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# Comparison of five measurement methods to determine the density of grass silage

29.06.2011

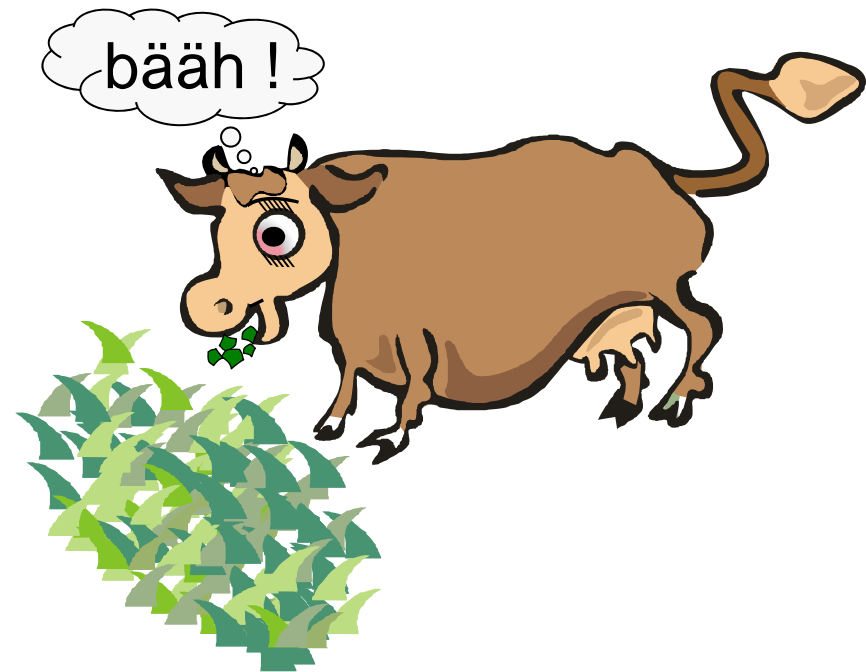
**Roy Latsch, Joachim Sauter**



# Introduction I

- High quality grass silage is the basis for good animal health and high productivity.
- Fodder compaction is essential to minimize the risk of reheating after opening the silo for feeding.

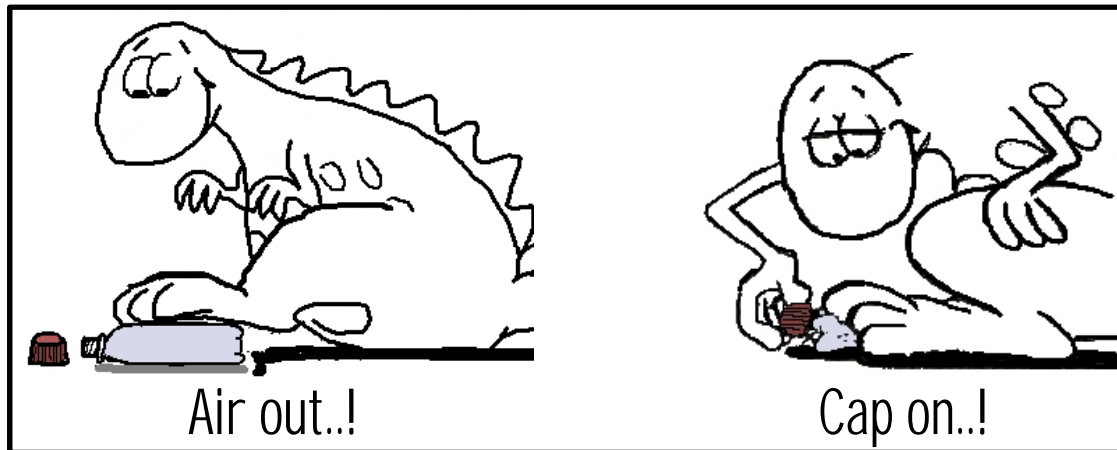
You do not want to watch your cows behaving like this one, do you..!?!





