Impact of temperature on milk yield: a multiyear analysis from Harper Adams University Future Farm

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Introduction

Climate change include heat stress impacting on livestock productivity, health, and welfare.

- In this study, we used milk production data from Harper Adams University Future Farm dairy unit for 6 years (2019 to 2024)

- Analysed the impact of heat stress on milk yield and discuss potential mitigation strategies.

- Meteorological data were obtained from HAU weather station and consisted of hourly temperature and relative humidity used to calculate Temperature Humidity Index (THI)

do "cold countries" have hot days?

- Hot Days (== THI > 68) are rare
- Some variation across years

NB full data for 2018 and 2024 incomplete

Hot Days per Year

Distribution of Hot Days from 2018 to 2024

Year	Not a Hot Day	Hot Day
2018	196	1
2019	357	8
2020	357	9
2021	357	8
2022	353	12
2023	353	12
2024	156	0

do "cold countries" have hot days?

Not surprisingly, hot days are in summer months

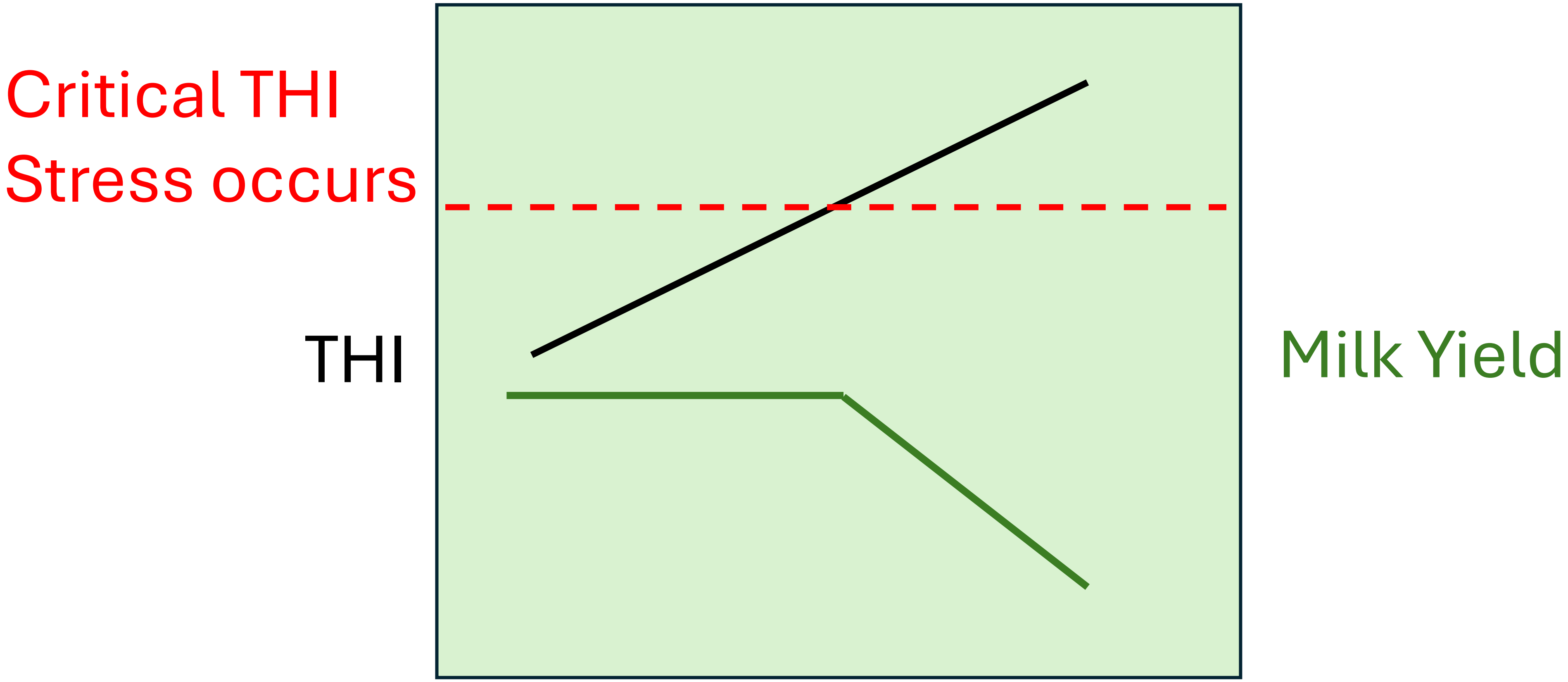
Hot Days per Month

Distribution of Hot Days (TRUE/FALSE) by Month

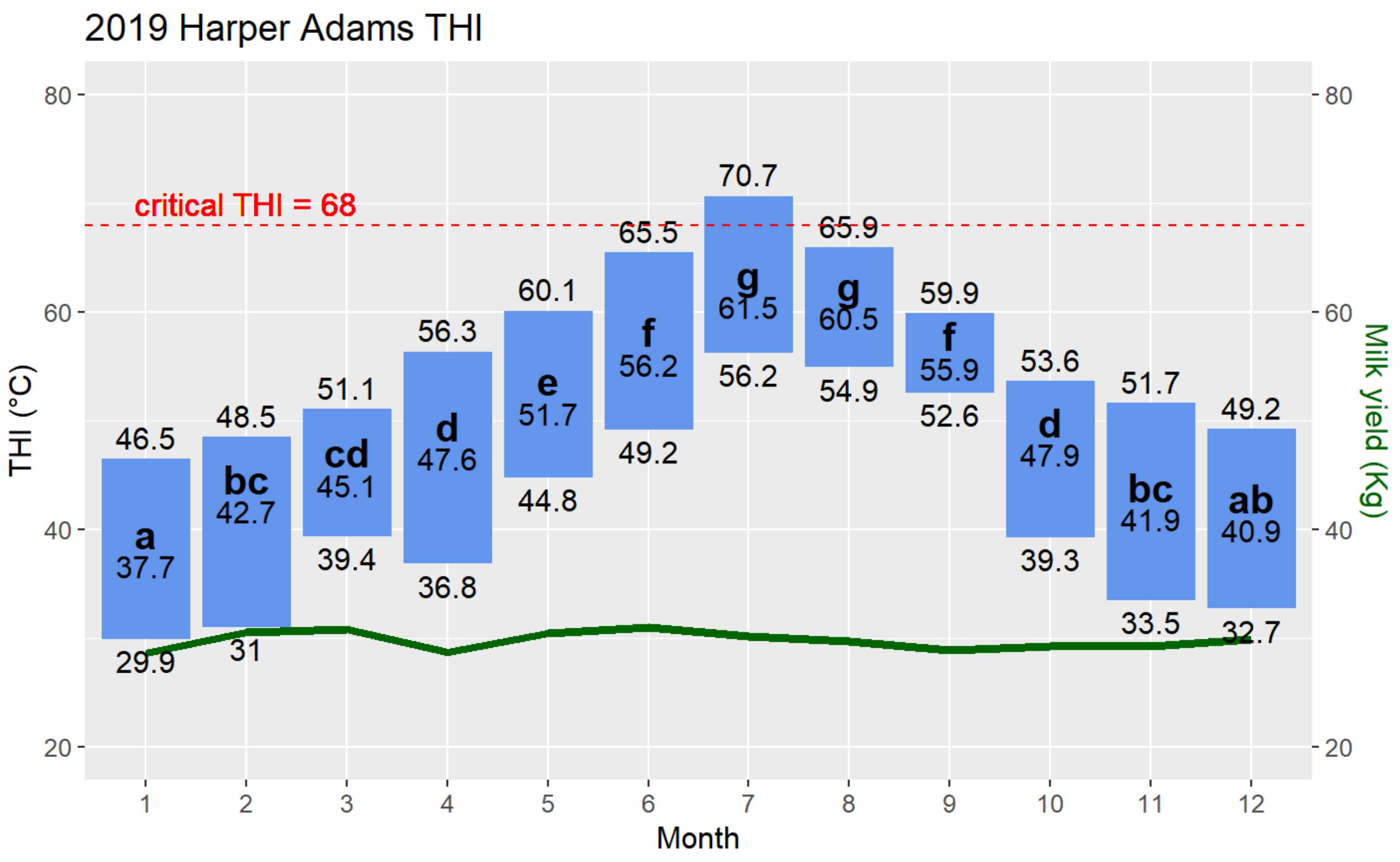
Month	Not a Hot Day	Hot Day
1	186	0
2	180	0
3	217	0
4	210	0
5	217	0
6	176	8
7	142	21
8	141	14
9	143	7
10	155	0
11	176	0
12	186	0

