + \sum \phi \beta + \sum \phi_s a + \sum \phi_s p + \sum \phi_s h + e$$

Model 3

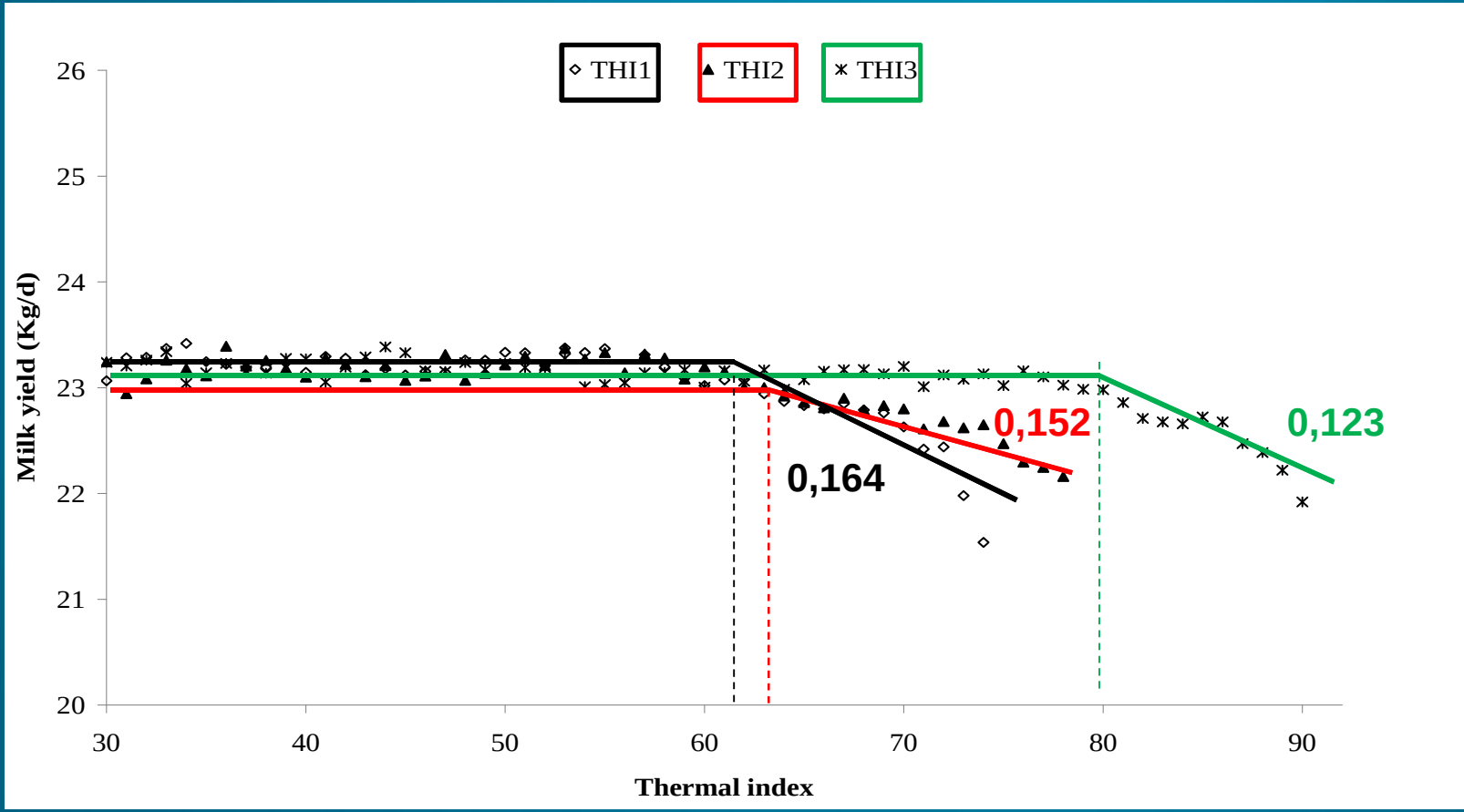
- 2- Yearly production losses (y_{loss})