## Introduction II

- With the improving efficiency of cylinder choppers and silage trailers, the focus is increasingly shifting to compaction in the horizontal silo as the designated bottleneck in the silage process.
- You have to get the air out of the silage and cover it in time.



Source:  
[www.petrecycling.ch](http://www.petrecycling.ch)

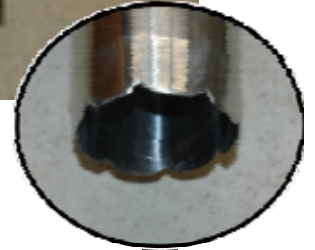
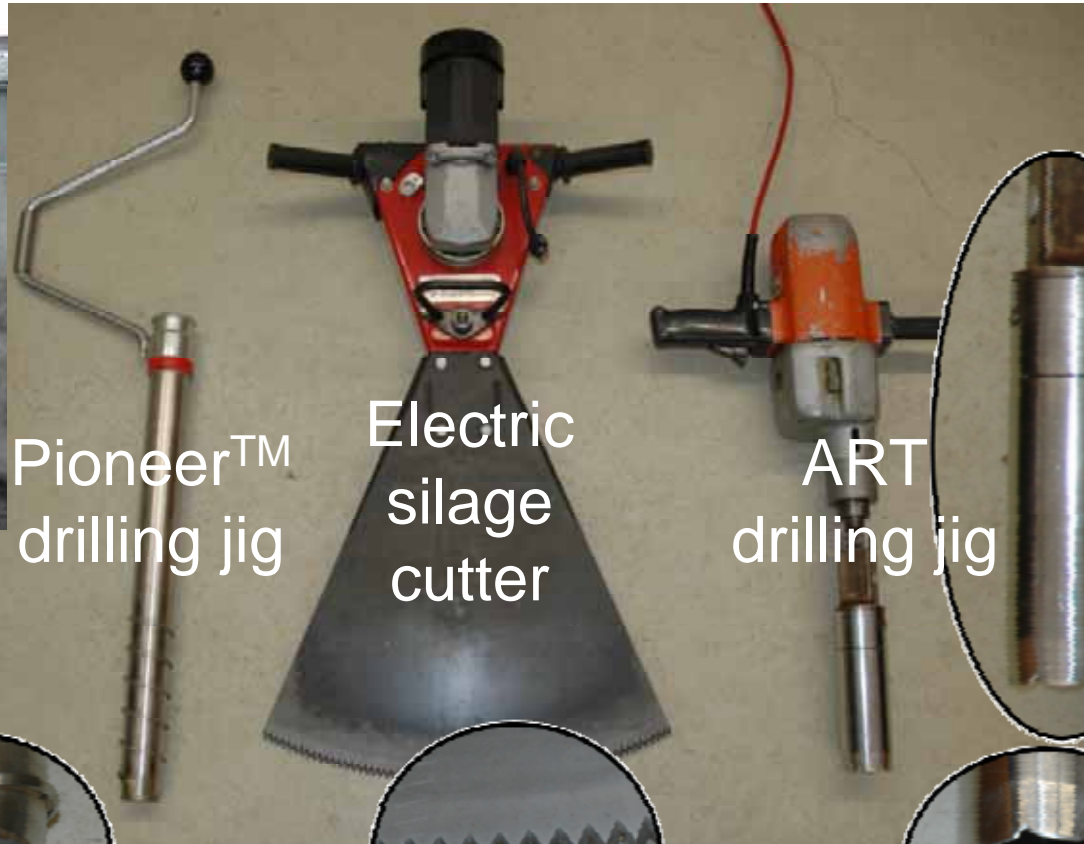
ART initiated a project dealing with silage compaction and quality.



# Introduction – Sampling methods

- To validate the results of the project, density samples had to be taken from the silage.
- Sampling is not standardised yet.
- *Fürll et al. (2008)* identifies 14 possible measurement methods, depending on the following measurement principles :
  - radiometric
  - pneumatic
  - mechanical
  - optical
  - electrical
- Mechanical procedures are the most common and practice-relevant sampling techniques.
- The presentation shows results of five mechanical sampling variants.

