PRESENTATION

Session:
Cotton Quality And Testing

Title:
Stickiness and fiber characteristics related to fiber processing efficiency and yarn quality

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Stickiness and fiber characteristics related to fiber processing efficiency and yarn quality

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Stickiness:
what is it, what are the incidences? (1/3)

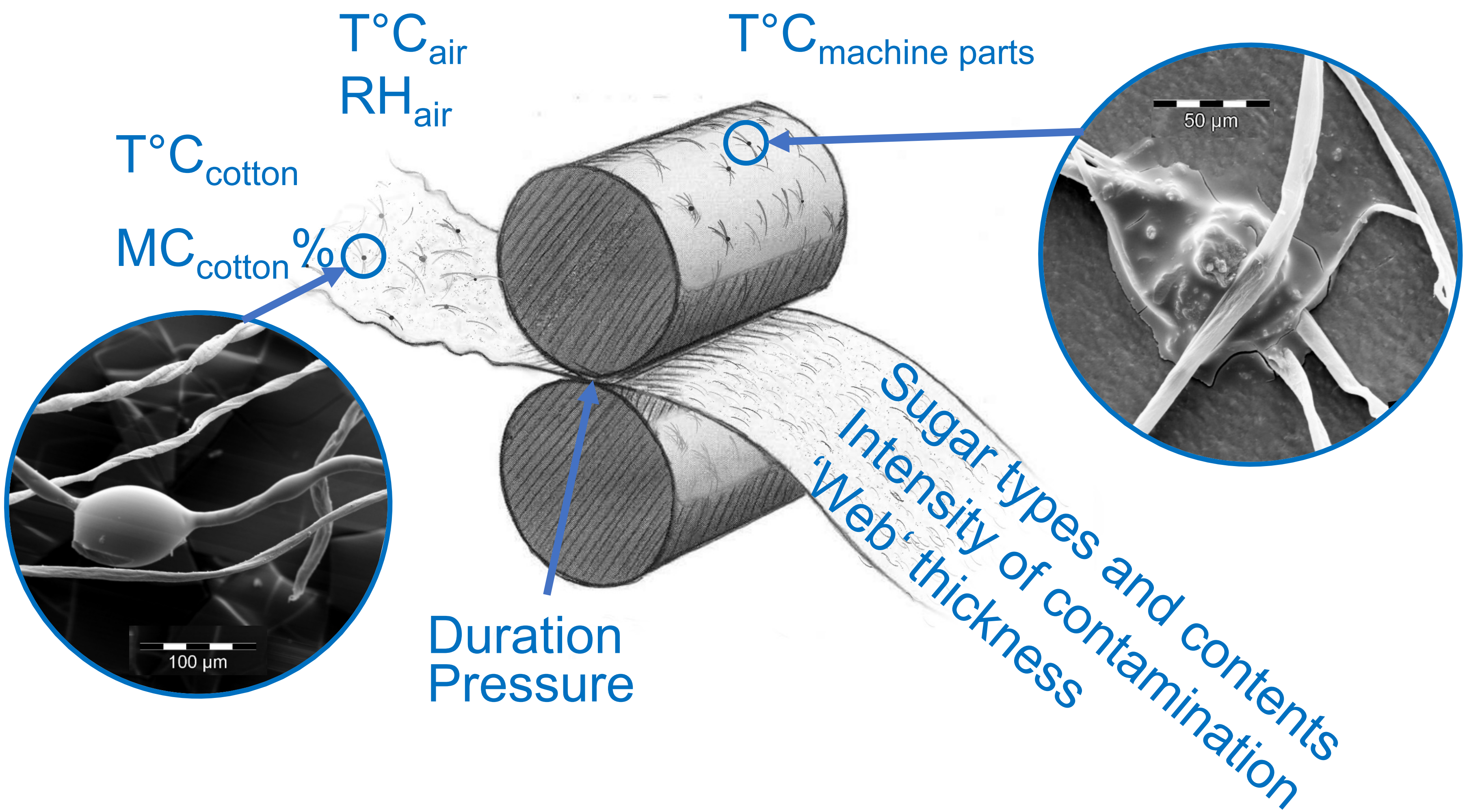
- Deposits from insect honeydew mainly onto fibers; composed by several individual sugars

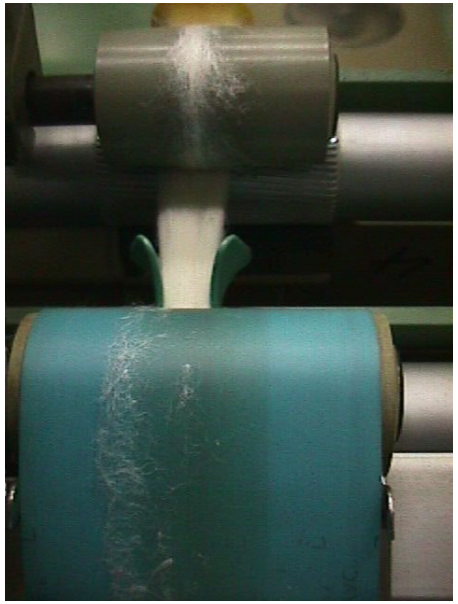


Pictures by Cirad

Presented in 2021 already

Stickiness:
what is it, what are the incidences? (2/3)





Presented in 2021 already

Illustration by Lena Kölsch, FIBRE

Stickiness:
what is it, what are the incidences? (3/3)

- Fibers + honeydew stick on machine parts such as cylinders
- Rolling-up and breaks affect spinning productivity (lower turnout)
- Un-evenness affects yarn quality
- Economical incidences (claims, discounts, reputation)

- Solutions exist
  - Choose cottons according to their stickiness
  - Blend origins in various percentages
  - Change spinning mills conditions: temperature and relative humidity

➔Need reliable measurements

Stickiness: Measurements and harmonization of results

ITMF-ICCTM Harmonization of Stickiness measuring methods (SMM)

- Based on periodic international round-tests (RTs), thermo-mechanical Methods* demonstrated as valid for further steps

- Based on well-known materials having reference information to which all results could be compared to

- Based on which reference Method?
  - Mini card (not made anymore, not precise enough, …)
  - Which thermo-mechanical method among others? Why? How?

* Cirad-H2SD; Cirad-SCT; Mesdan Contest-S with reference to ITMF-ICCTM minicard test

Stickiness: Measurements and harmonization of results

Decision (Bremen 2021):

- A good Stickiness Measurement Method (SMM) must be related to Stickiness in Practice (SIP) as recorded during spinning tests
- SIP is based on spinning productivity and yarn quality characteristics
  - Is there data about spinning using sticky materials?
  - Is there any published prediction equations?

➔ What are the known impacts of stickiness on spinning productivity and yarn quality characteristics?

Stickiness: Impacts on spinning productivity and yarn quality characteristics

Requirements:

- Spinnability of sticky materials with measured stickiness level
- Measured spinning productivity and yarn quality characteristics
- Microspinning and/or industrial spinning experiments

Questions raised:

- Are microspinning experiments valid to predict industrial spinnability?
- Are fiber characteristics and/or stickiness found as predictive of spinnability (in research and industrial contexts)?

Stickiness: Impacts on spinning productivity and yarn quality characteristics

- Microspinning experiments vs industrial spinnability

  ➔Microspinning results predict well industrial RS spinning process (when no or few contaminants)

  Balls W. L. (1920), Landstreet et al. (1959, 1962), El-Sourady et al. (1974), Krifa et al. (2003, 2005, 2006), Frydrych et al. (1999)

- Fiber characteristics (research and industrial)

  ➔Suitable relationships exist (not taking care of stickiness)

  Ramey Jr et al. (1977), Ethridge et al. (1982), Gutknecht J. (1984), Drean et al. (1991), Frydrych et al. (1991, 1993), Deussen & Faerber (1995).

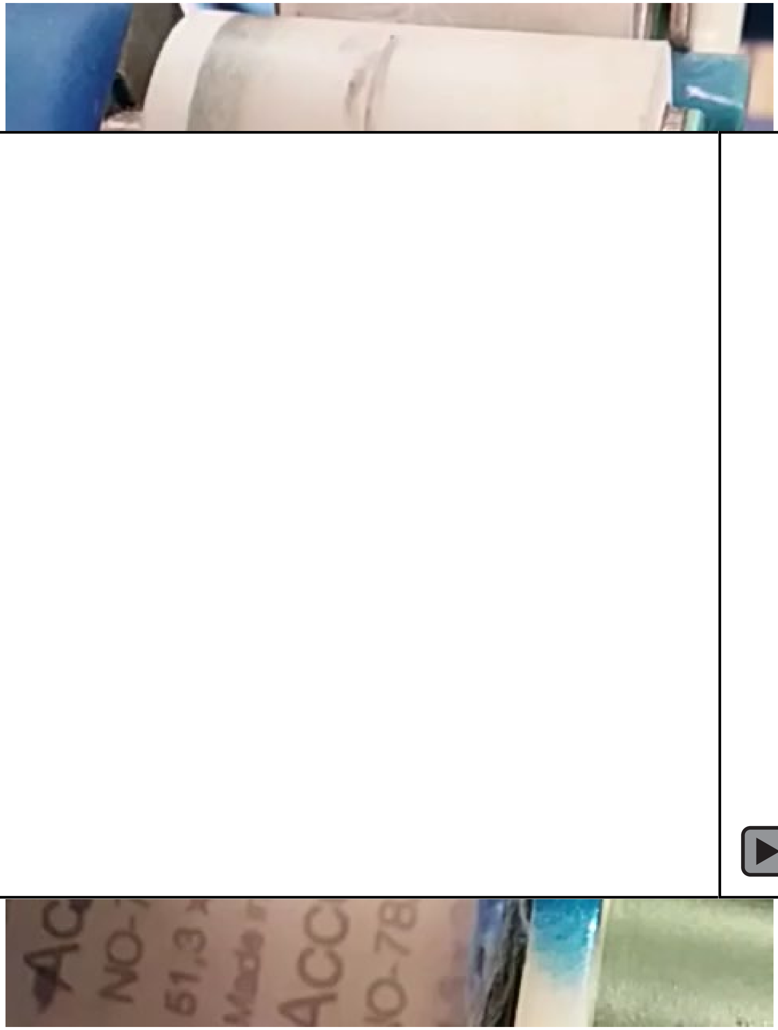
- Stickiness alone (research and industrial)

  ➔Suitable relationships exist (not taking care of fiber characteristics)

  Fonteneau-Tamime, Frydrych et al. (2001), Hequet et al. (2007), Gourlot et al. (2016)