NB this for later reference

Predictions at Critical THI – Chen et al. 2022

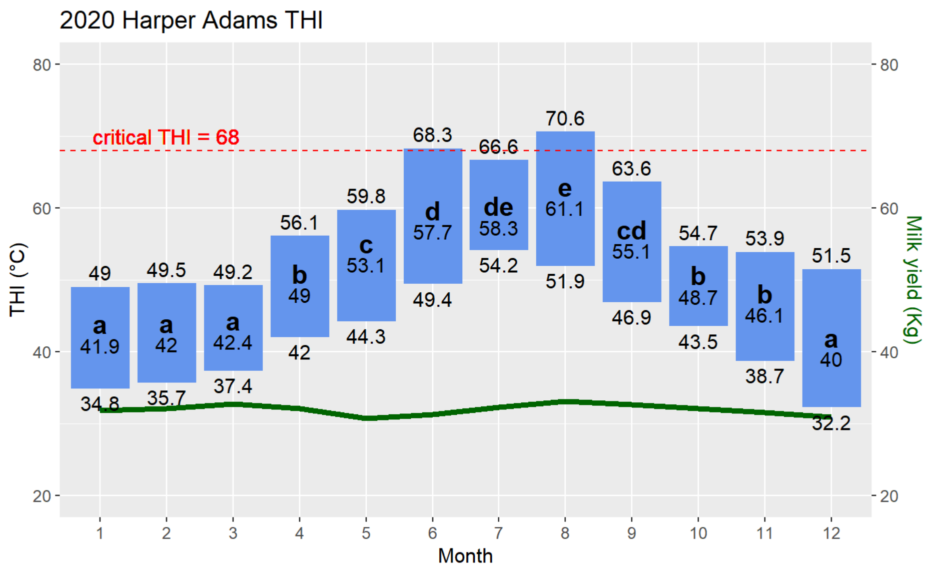


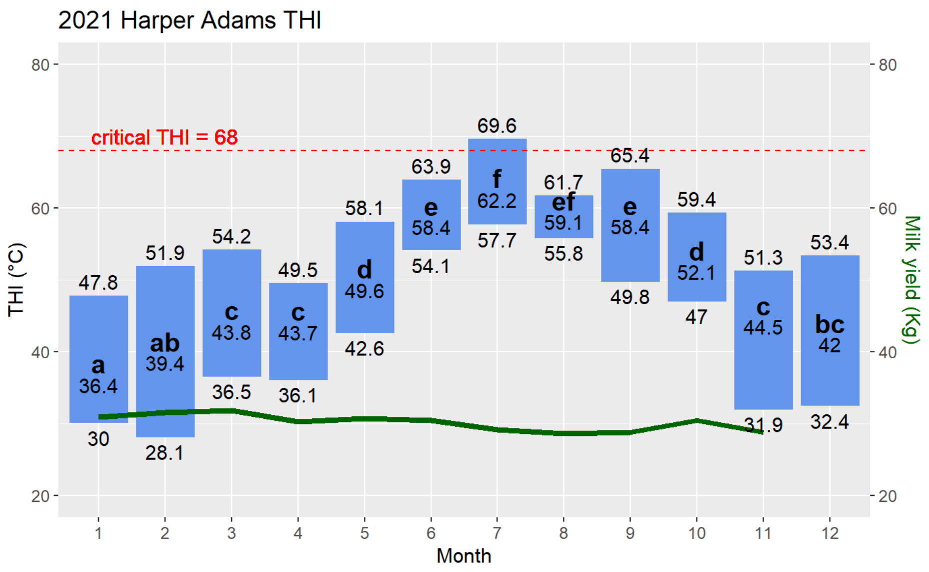
What does this look like in detail for a particular year?

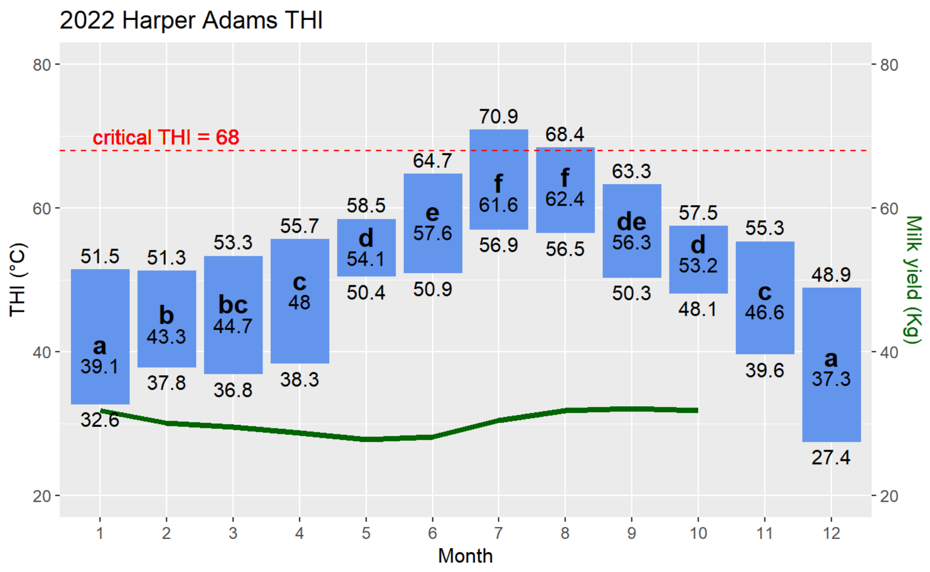


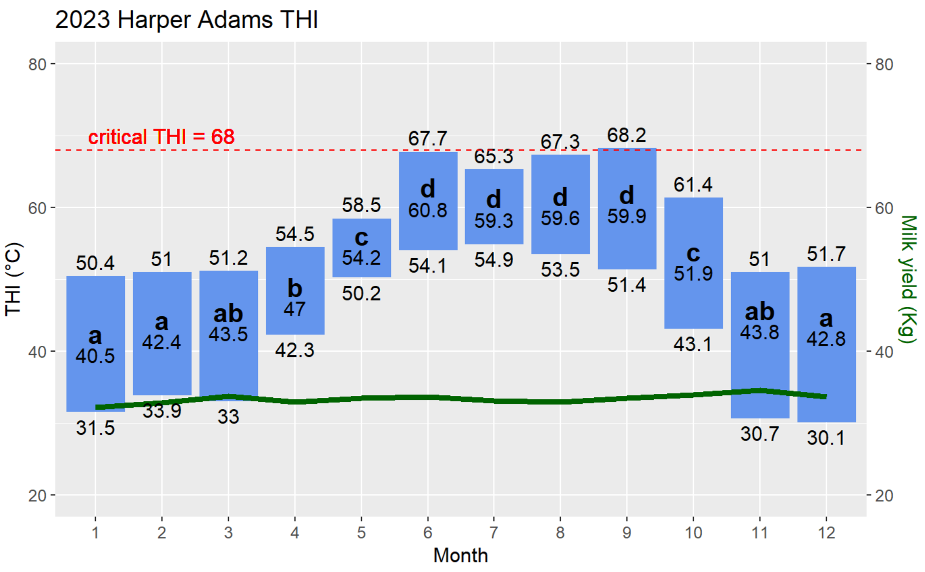
- THI and Yield graphs don't follow the predictions
- THI clearly changes over time
- Milk yield is variable but flat on average
- Need to correct for explanatory factors
- NB: we do not have individual cow info here like # calving