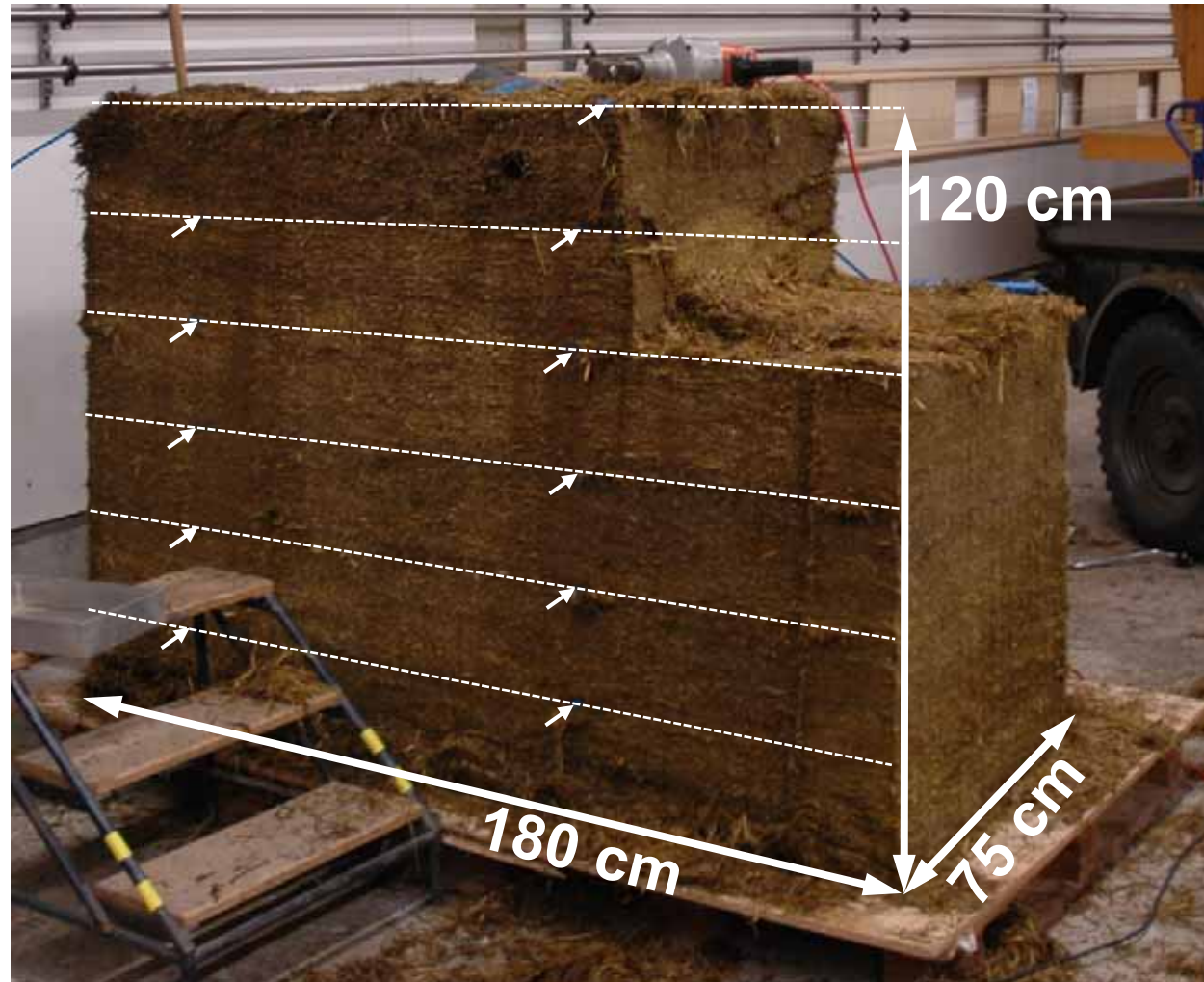
# Material – Samplers