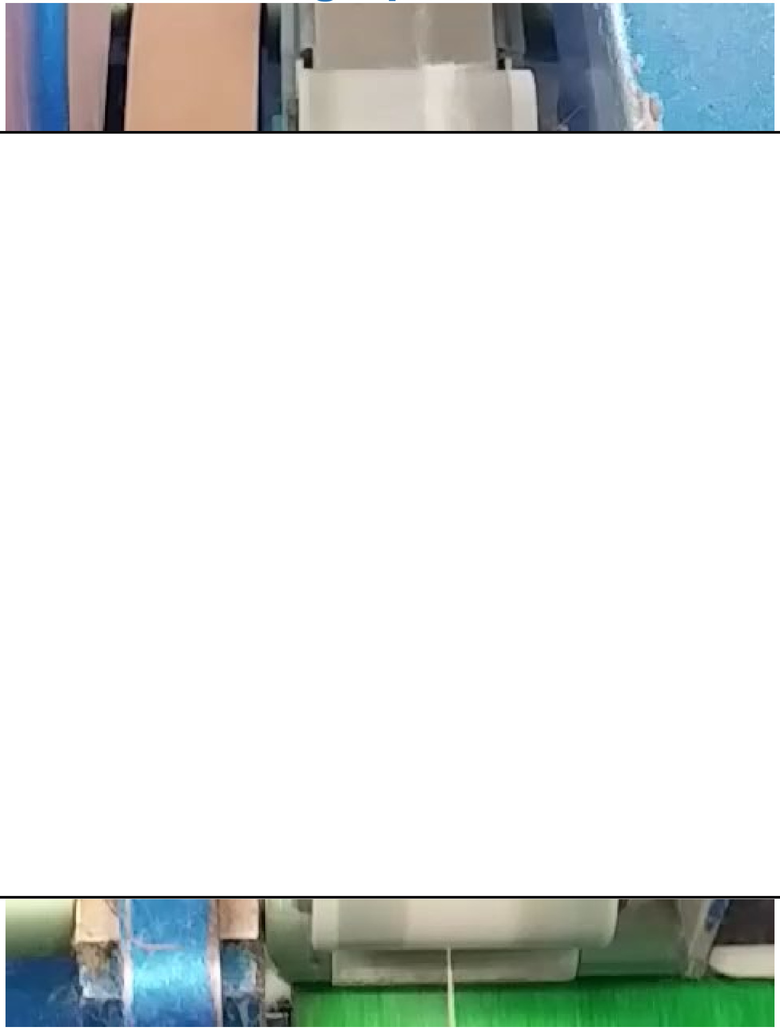
When we see these videos, may other answers exist?

Attachment



Attachment & release

Rolling-up & break

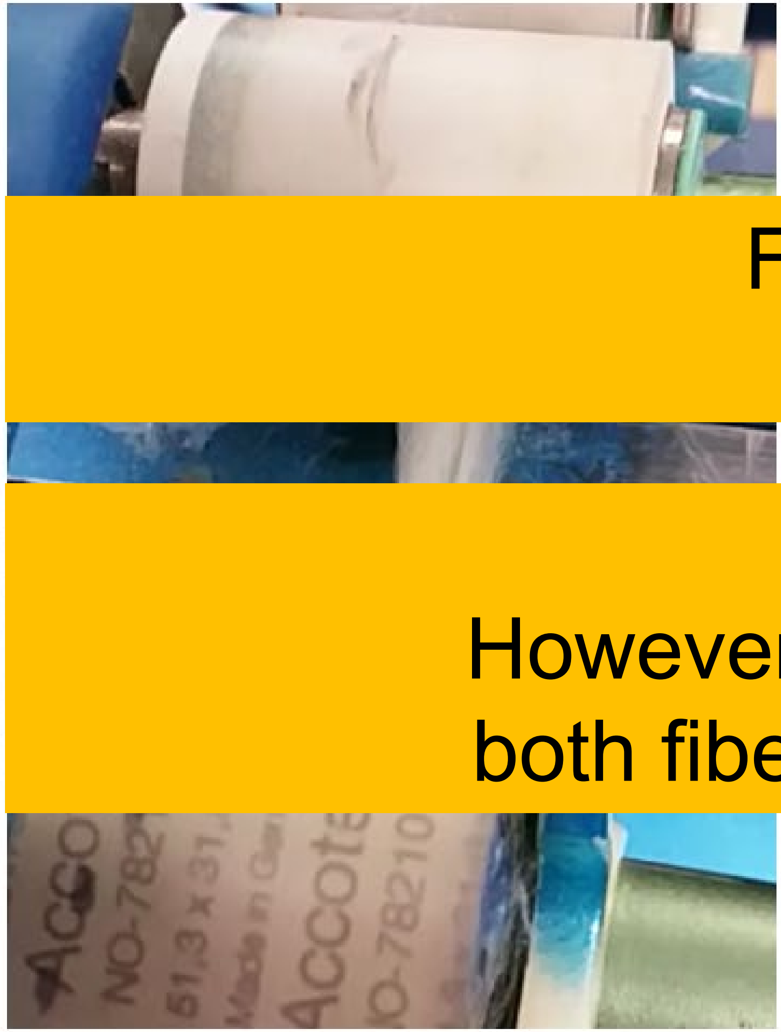


Microspinning, Cirad-LTC, ring-spinning, 20 tex yarn, 23°C & 55%RH

All captures by Gourlot J.P., 2020 reprocessed in 2024

When we see these videos, may other answers exist?

Attachment



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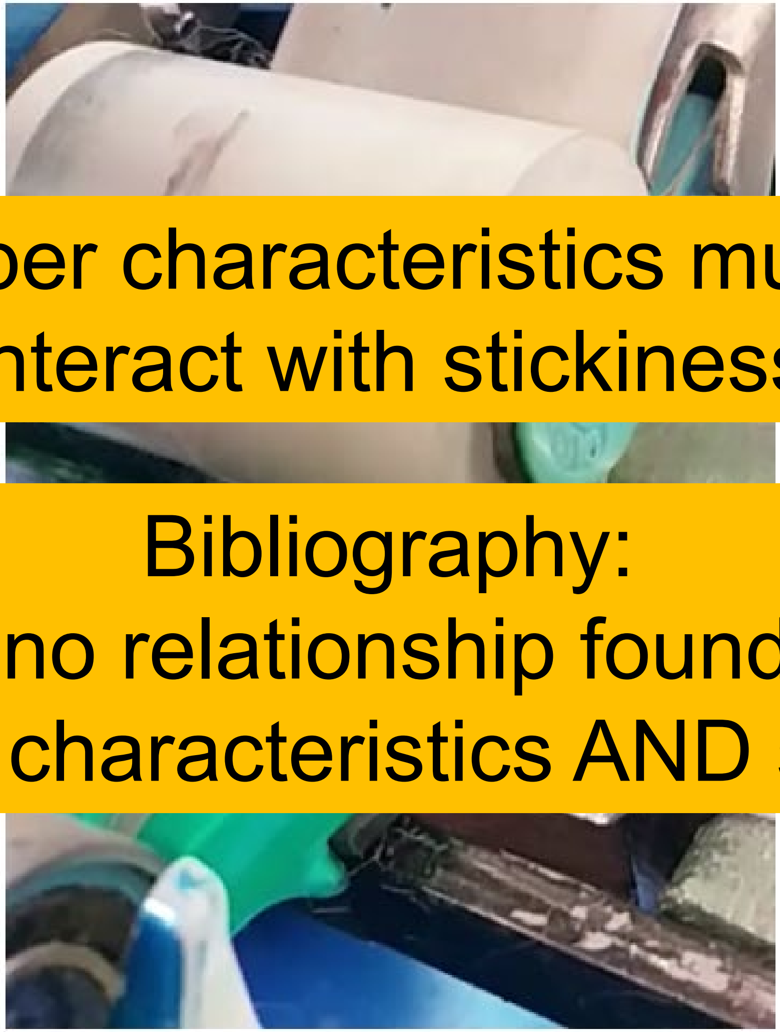
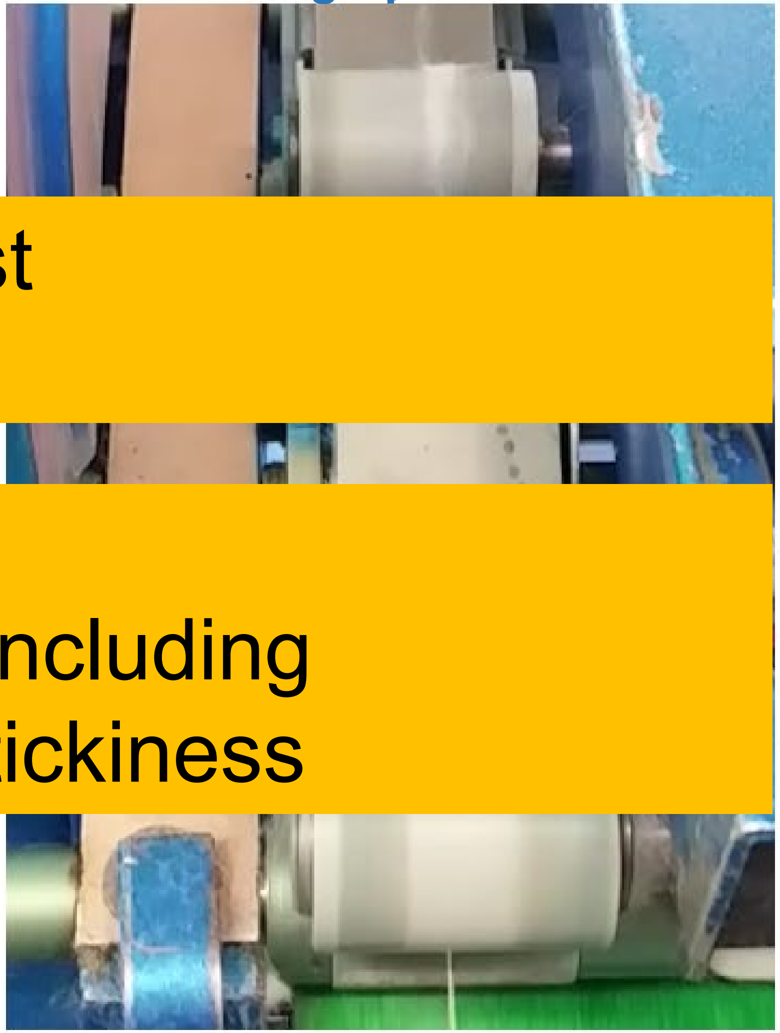