Other (whole) years



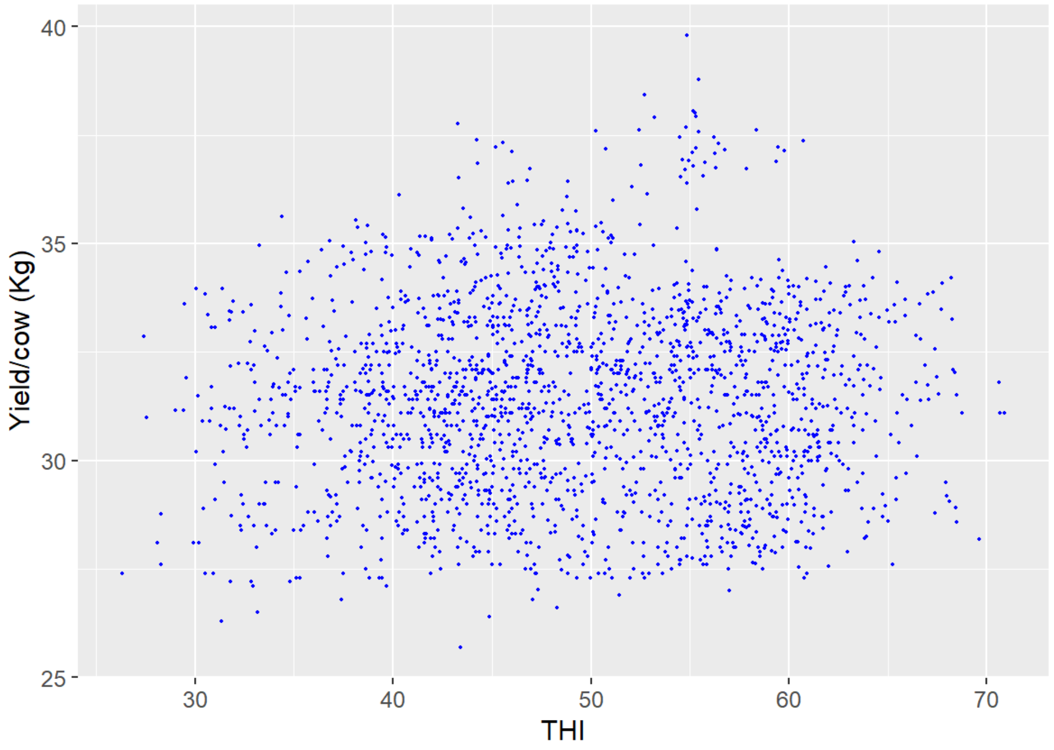






Crude views of the data are not helpful

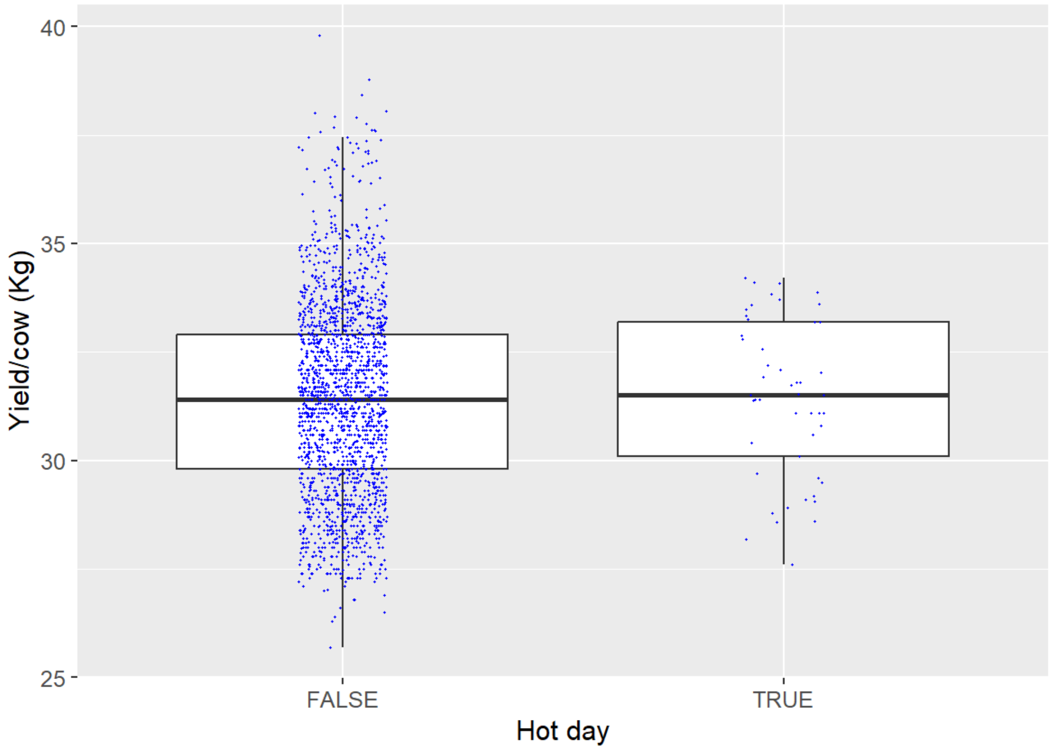
Correlation r = 0.03, P = 0.14



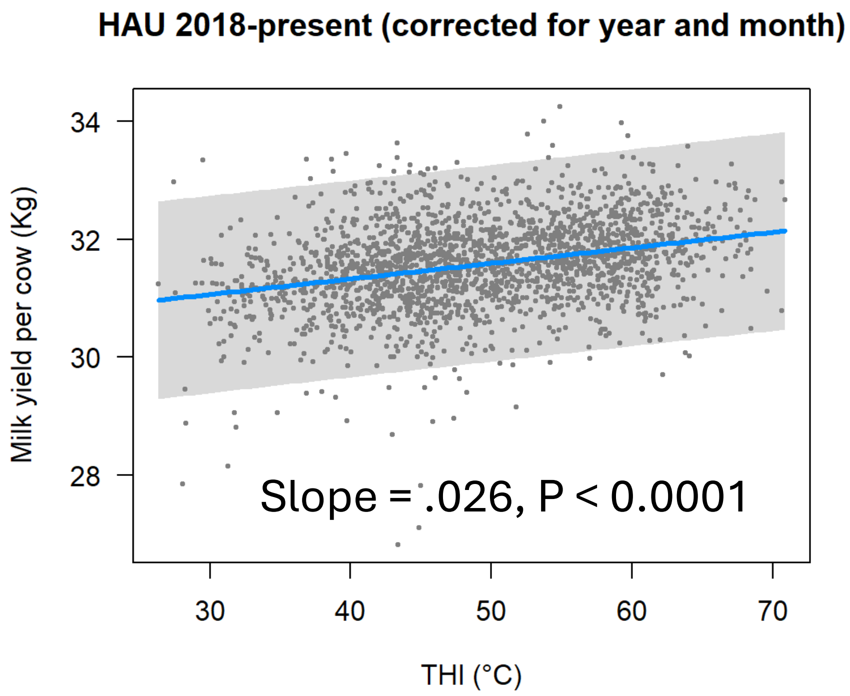