$$y_{loss} = \beta * \sum_{day=1}^{365} (TI_{day} \ddot{\imath} THR)$$

β: rate of decline and THR: the specific threshold for each TI

Thresholds

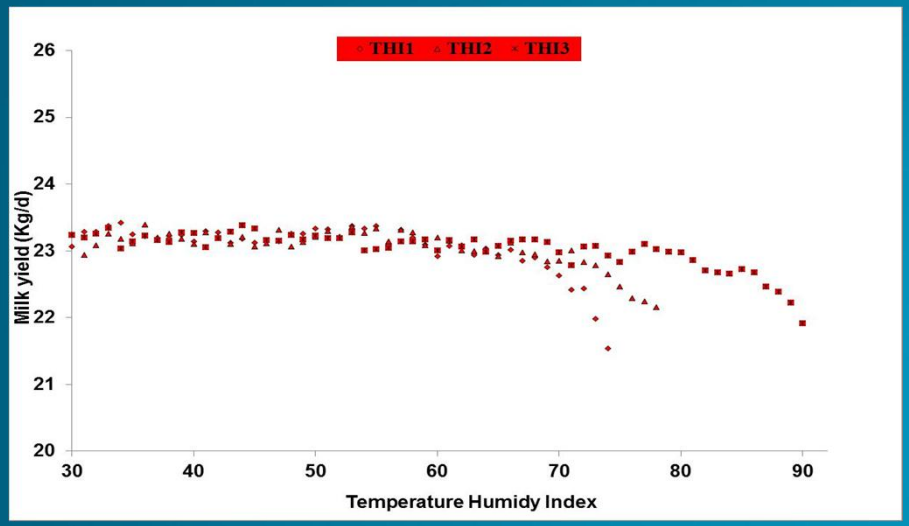
A- Milk



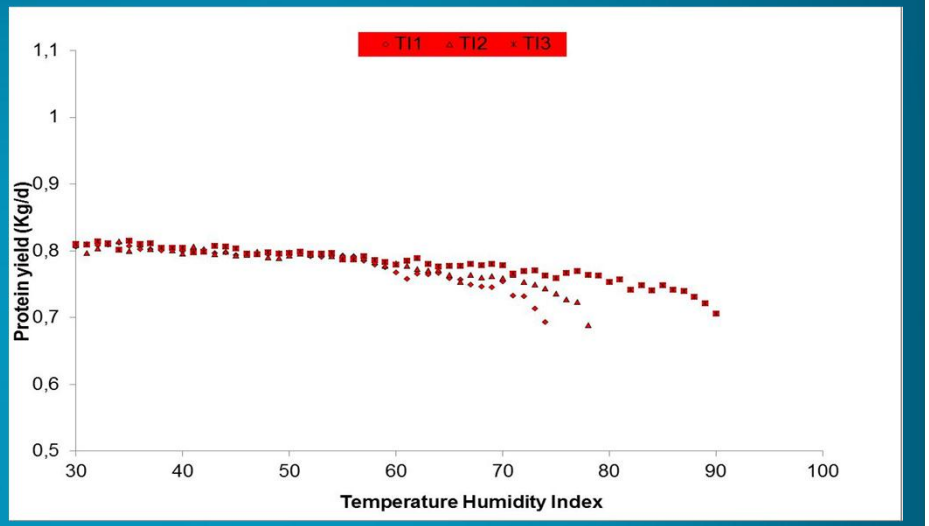
Least square means (LSM) for daily milk yield using different THI indices