Rolling-up & break



Fiber characteristics must interact with stickiness

Bibliography:
However, no relationship found including both fiber characteristics AND stickiness

Microspinning, Cirad-LTC, ring-spinning, 20 tex yarn, 23°C & 55%RH

All captures by Gourlot J.P., 2020 reprocessed in 2024

Objective of this research

To check if the association of fiber characteristics and stickiness results in better explaining

- spinning productivity
- yarn quality characteristics

Experimental design

- 53 cottons
- Covering stickiness & fiber characteristics ranges
- Micro ring-spinning
- 55 or 58 %RH
  (maximizes stickiness impacts)
- 20 tex (Ne 30, Nm 50)
- Planned 2 replicates

➔ 53 * 2 = expected 106 lines

Laboratory opening machine

2 x 1 fleece
(L=1.75m each; tex=31000)

Mini-card

2 x 1 fleece
(L=1.75m; tex=57200)

Drawing frame, pass 1

2 x 5 slivers
(L=3.35m each; tex=5800)

Drawing frame, pass 2

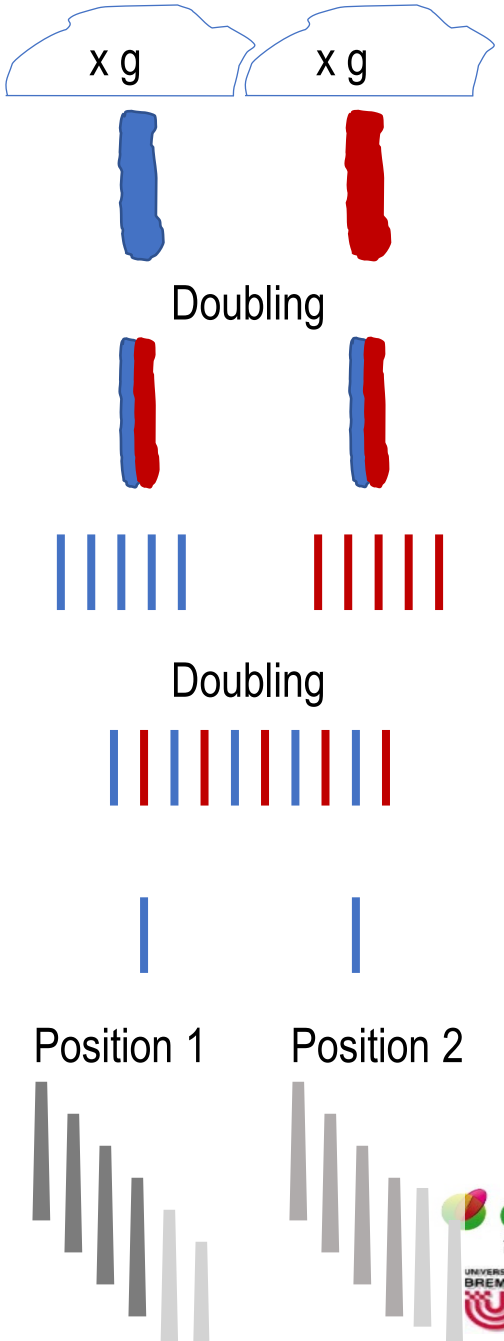
10 slivers
(L=3.35m each; tex=2900)

Drawing frame, pass 3

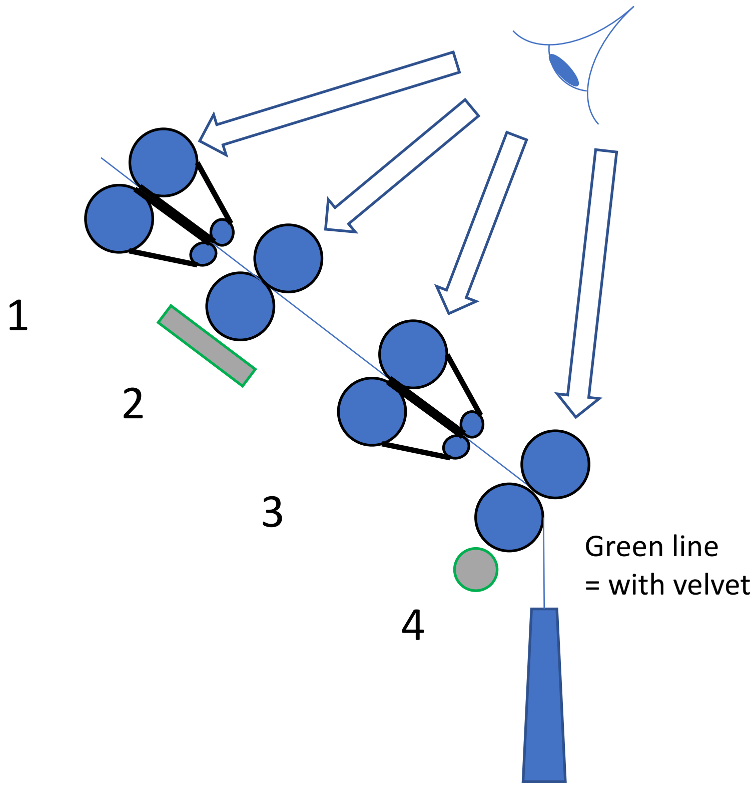
2 slivers
(L=37.40m each; tex=2300)

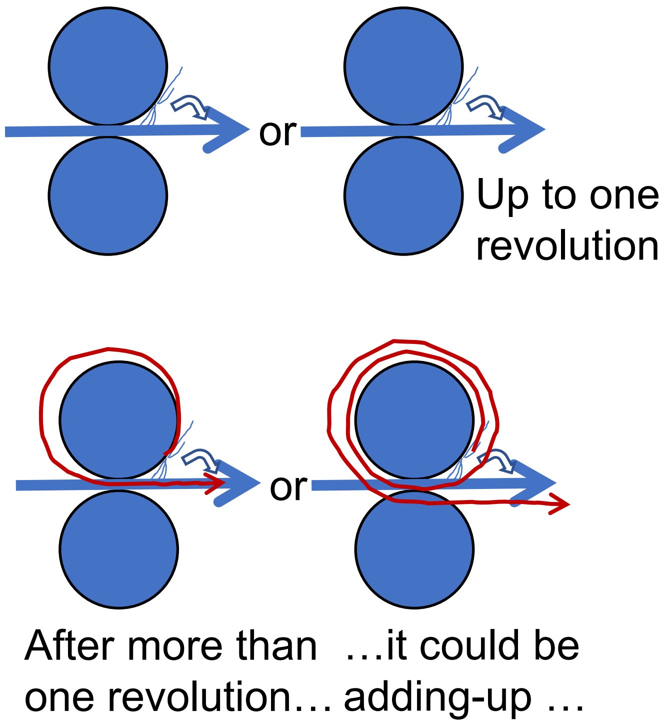
Spinning frame

n bobbins
(L=500 m each; tex=20)



Experimental design: productivity records → Y





= Attachment (A)
Requires no human intervention
No machine stop

= Rolling-up (R)
Requires human intervention
to continue production of yarn
No machine stop

+ breaks (B)
Machine stop

+ required cleanings (C)
Machine stop

Number of events at spinning frame = A+R+B+C

(computed by km of yarn)

Experimental design: productivity records → Y

A: Attachment
R: Rolling-up
C: Cleaning
B: Break

Spindle	Doffing		A	R	C	B	
Pos	Lev	Code	Soulèvement	Enroulement	Nettoyage	Casses	Commentaire
1	1	11	0	1	0	0	Hdeb : 7h04 HFin : 7h53 Cpt : 6245 23,1°C 54,9%
2	1	21	0	1	0	0	11,0 11,5 22,5 tex
1	2	12	0	1	0	0	Hdeb : 7h57 HFin : 8h47 Cpt : 6245 23,2°C 54,7%
2	2	22	0	0	0		10,4 9,8
1	3	13	0	1			
2	3	23	0	2			
1	4	14	0	0	0		
2	4	24	0	0			

			A	R	C	B	
Pos	Lev	Code	Soulèvement	Enroulement	Nettoyage	Casses	Commentaire
1	1	11	11	15	0	17	Hdeb : 7h15 HFin : 8h23 23,3°C Cpt : 6241 52,6%
2	1	21	15	19	0	3	10,3 9,2 19,5 tex
1	2	12	8	14	0	4	Hdeb : 8h26 HFin : 9h23 23,3°C Cpt : 6249 54,0%
2	2	22	10	16	0	0	9,7 10,3 20,2 tex
1	3	13	10	12	0	9h46 10h20 3	Hdeb : 9h26 HFin : 10h54 Cpt : 6253 23,3°C 54,6%
2	3	23	7	13	0	0	9,6 11,7 21,4

Experimental design: yarn quality records → Y

- **Evenness Tester*:** CV(%), thin (nb), thick (nb), neps (nb),…
  100 m * 2.5 min / bob.

- **Dynamometer**:** yarn tenacity (cN/tex), elongation (%), …
  100 breaks / bob., 5000 mm/min, 500 mm gauge length

> 1500 individual data lines

* Uster UT3 ** Uster Tensorapid 3

Experimental design: fiber quality records → X

- SITC*: UHML(mm), ML (mm), UI%, Strength (cN/tex), elong (%)

- Fineness Maturity Tester**: Micronaire, maturity ratio, linear and standard fineness
  (cleaned fibers)