Mean yield = 31.41 Kg, 31.45 Kg

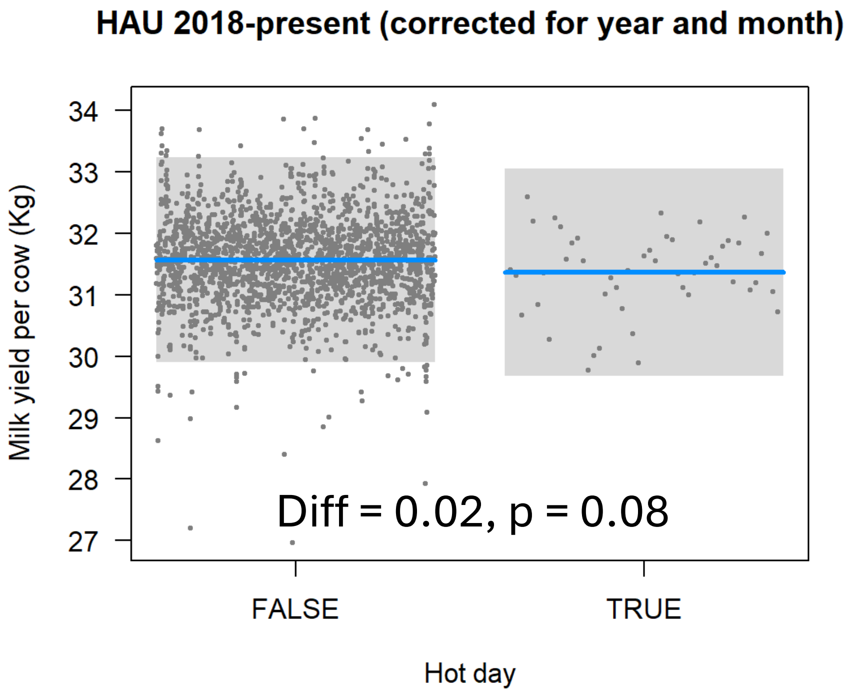
T-test t = -0.15, P = 0.88

NB slight positive difference



Mixed effect model





Month nested in year as random effects (year random effect = 71% variance)