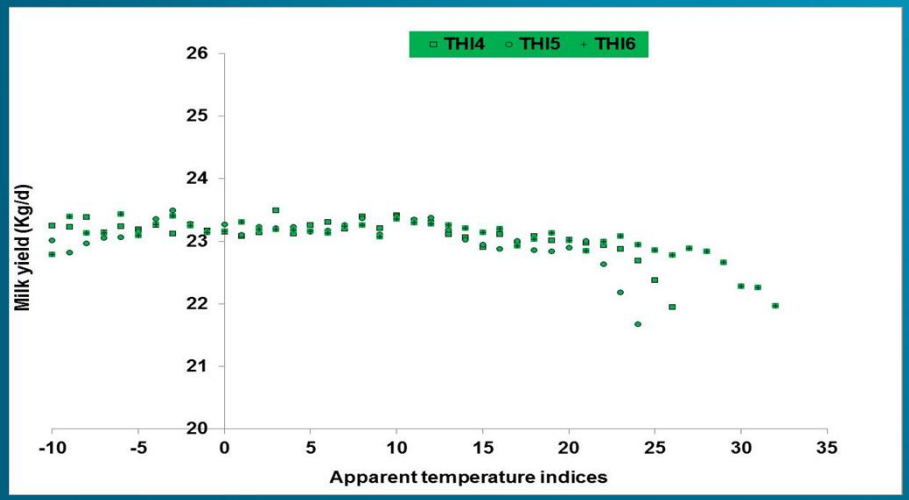
Thresholds

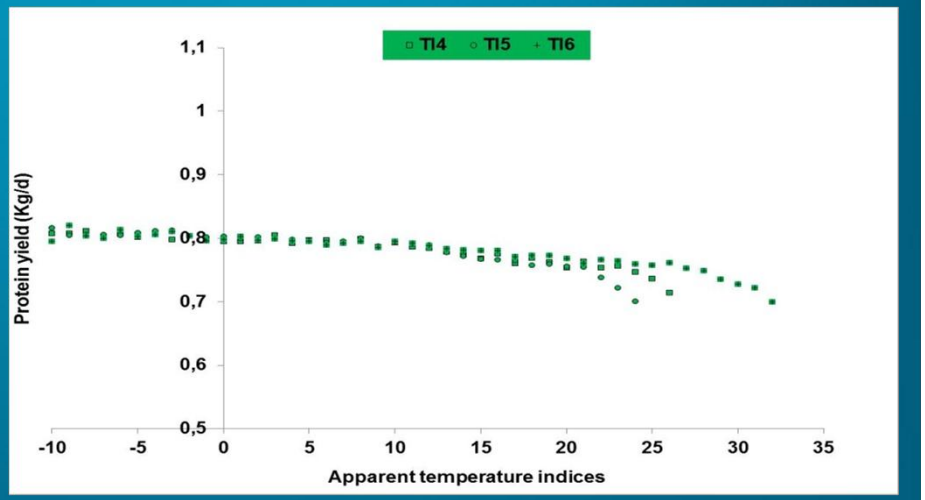
1- Milk



2- Protein



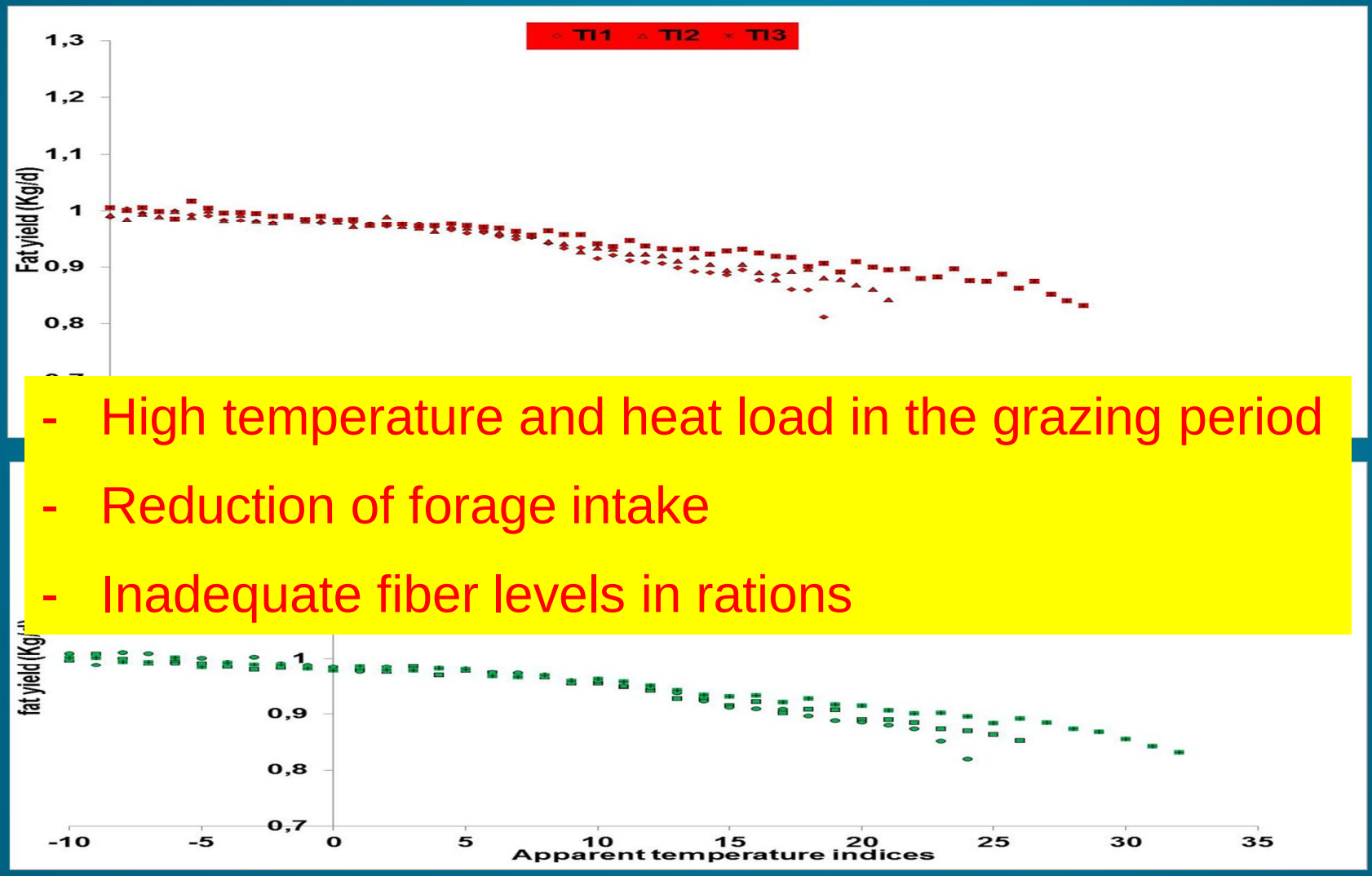




LSM for daily 1) milk and 2) protein yields using different THI and Apparent temperature indices