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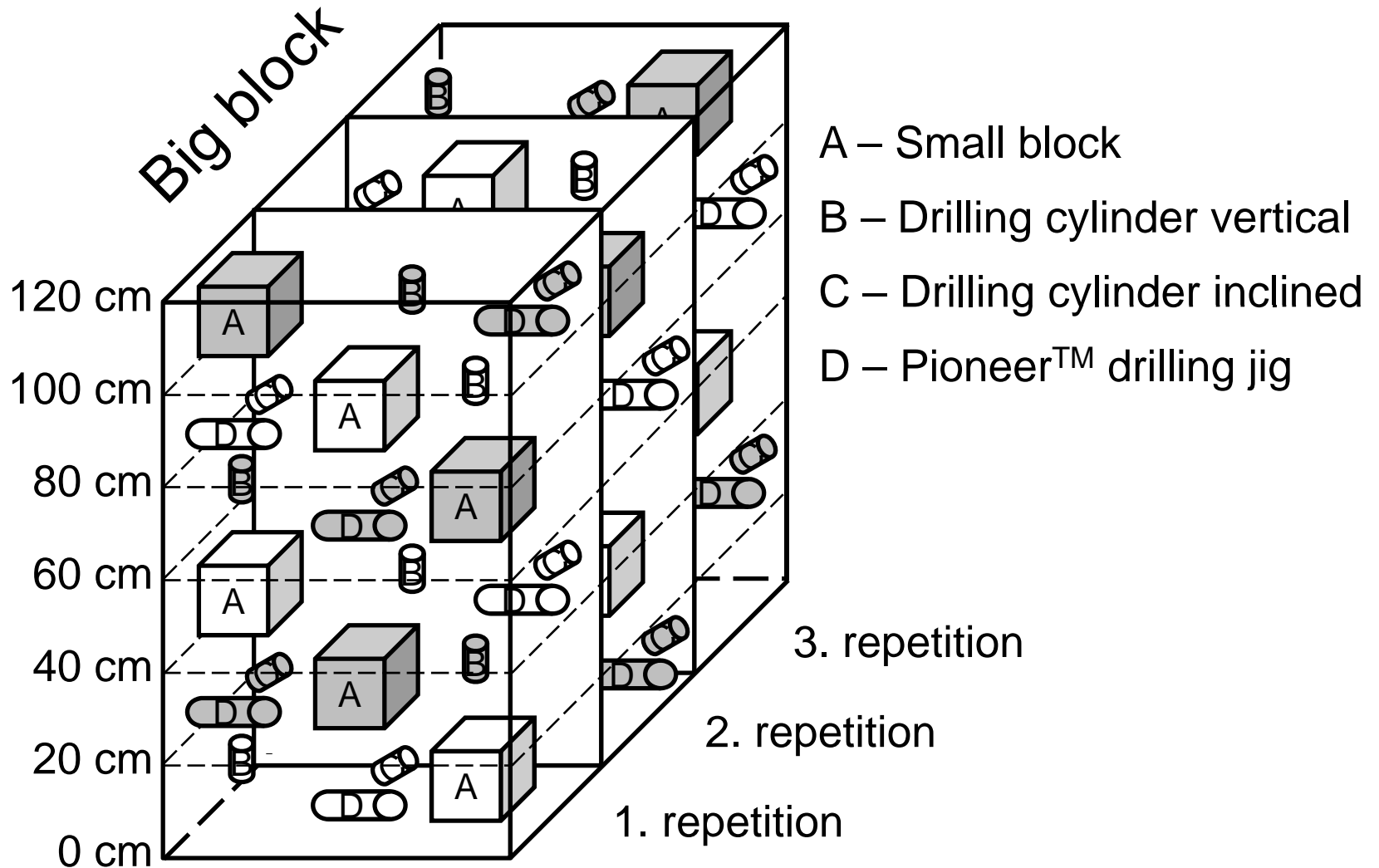