- Stickiness***: Number of sticky points

* Uster Technologies HVI1000/700 ** SDL Micromat *** Cirad-H2SD

Dataset and studied characteristics

106 expected lines of averages, but Covid & lab. constraints

→ **81 available data lines of averages**

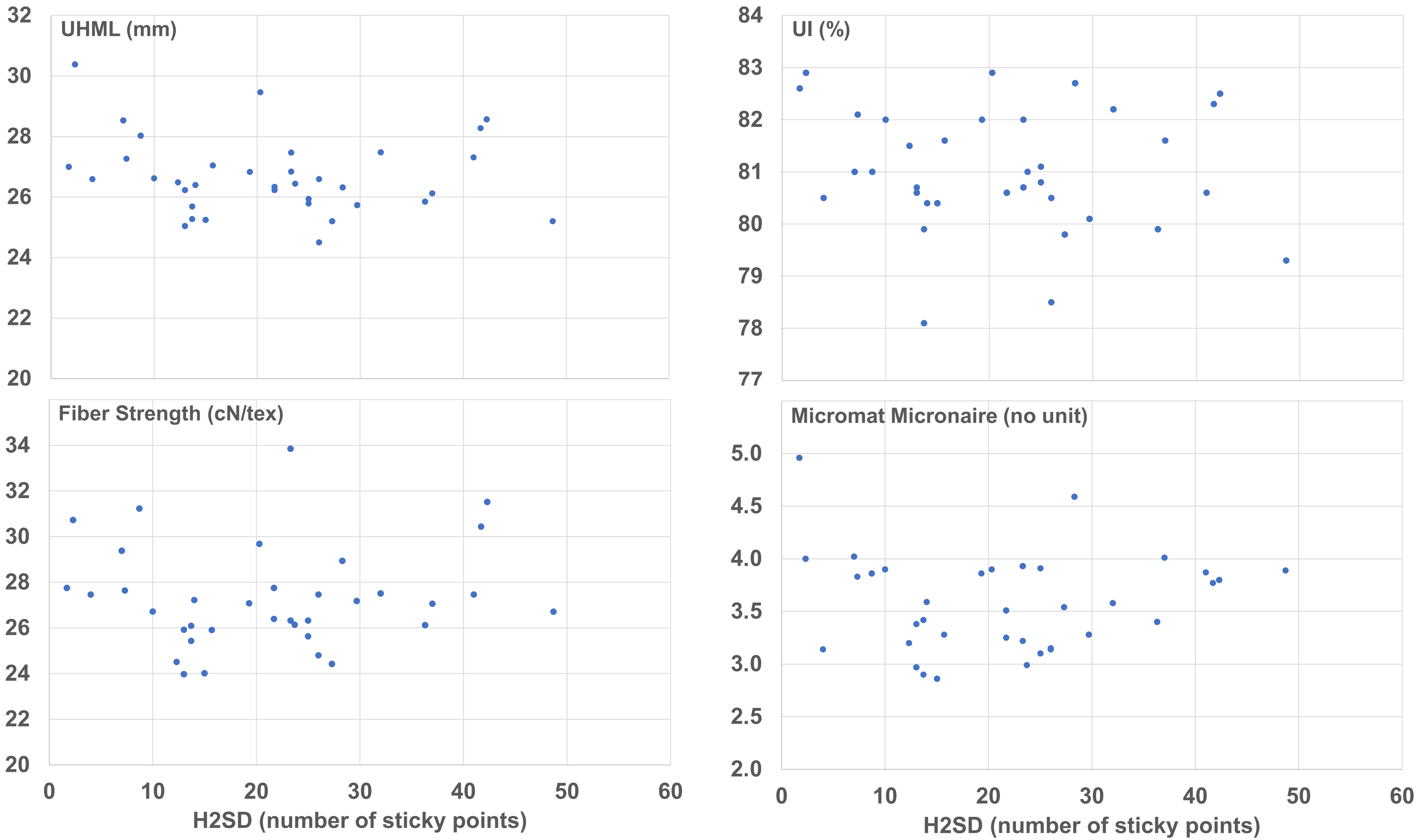
- Considered spinning and yarn characteristics (explained variables Y)
  - Productivity indicator: **number of events / kilometer of yarn**

    Needs to transform raw counts into 'square roots of number of events per km'

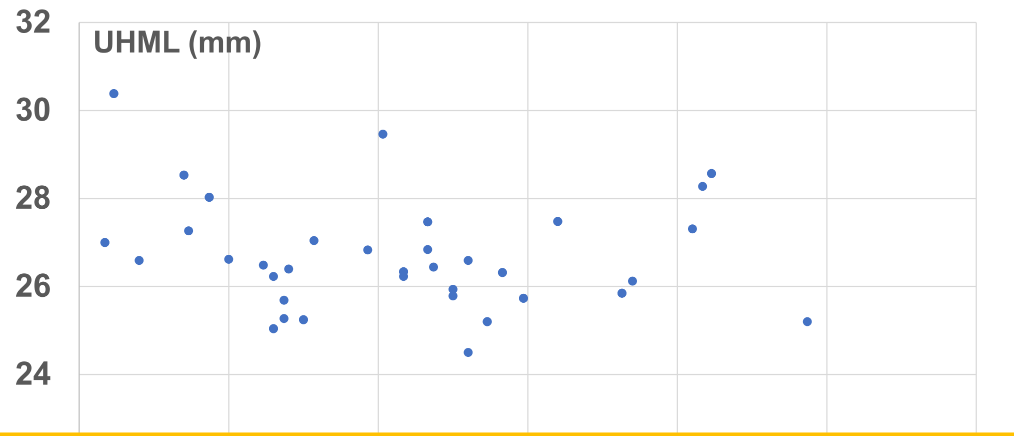
  - Quality indicator: **yarn tenacity (cN/tex)**

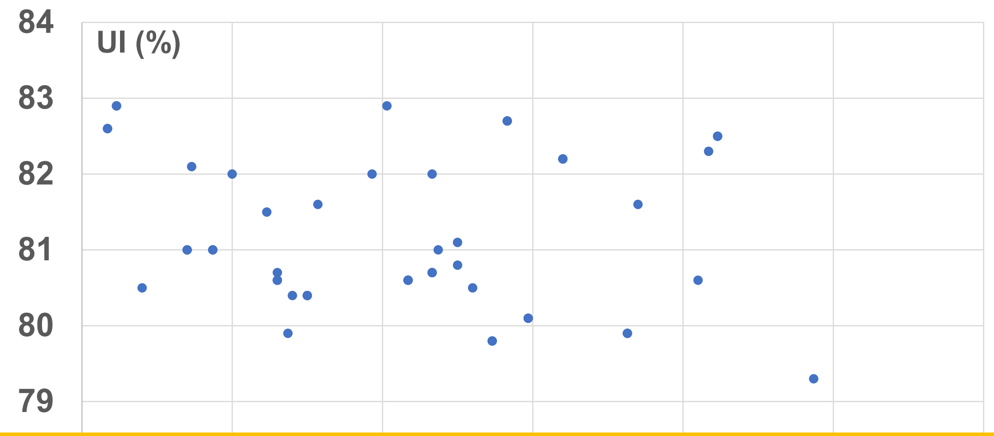
    Integrating characteristic or proxy for other yarn quality characteristics