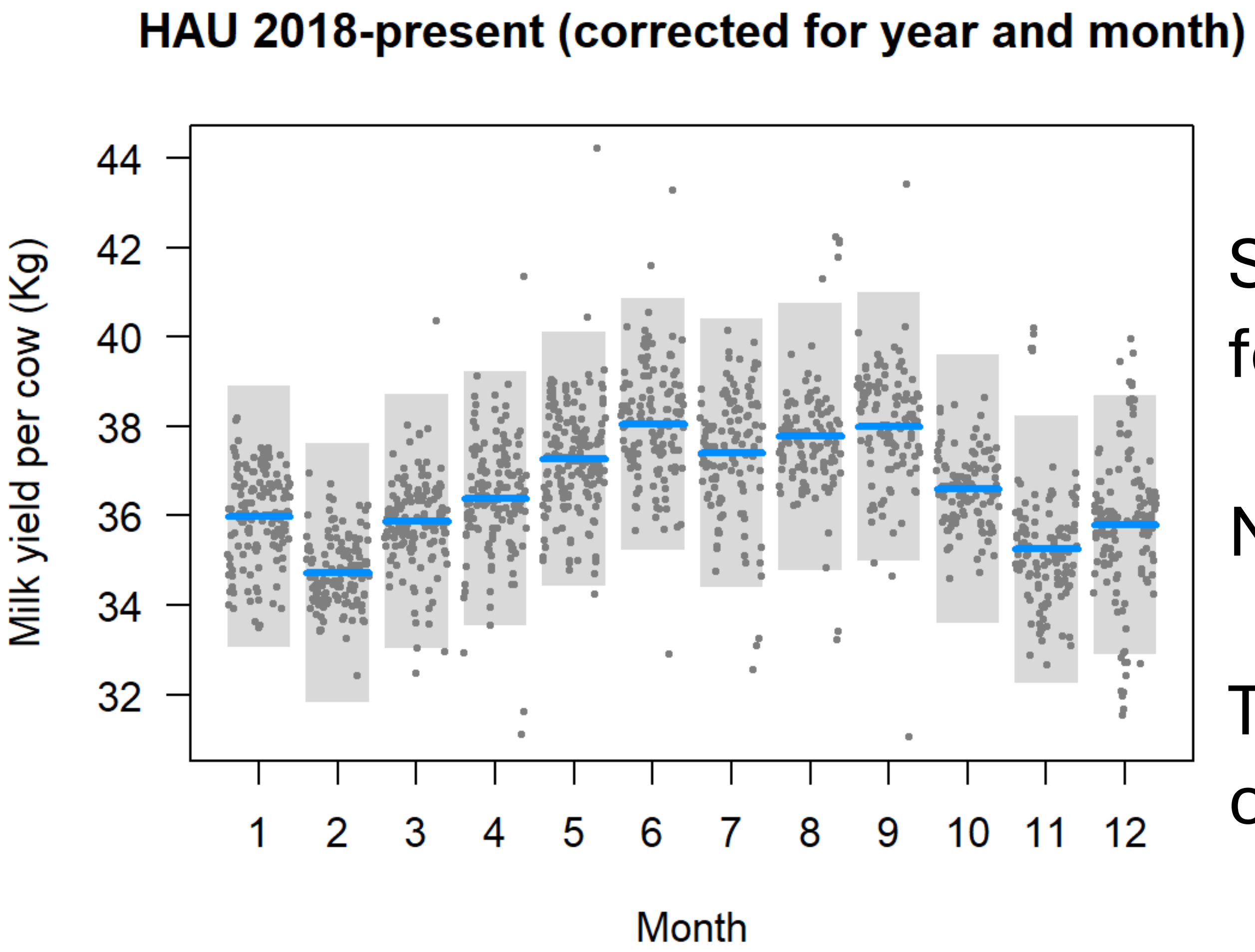
Significant positive relationship (opposite to prediction, at least for "hot countries")

Very small effect size (slope)

Best model Mixed effects

Random effects: month nested in year. Fixed effects: THI, “hot days” (above 68 THI), Year, Month

R squared = 89.4% variance in yield explained (“highs” only)