# Material – Silage bock





# Material – Scheme of the silage block





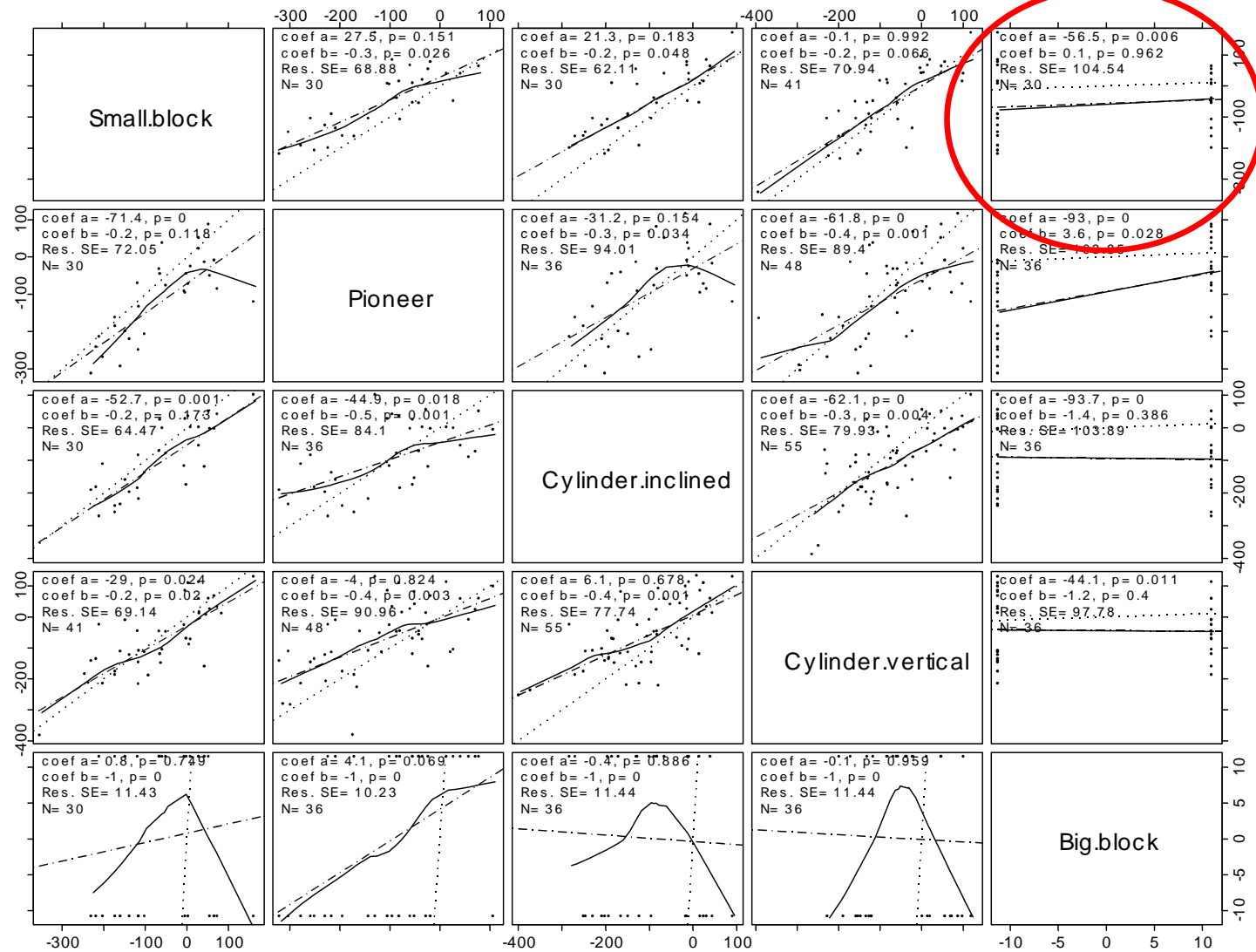
# Methods – Statistics

- Analysis of data with a pair-wise linear regression model
- Software: Tibco Sporfire S+
- Results plotted as scatter plot matrices