Thresholds

3- Fat



- High temperature and heat load in the grazing period
- Reduction of forage intake
- Inadequate fiber levels in rations

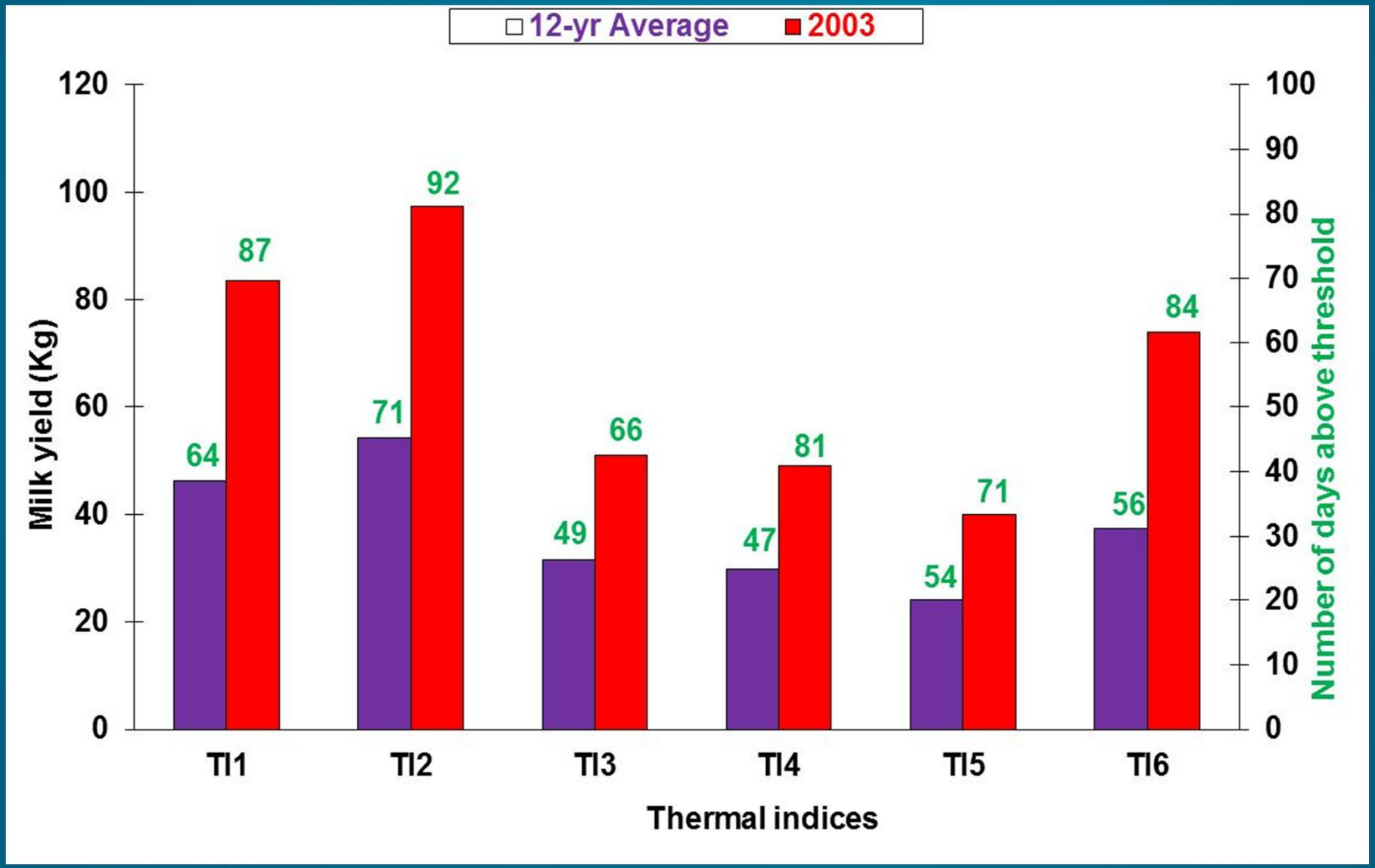
LSM for daily fat yields using different THI and Apparent temperature indices