Results: fiber characteristics → X



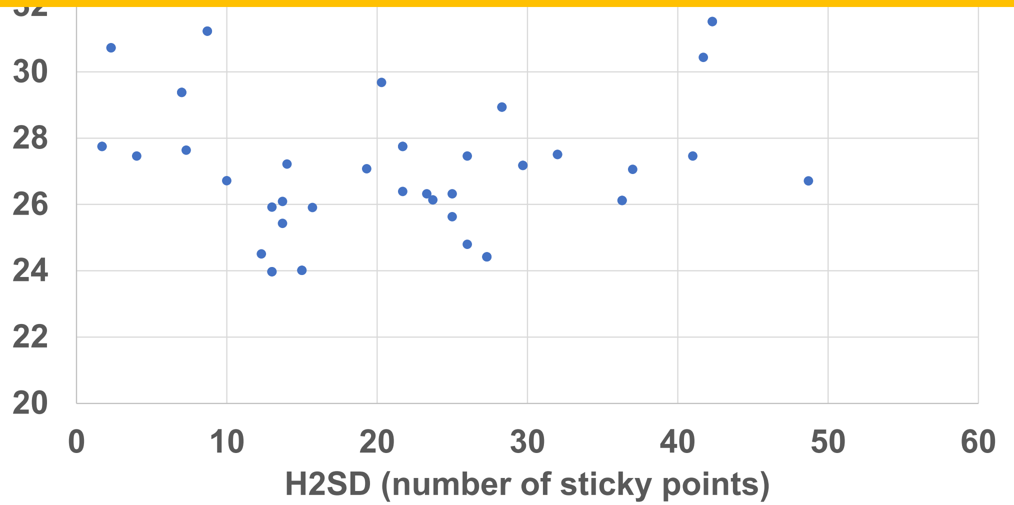
Results: fiber characteristics → X

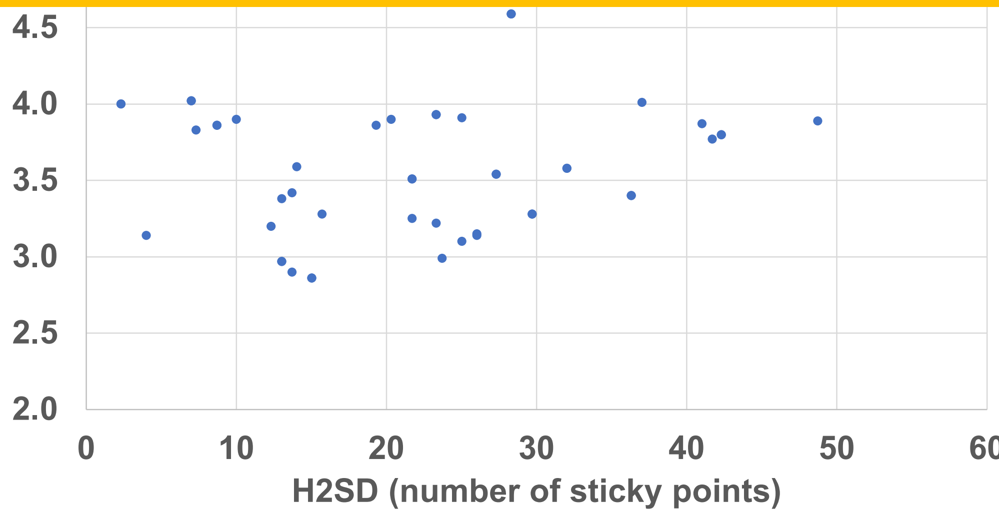




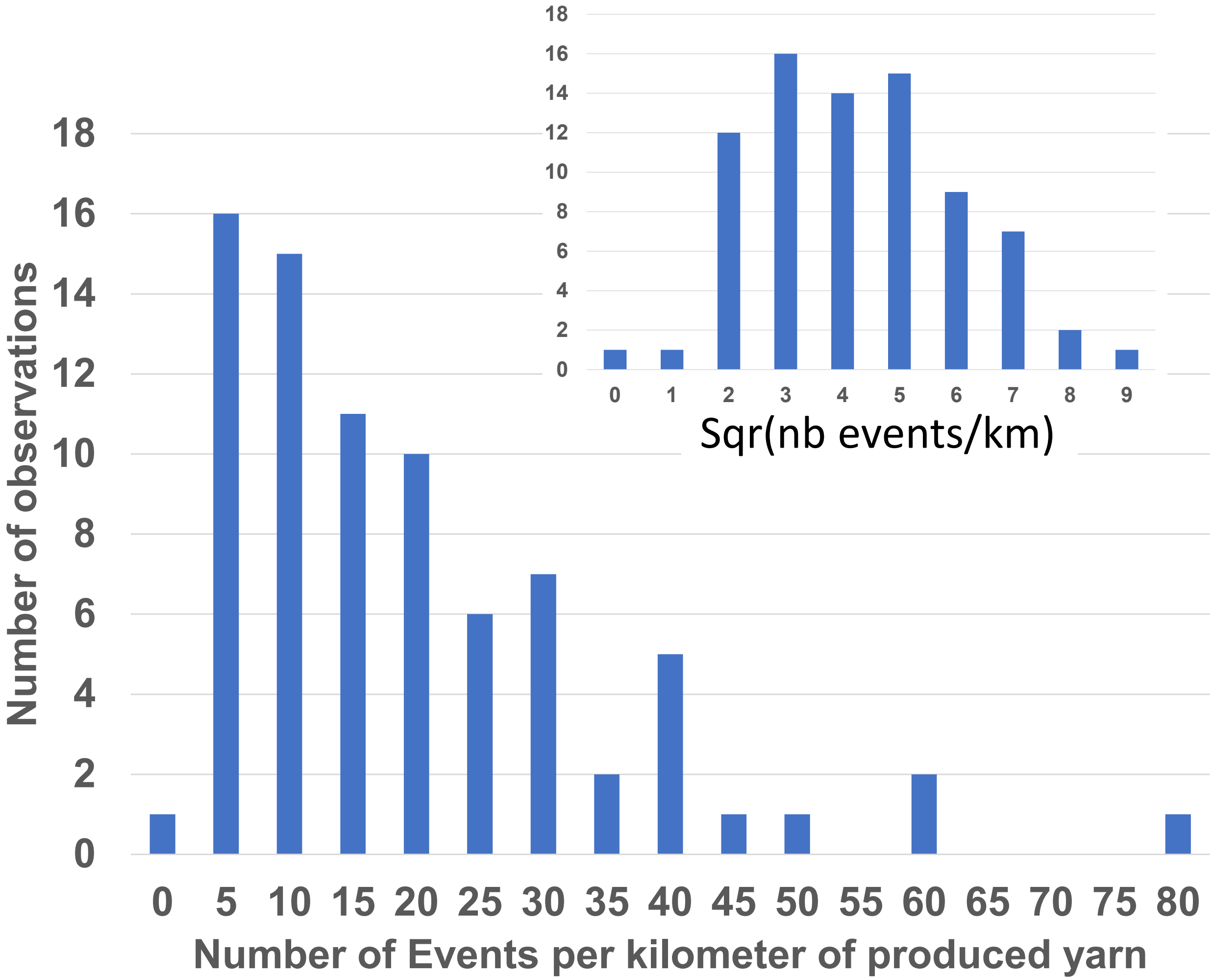
Wide ranges of fiber characteristics

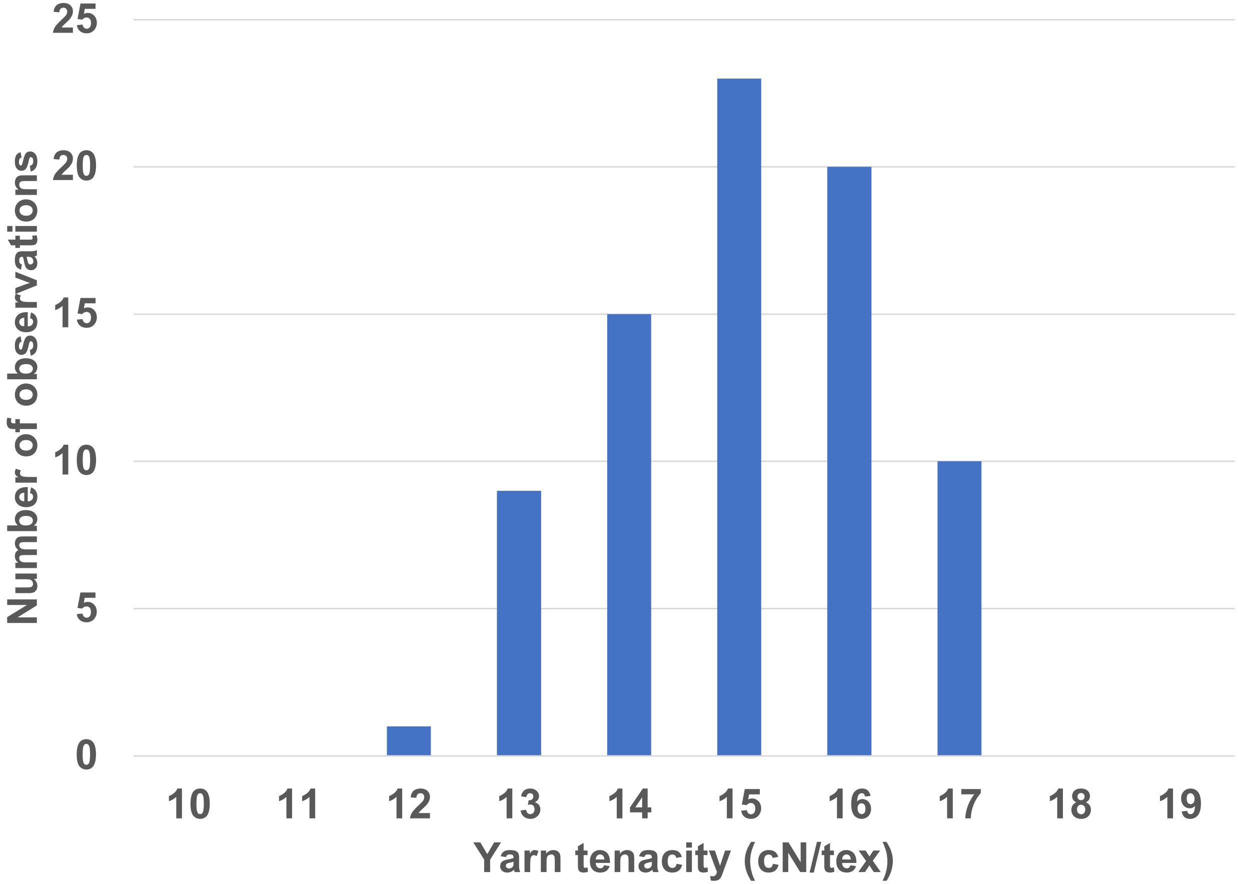
Independency from stickiness level



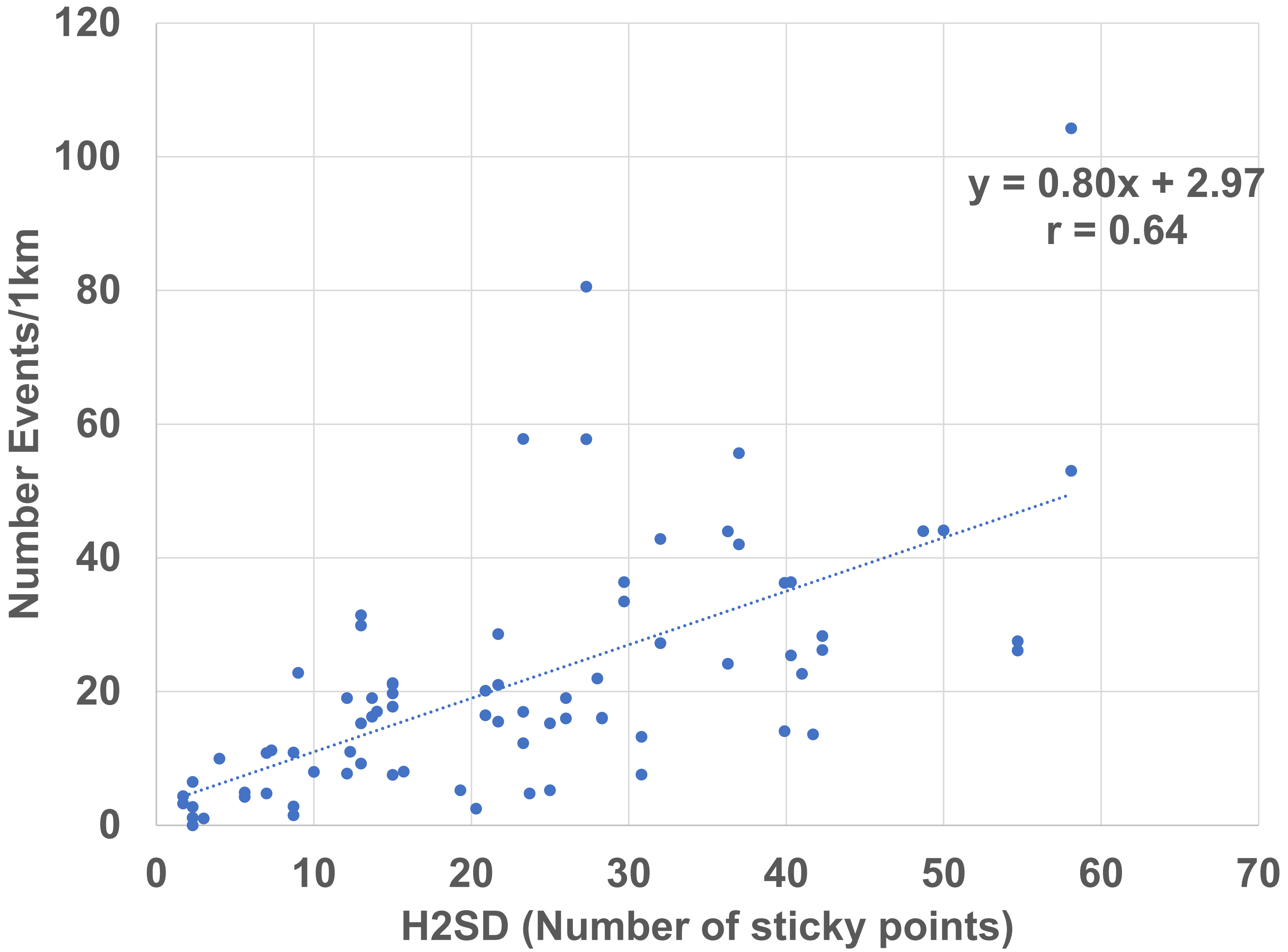


Results: productivity & yarn quality → Y





Simple model: number of events/km *vs* sticky points

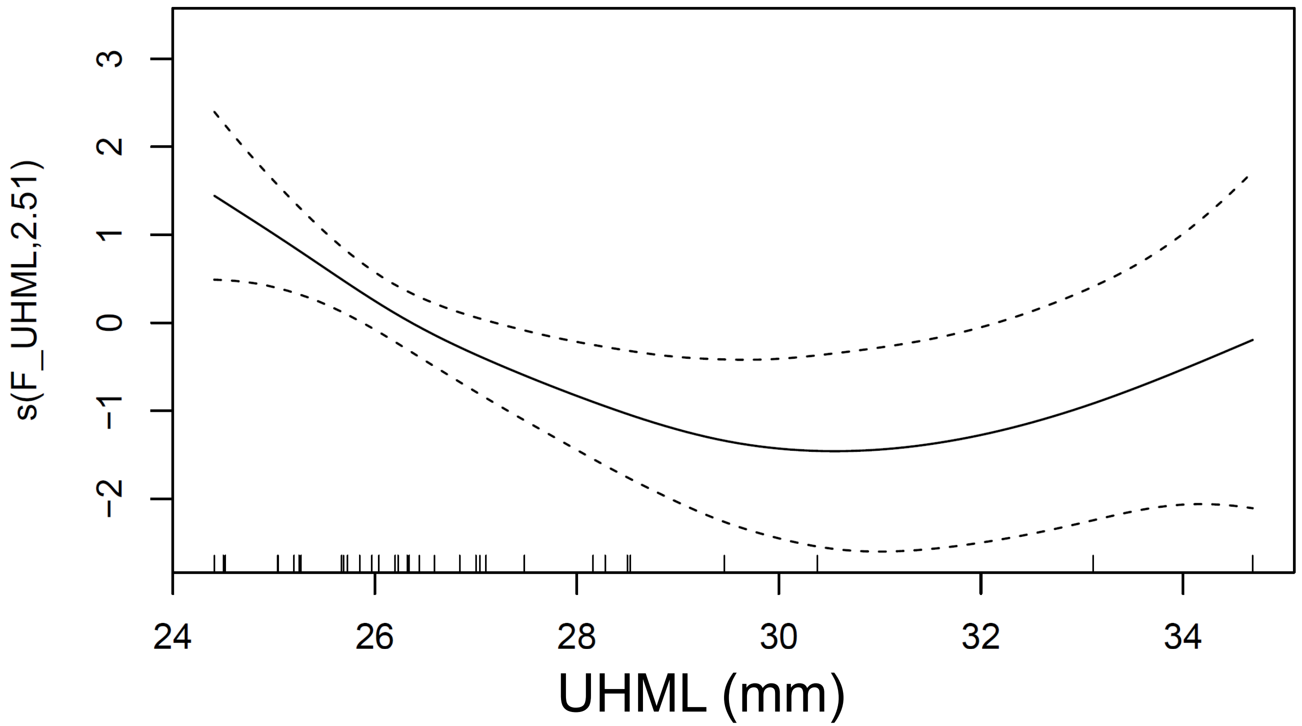


Complex model: number of events / km (sqr)