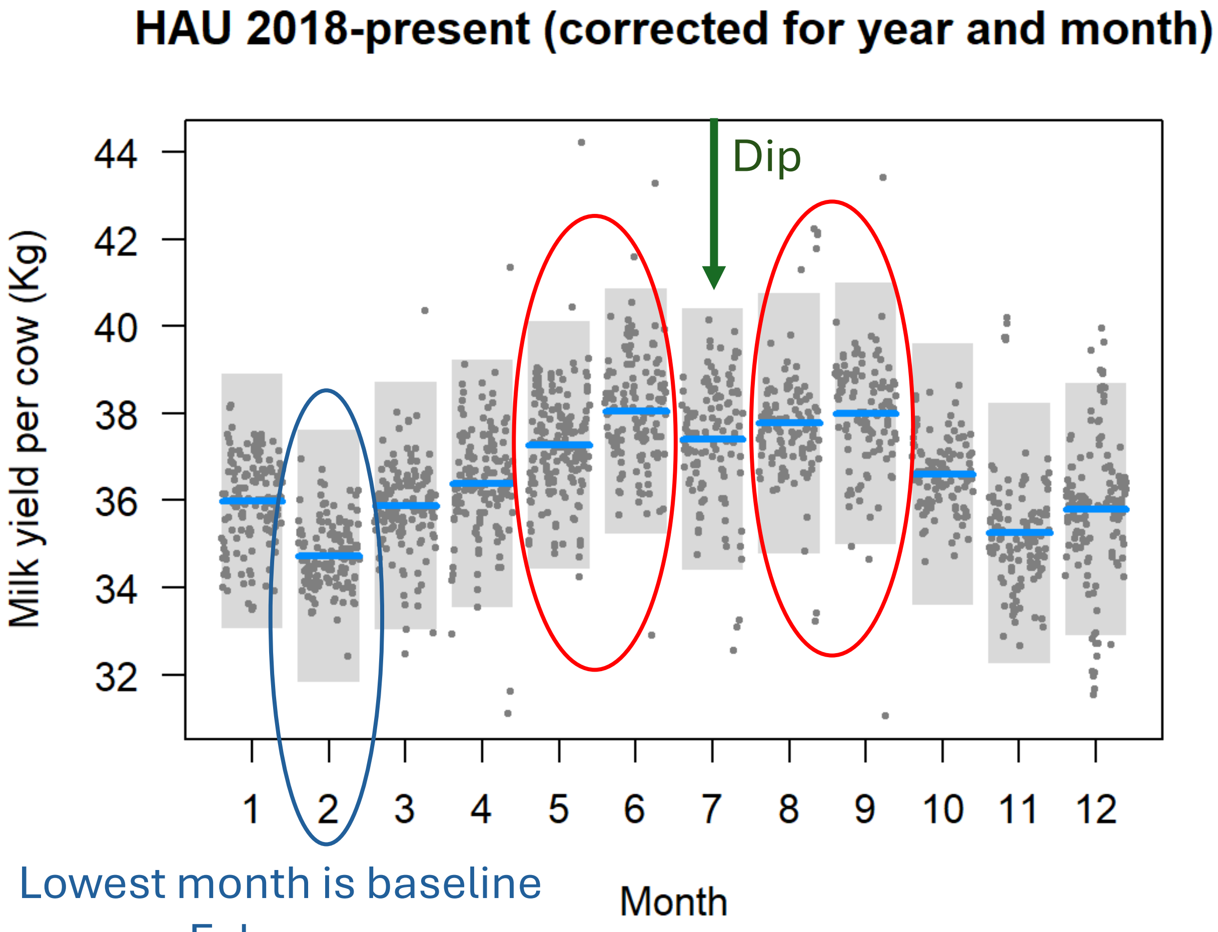
Strong monthly pattern correcting for year

NB scale and consistent variance

This pattern for “highs” is similar to other subsets

Best model

Mixed effects
Random effects: month nested in year
Fixed effects: THI, “hot days” (above 68 THI), Year, Month
R squared = 89.4% variance in yield explained (“highs” only)