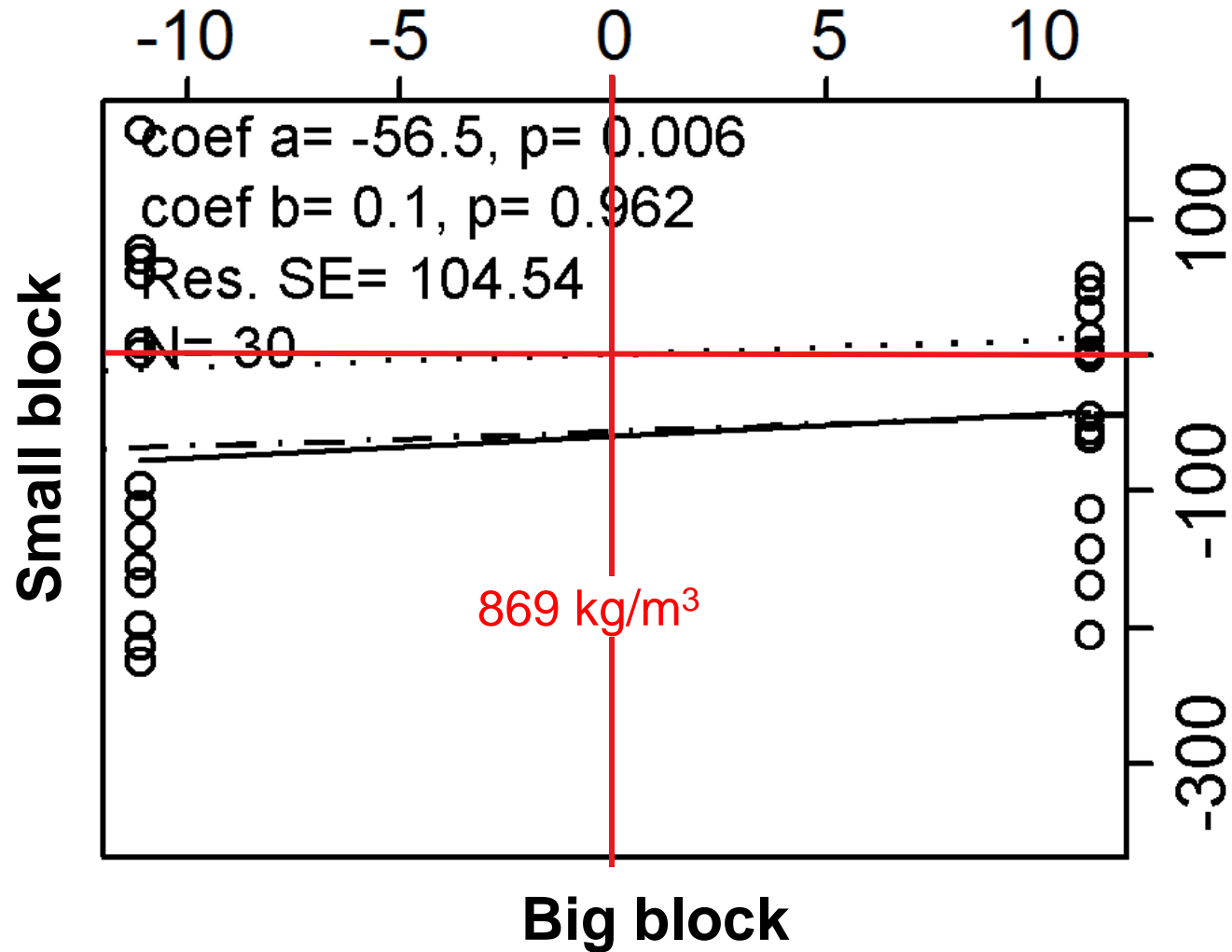


# Results – Scatter plot matrix I



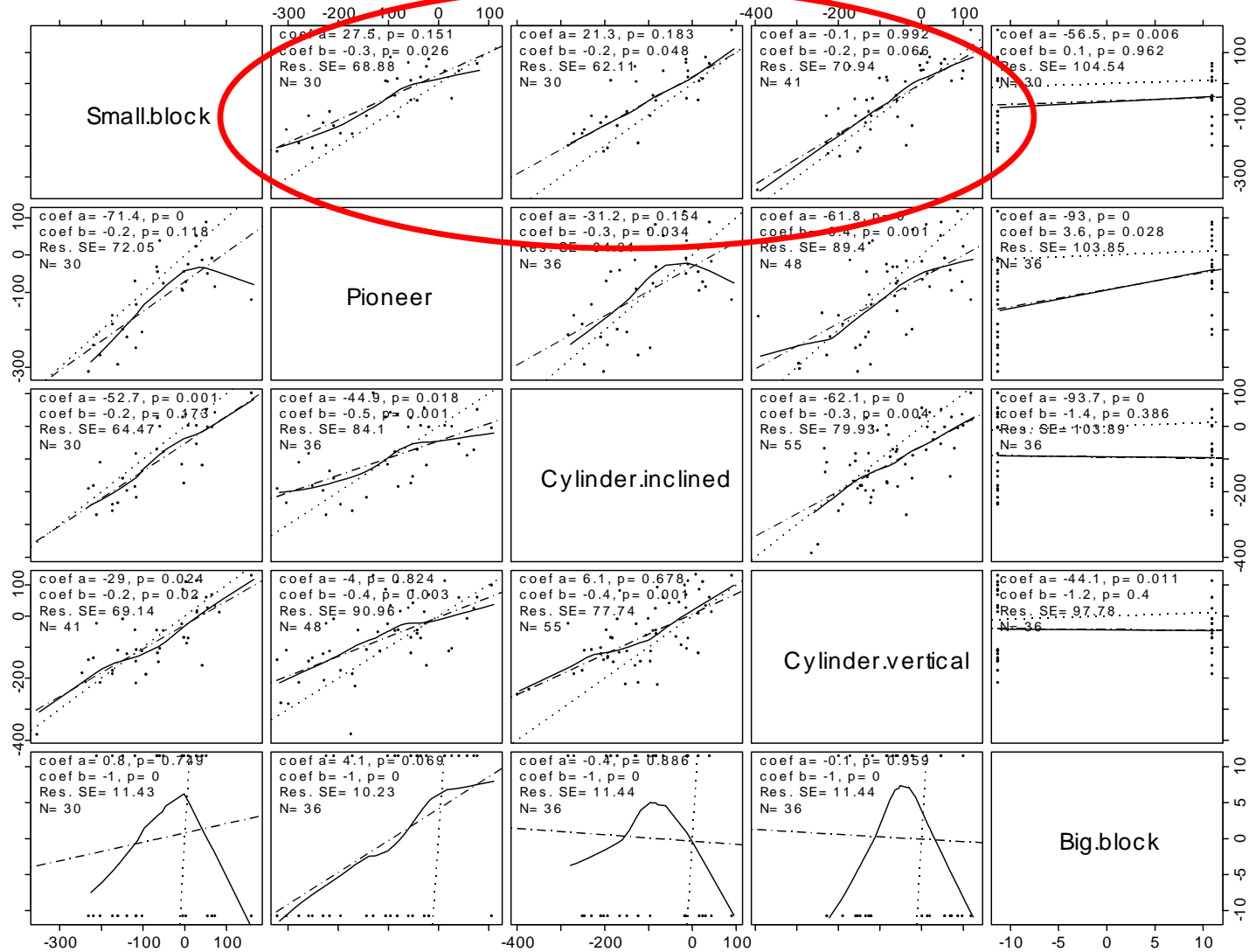


# Results – Scatter plot matrix II





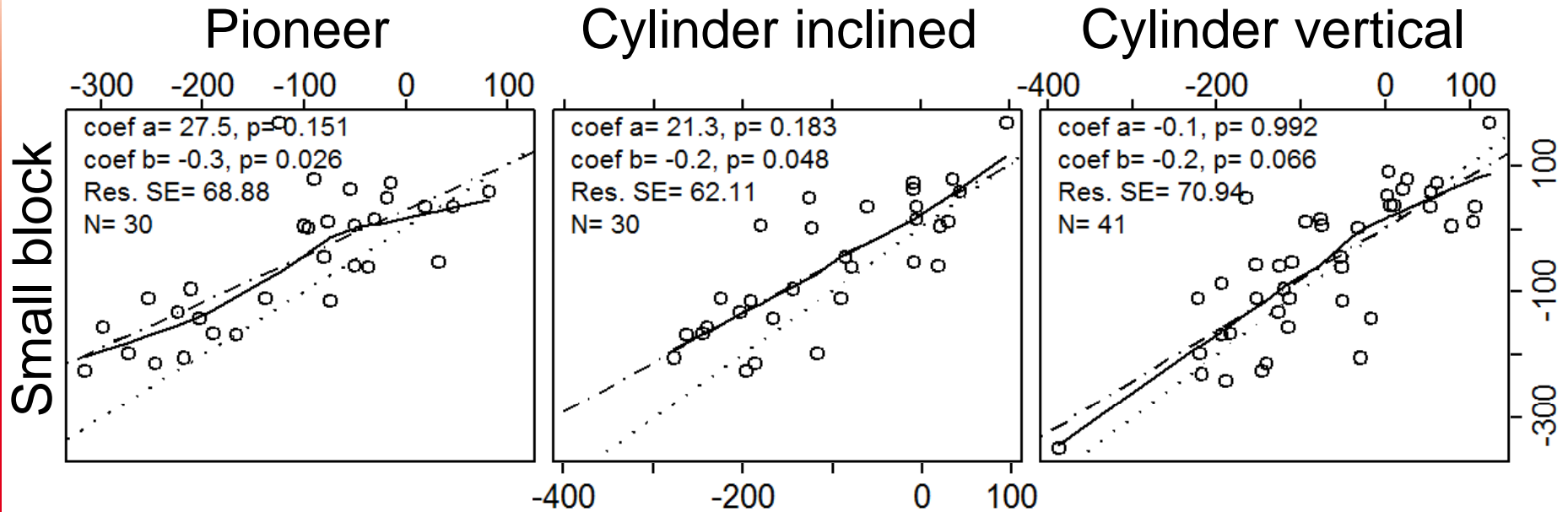
# Results – Scatter plot matrix III



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# Results – Scatter plot matrix IV



— · — regression line    ······ X=Y-line    — approximation line

coef a – Shift of regression line from x=y-line in point x=0

coef b – Difference in inclination between regression line and x=y-line

Res. SE – Residual Standard Error



# Summary I

## Big silage blocks

- are a practicable way to determine the average silage density in horizontal silos.
- show high variations in density.
- are unsuitable, if precise and quick sampling is needed.

Often only one block is taken from the centre of the horizontal silo. This leads to an overestimation of the density.