Threholds

Thermal Indices	THR	Other Studies	Rate of decline / unit of TI (β)		
			Milk (kg)	Fat (kg)	Prot (kg)
TI_1	62	69[1], 72[2],78[3], 80[4] **60**[5]	-0.164	-0.020	-0.013
TI_2	64		-0.152	-0.014	-0.012
TI_3	80		-0.123	-0.013	-0.010
TI_4	18		-0.146	-0.022	-0.012
TI_5	16		-0.109	-0.023	-0.011
TI_6	20		-0.154	-0.021	-0.013

[1]Bouraoui et al. (2002); [2] Bohmanova et al. (2007); [3] Dikmen and Hansen (2009);
[4]Bookum et al. (2011); [5] Brügemann et al.(2011)

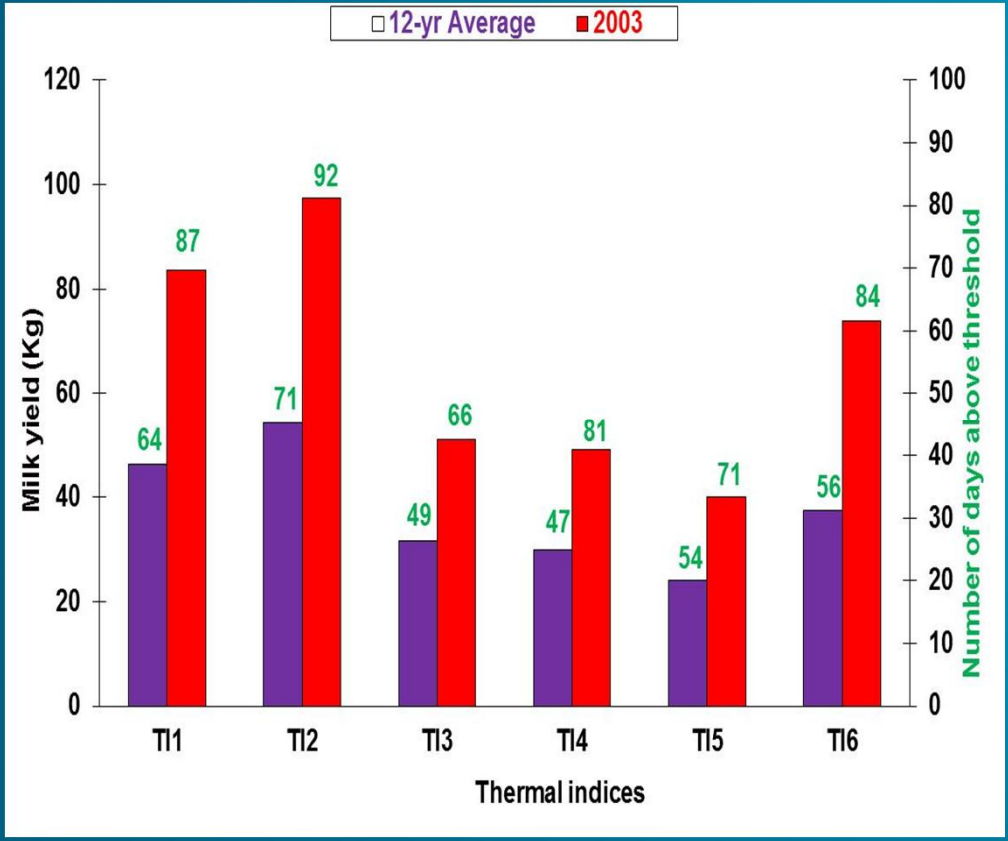
Production losses



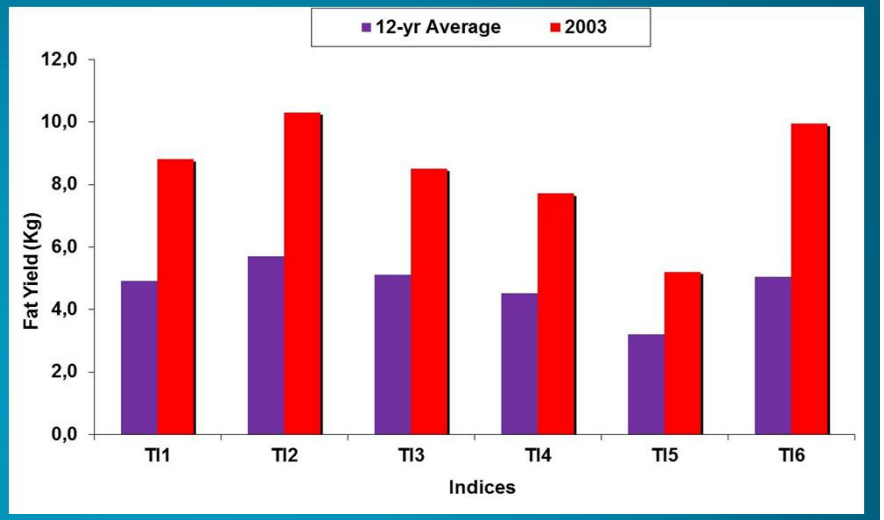
Yearly loss of milk during 2000-2011 (12-yr Average) and the year of 2003