- Training dataset: 70% of the available lines using a D-optimal design
- Additive model fitted, with variables (UHML, UI, Mic, MR, H, and H2SD)
- Non-significant effects removed one after the other

➔ Linear effect of H2SD Stickiness

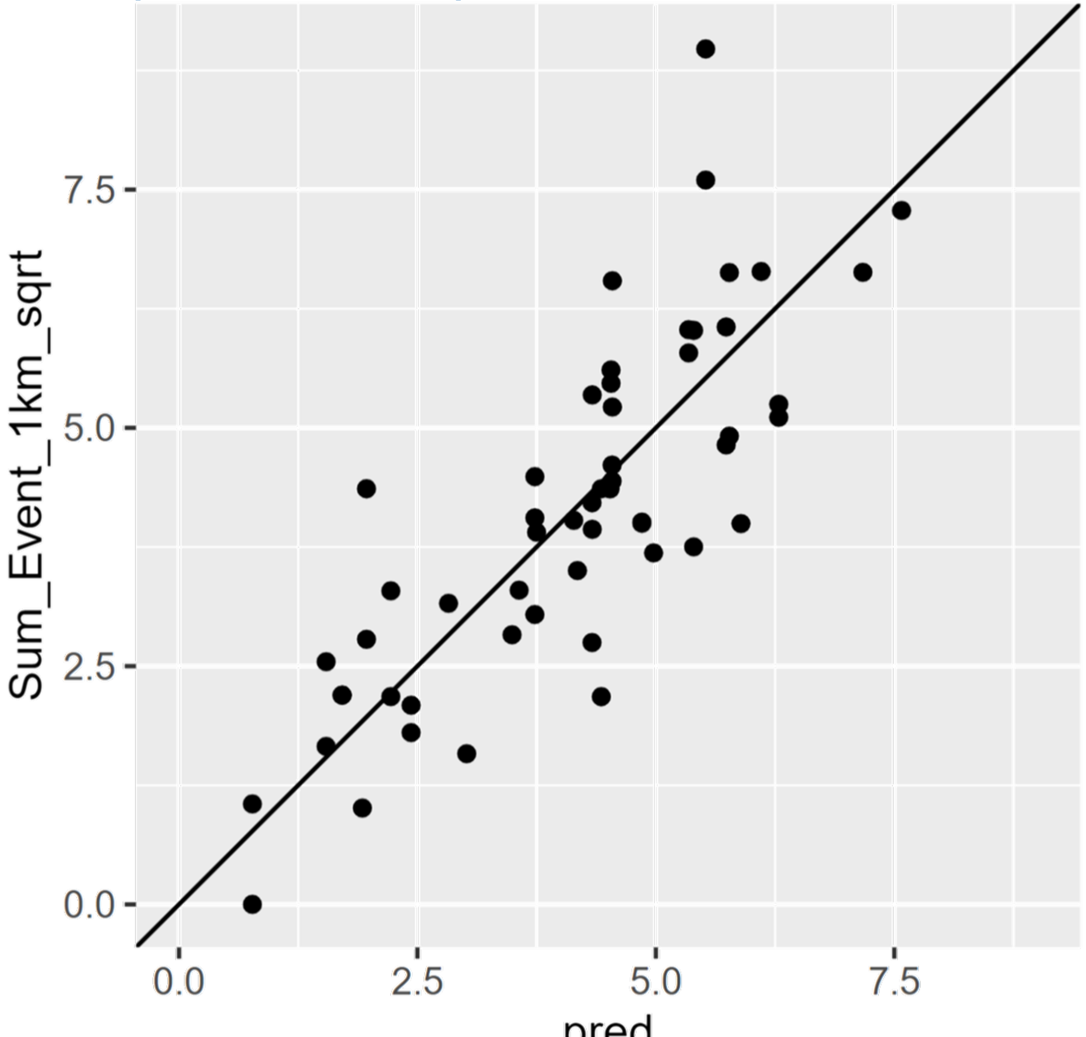
➔ UHML: essential explanatory variable, non-linear effect



Complex model: number of events / km (sqr)

- Training dataset*: sqr(observed) *vs* predicted:

r = 0.82

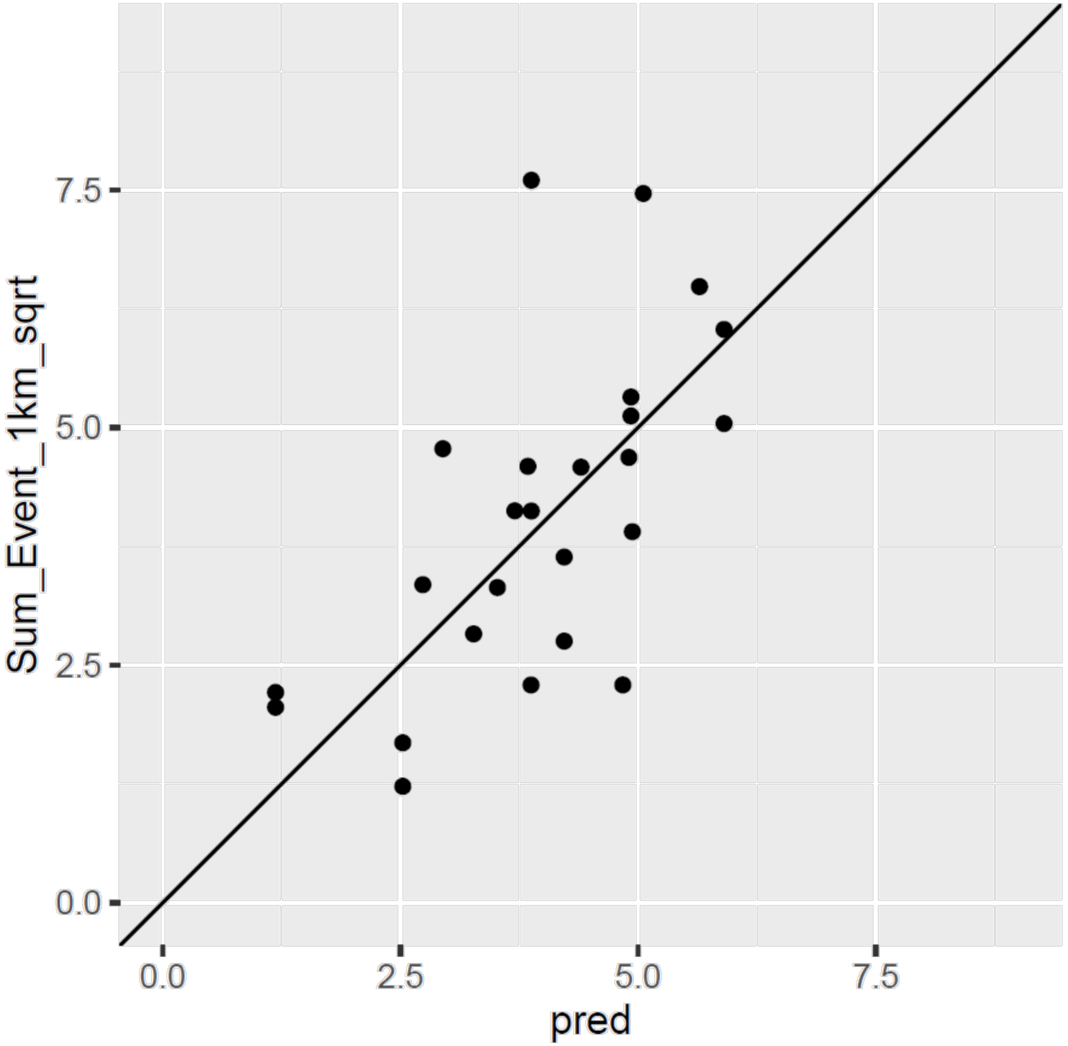


*: 70% lines from the original dataset

Complex model: number of events / km (sqr)