Lowest month is baseline
February

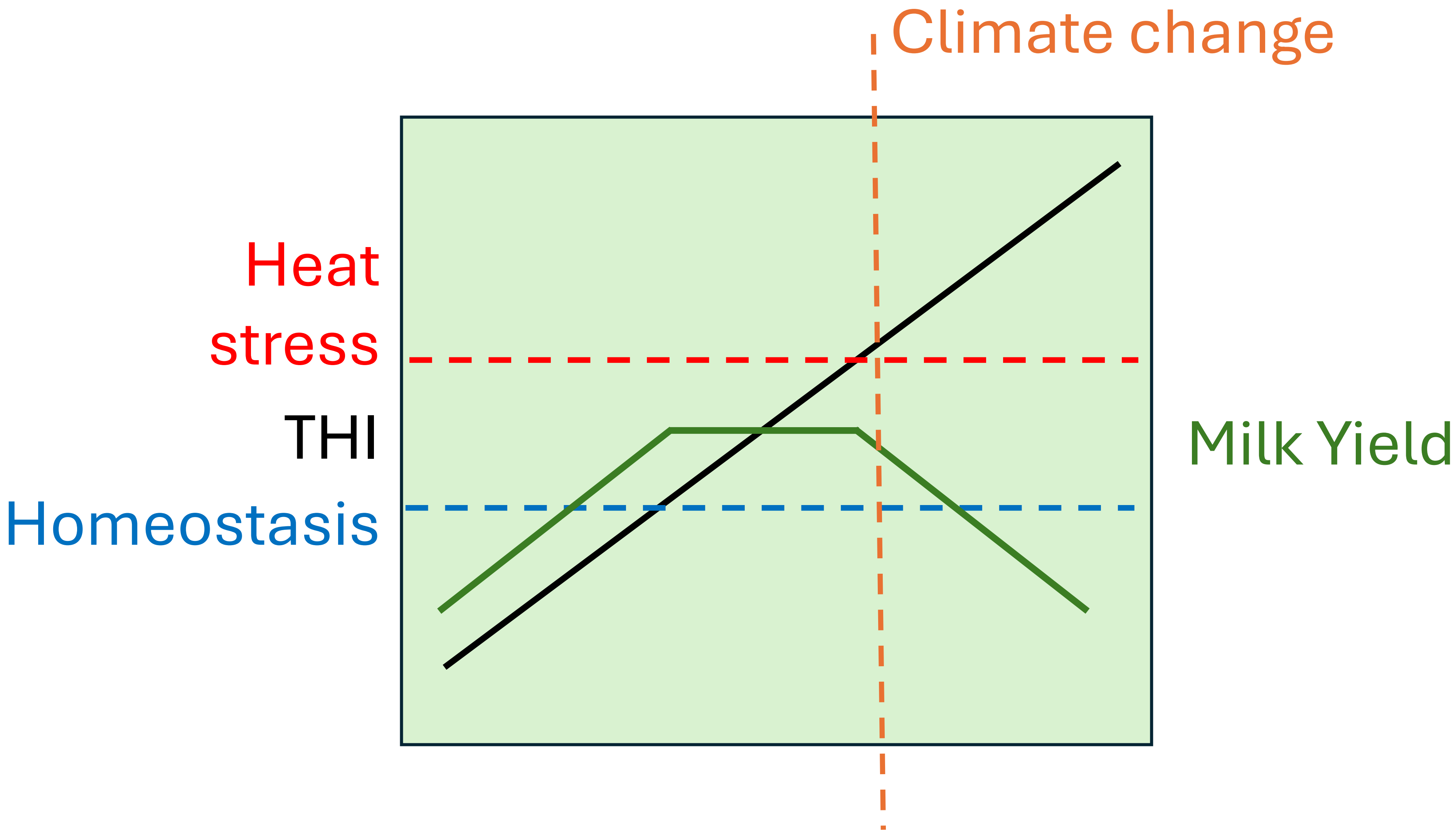
Coefficient Table

Regression Coefficients with Standard Errors and p-values

Month	Estimate	Std. Error	p-value
(Intercept)	30.48	1.59	1.00
MM1	1.25	1.29	0.34
MM3	1.13	1.22	0.36
MM4	1.66	1.22	0.18
MM5	2.54	1.22	[1] 0.04
MM6	3.32	1.20	[1] 0.01
MM7	2.67	1.32	0.05
MM8	3.04	1.32	[1] 0.03
MM9	3.27	1.32	[1] 0.02
MM10	1.87	1.32	0.16
MM11	0.52	1.32	0.70
MM12	1.06	1.23	0.40

[1] Significant p-values (< 0.05) are highlighted in red.

Hot days in cool countries, a different heat stress model

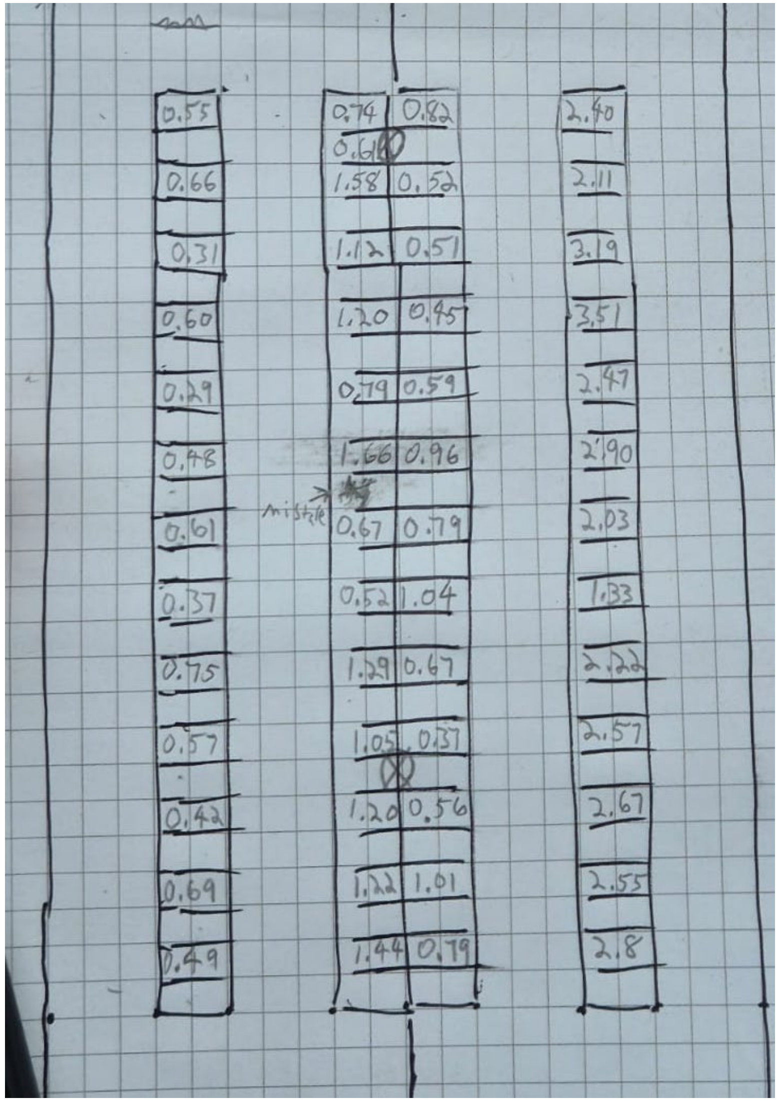


Some evidence of **dip in productivity** due to **heat stress**

0.6 Kg difference in dip from highest yield is **18% smaller yield** compared to lowest productive months

Threat of **increase in extreme weather events**, an increase in detrimental animal welfare conditions, and impact to productivity in an economic climate when farm efficiency is paramount

Mitigations at Harper Future Farm include “ceiling fan” arrays and monitoring to determine effectiveness



Conclusion and Implications

- Heat stress significantly impact on milk yield.

- Mitigation strategies needed in warmer months.

- Further work to explore on the impact on other production, health and welfare parameters.

Acknowledgements

- Harper Adams University Future Farm for providing data
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References

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