Production losses

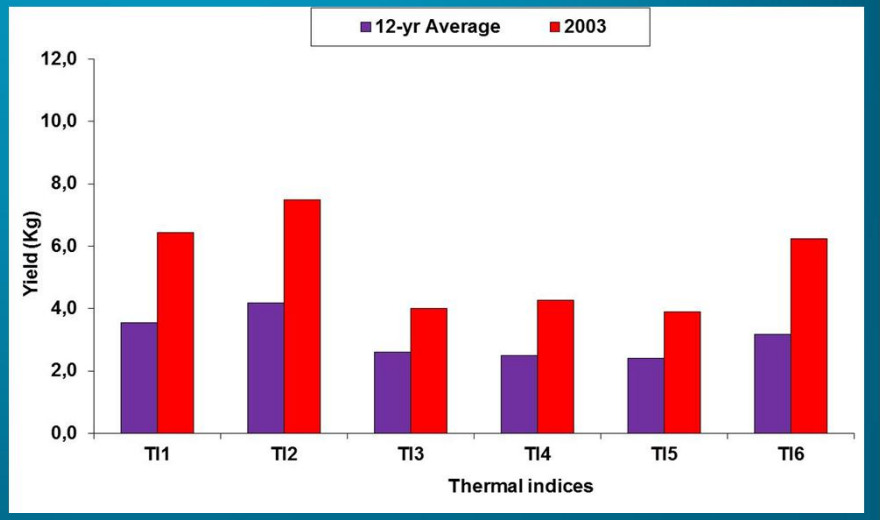
Milk



Fat



Protein



Yearly loss of milk, fat and protein during 2000-2011 and the year 2003

Conclusions

- Losses for production traits were confirmed
- The six TI identified lower heat stress thresholds compared to tropical, subtropical and Mediterranean regions
- TI_2 and TI_6 showed highest production losses
- Genetic variation of heat stress tolerance should be evaluated for the six TI

Aknowledgments

Financial support via a post-doctoral fellowship

Production data

Meteorological data

Thank you for your attention

Corresponding authorâs e-mail: hedi.hammami@ulg.ac.be