- Validation dataset*: sqr(observed) *vs* predicted:

r = 0.64

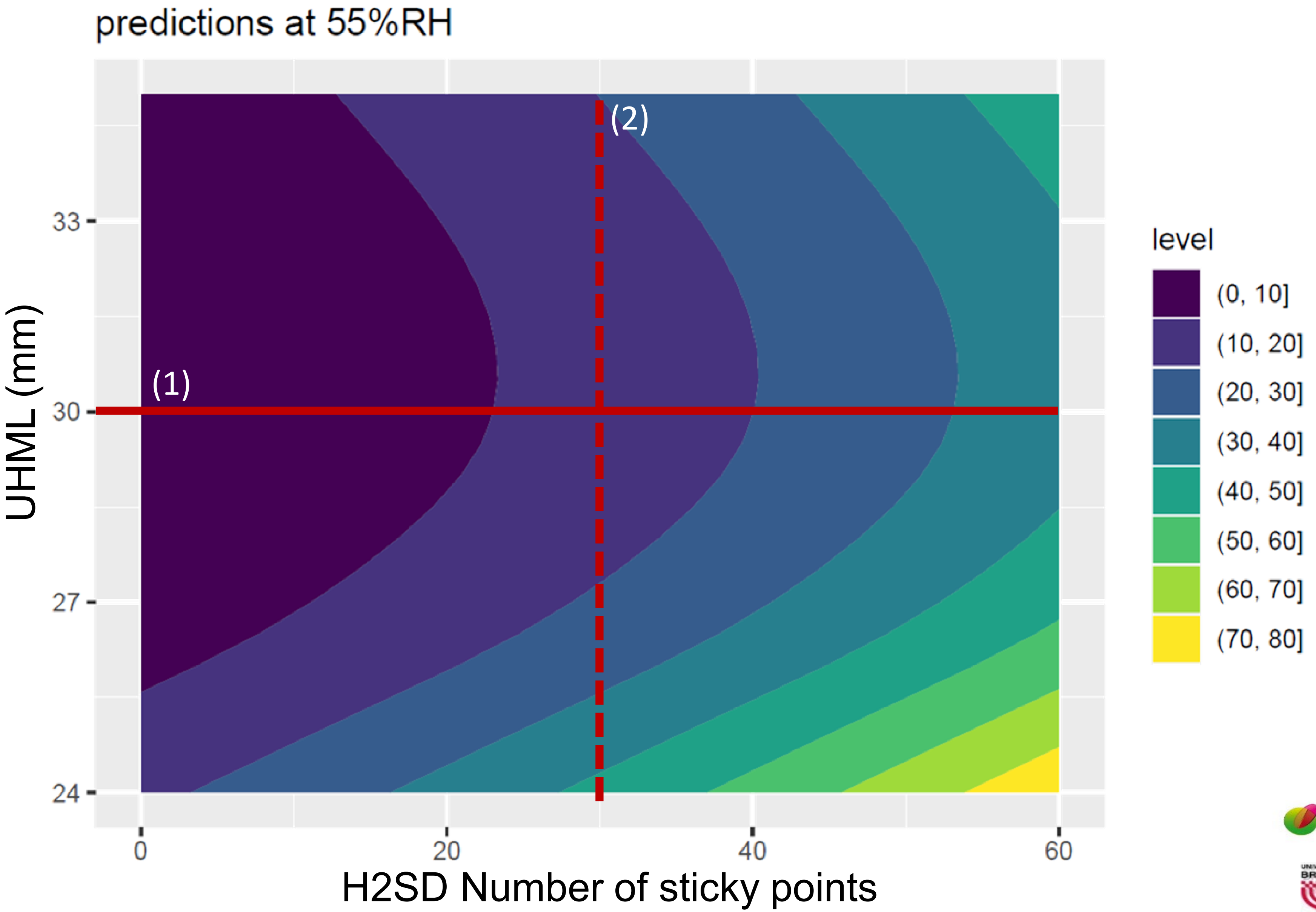


*: 30% remaining lines from the original dataset

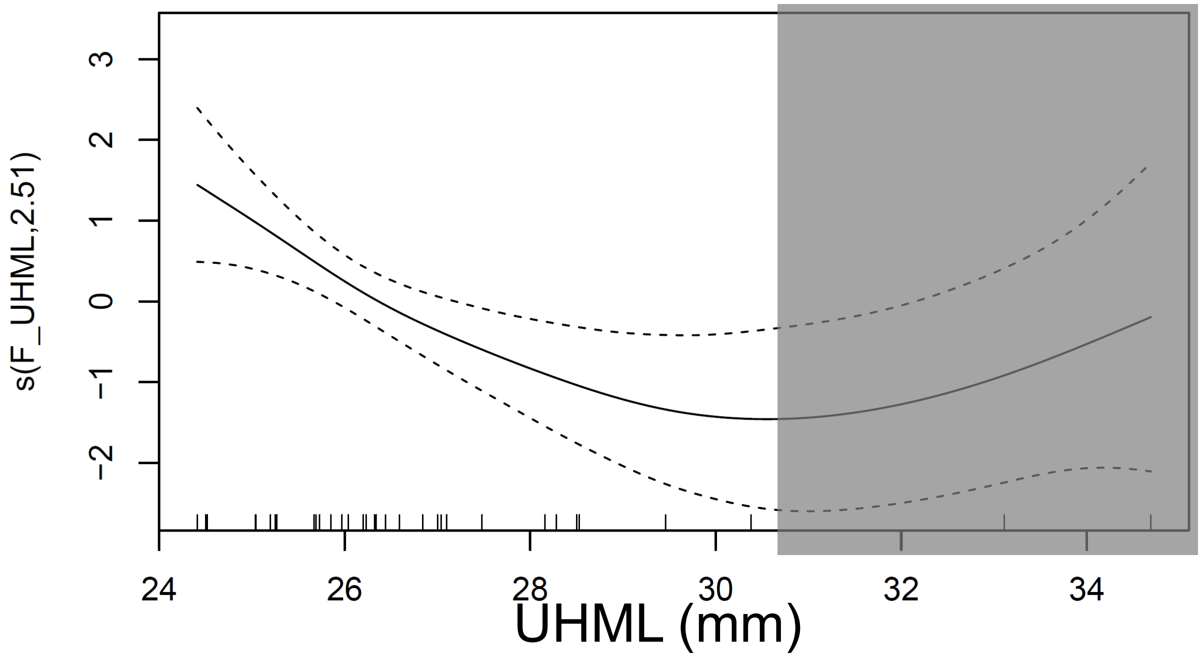
Complex model: number of events / km

Training
+
Validation
datasets

r = 0.88



Complex restricted model: number of events / km (sqr)



UHML < 30.5 mm (or 1.20 inch)

$\sqrt{\text{Number of Events / km}}$ =

13.613 + 0.080 × H2SD – 0.412 × UHML(mm)
+/- two independent errors

R^2(adj) = 0.87 or <u>r = 0.93</u>

Two independent errors are independent of each other:

- Measurement error (one for each replicate), with SD = 0.757
- Prediction error (one for each cotton), with SD = 0.906