## Small blocks

- give a good approximation to the real density conditions.
- are not easy to take, so they are not a practicable sampling method.
- were taken as “gold standard” in this comparison.



# Summary II

## Variants Pioneer and Cylinder inclined

- show a significant diverging inclination between regression line and  $x=y$ -line. This means, that the density measurement is getting more improper, the looser the silage is.
- also show a certain shift between regression line and  $x=y$ -line, which leads to an underestimation of silage density in relation to the small block when the silage is getting looser.
- have relatively good residual standard errors. This good fit between determined density data and regression line could be used to calibrate the methods.

## Cylinder vertical

- shows the best fit between regression line and  $x=y$ -line.
- shows a minimal shift under the given conditions of statistical analysis (average of big block densities set as zero).



# Conclusions

- A large number of small samples illustrate the conditions in horizontal silos better than few large samples.
- Drilling jigs can be used for taking a lot of samples quickly.
- Sampling direction is crucial for good sampler filling due to the fibrous structure of the silage.
- The steeper the angle of the core drill to the bedding direction of the silage, the better the fibre separation and the more accurate the determination of density.
- Of the drilling methods tested the drilling cylinder vertical is the preferred variant, because of its good statistical fit with the chosen standard method and its easy handling.



# Thank you!



## ART – Research for Agriculture and Nature