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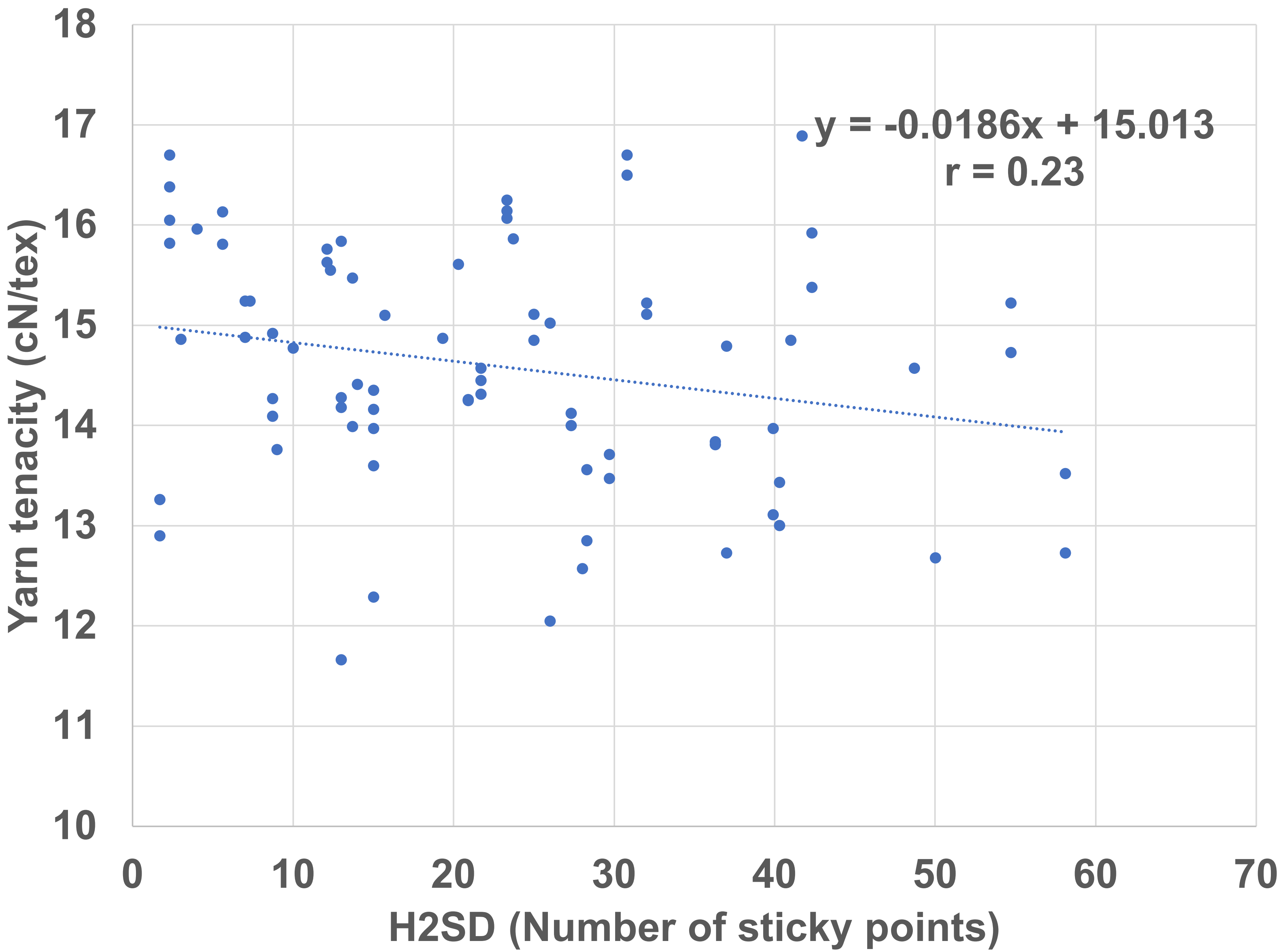
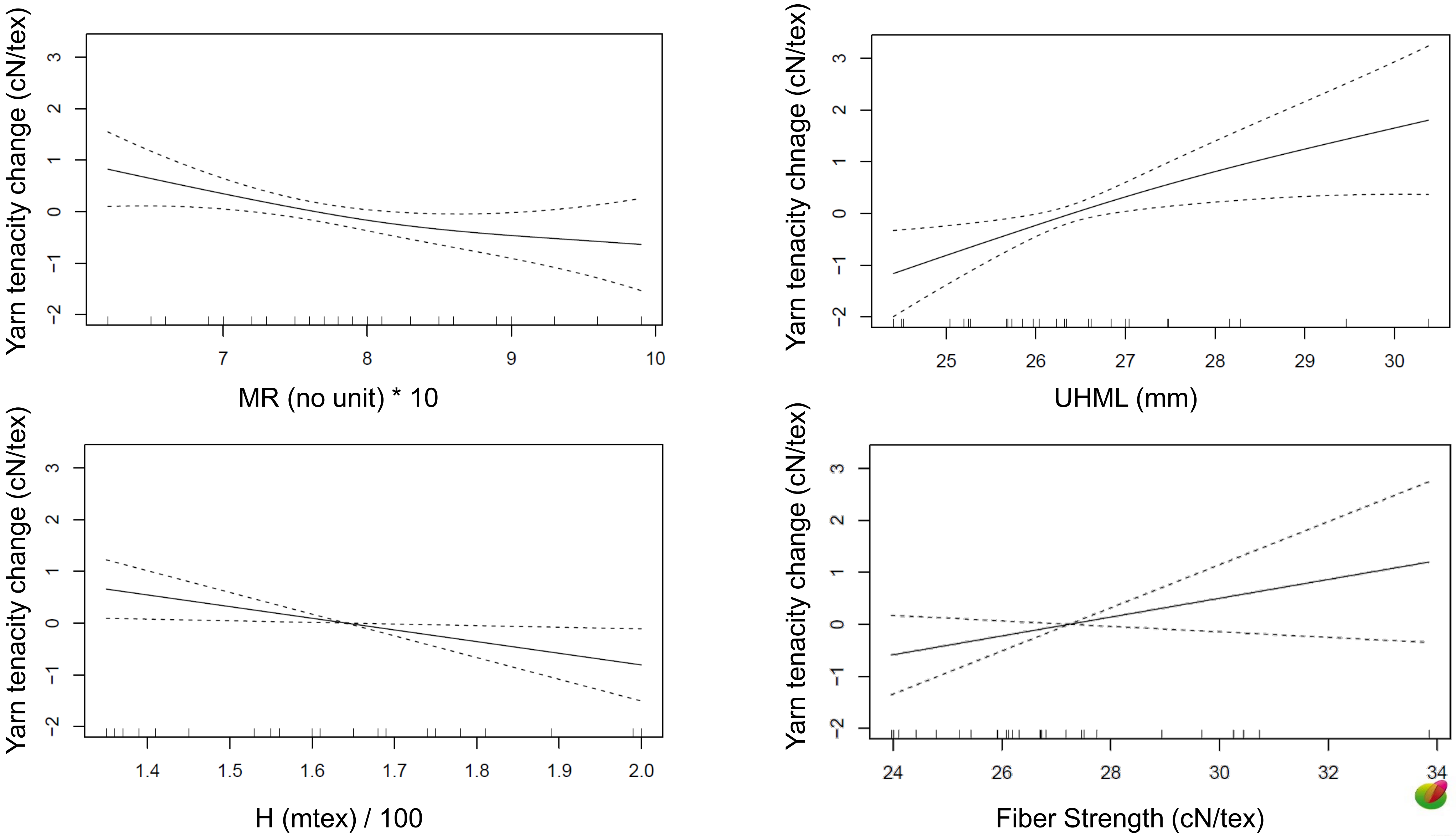
Simple model: yarn tenacity *vs* sticky points



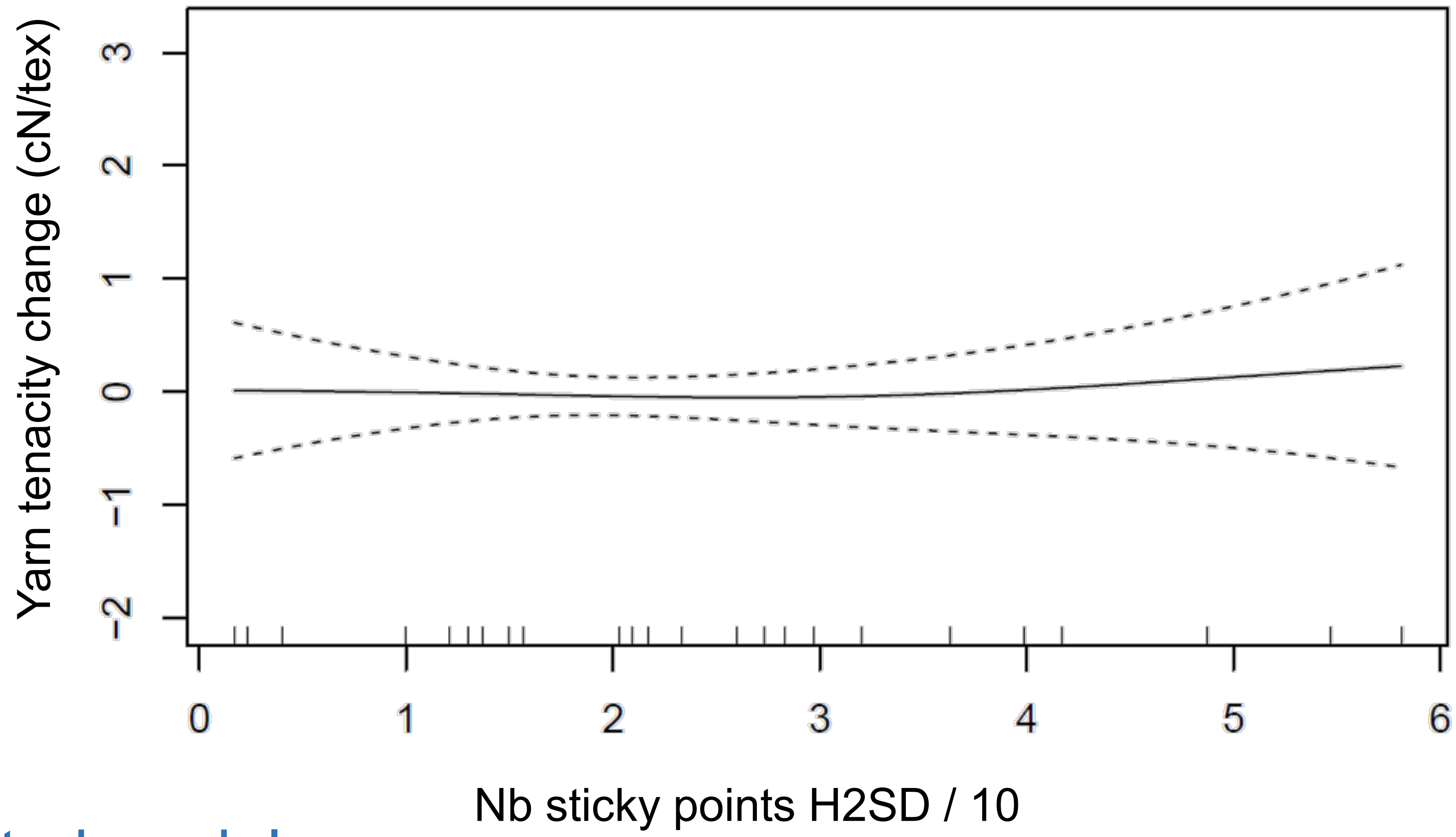
Complex model: yarn tenacity

- New training dataset: 70% of the lines with D-optimal design
- Additive model fitted, 7 variables (UHML, UI, Strength, Mic, MR, H, and H2SD)
- Non-significant effects removed one after the other

Complex model: yarn tenacity: fiber characteristics effects



Complex model: yarn tenacity: additional stickiness effect



No restricted model

Discussion

- Concerning number of events per kilometer
  - Clear effect of UHML and stickiness on the number of observed events during spinning
  - Possibility to compensate some stickiness by an increase of UHML
- Concerning yarn tenacity
  - Clear effect of all fiber characteristics, probably due to structural changes in the yarns
  - Even though the influence of stickiness was not significant, possibility of a non-negligible effect on yarn strength for contaminated cottons
- Combining number of events per kilometer <u>and</u> yarn tenacity
  - Number of events increased with stickiness, but in a too limited manner as:

    => no impact on yarn structure (as thin, thick, or neps places under statistic analysis)

    => no increase in the number of place(s) of least resistance

    => low change in yarn tenacity

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Conclusion

Needed development of Stickiness Measuring Methods (but various approaches not always relevant) ➔ Need for harmonization, based on spinning observations

- Preliminary study conclusion: thermomechanical methods able to predicting yarn productivity and quality yarn indicators

Needed confirmation of relationships fiber + stickiness characteristics, to stickiness-induced events and yarn quality characteristics

What we found:

For any given level of stickiness:

- The shorter the cotton, the more events (the lower yarn tenacity)
- The longer the cotton, the fewer events (the higher yarn tenacity)
- Fiber strength, maturity & linear fineness: interesting contributions for yarn tenacity

Perspectives

Available data on spinning productivity and yarn quality

- Harmonization of Stickiness Measuring Methods
- Continuation of international round-trials for harmonizing Stickiness Measuring Methods results by ITMF-ICCTM working group on stickiness
- Possible production of reference materials for checking the reading levels of the Stickiness Measuring Methods

With these results, need a funded project similar to 'HarCoStiC'?

- More materials
- More technological and finer determinations
- Additional various sources of contamination (by insects)
- Multiple locations of the studied insect honeydews
- More spinning test results…

Stickiness and fiber characteristics related to fiber processing efficiency and yarn quality

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Acknowledgments to:

-Participating laboratories and material providers

-Funders for this work : CIRAD & FIBRE

-Serge Lassus, Gérard Gawrysiak, and Marie-Elyse Lapeyre for their expertise and strong support

Thanks for listening

We welcome your questions and comments