

# **Near Infrared Spectroscopy (NIRS) Methods for the Assessment of Quality in Fresh Forages**

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# Overview

- Instrumentation
- Material
- Calibration Examples
- Prospects



# Instrumentation

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## NIRSystems 6500



- Diffuse Reflectance / (Transmittance)
- Wavelength range: 400 - 2500 nm
- Scans per second: 1 Scan
- Resolution: 2 nm
- Wavelength accuracy: +/- 0,5 nm



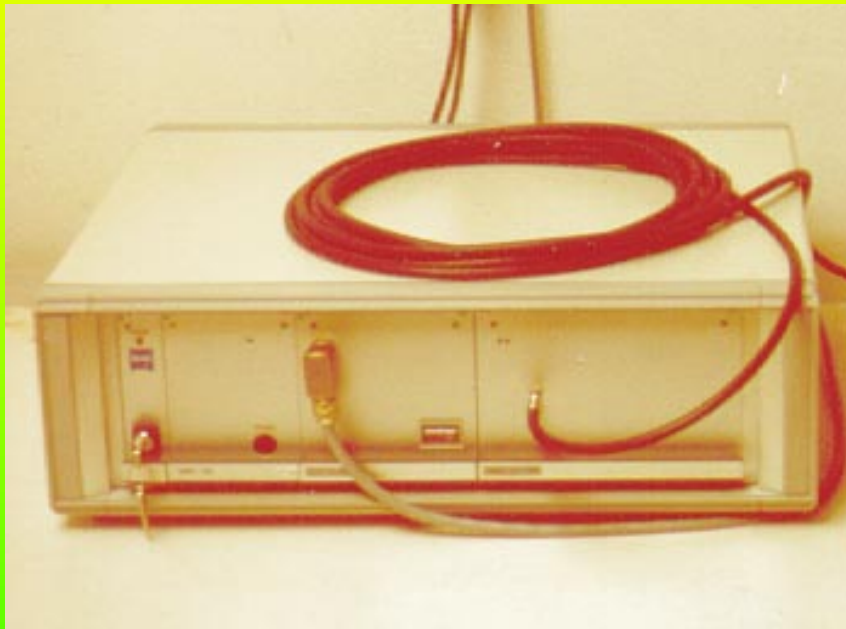
# Infratec Meat Analyzer



- Transmittance
- Wavelength range:  
850 - 1050 nm
- Scans per second:  
1 Scan
- Resolution:  
2 nm



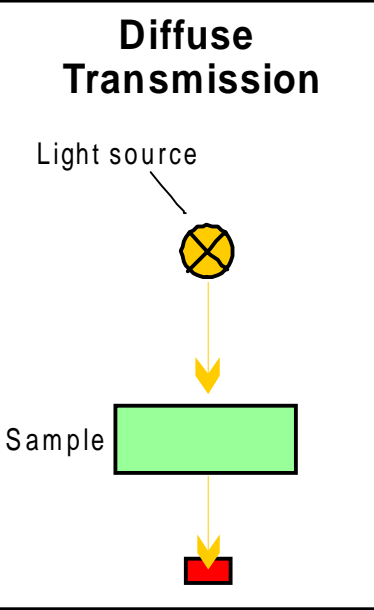
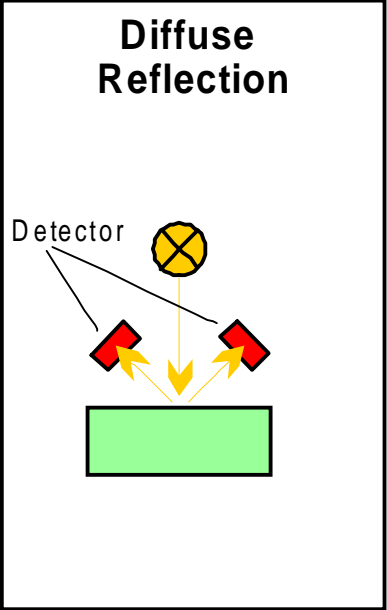
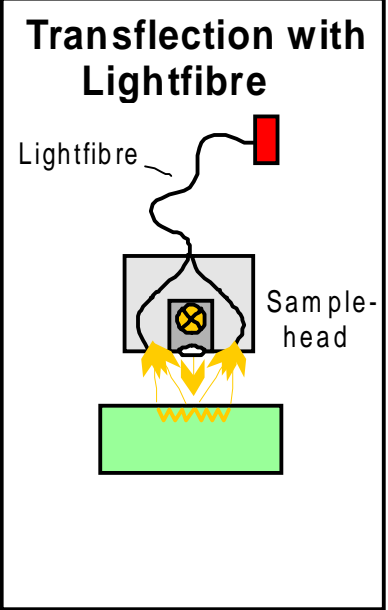
## Zeiss MMS-NIR 1.7



- Diffuse Reflectance / (Transmittance)
- Wavelength range: 945 - 1700 nm
- Scans per second: 100 Scans
- Resolution: 6 nm
- Wavelength accuracy: +/- 0,6 nm



# Instruments / Sampling methods

Construction-principle	<p style="text-align: center;"><b>Diffuse Transmission</b></p> 	<p style="text-align: center;"><b>Diffuse Reflection</b></p> 	<p style="text-align: center;"><b>Transflection with Lightfibre</b></p> 
<b>Detector</b> : <b><math>\lambda</math>- Range (nm)</b> :	<b>Si</b> <b>800-1050</b>	<b>Si + PbS</b> <b>400-2500</b>	<b>InGaAs</b> <b>900-1700</b> <b>(900-2500)</b>
<b>Area (cm<sup>2</sup>)</b> : <b>Scans / sec</b> :	<b>3</b> <b>~ 1</b>	<b>5</b> <b>~ 1</b>	<b>5</b> <b>~ 100</b>



# Material

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# Grasses and Legumes

## - Grasses

- *Lolium perenne*
- *Lolium multiflorum*
- *Dactylis glomerata*
- *Festuca arundinacea*

## - Legumes

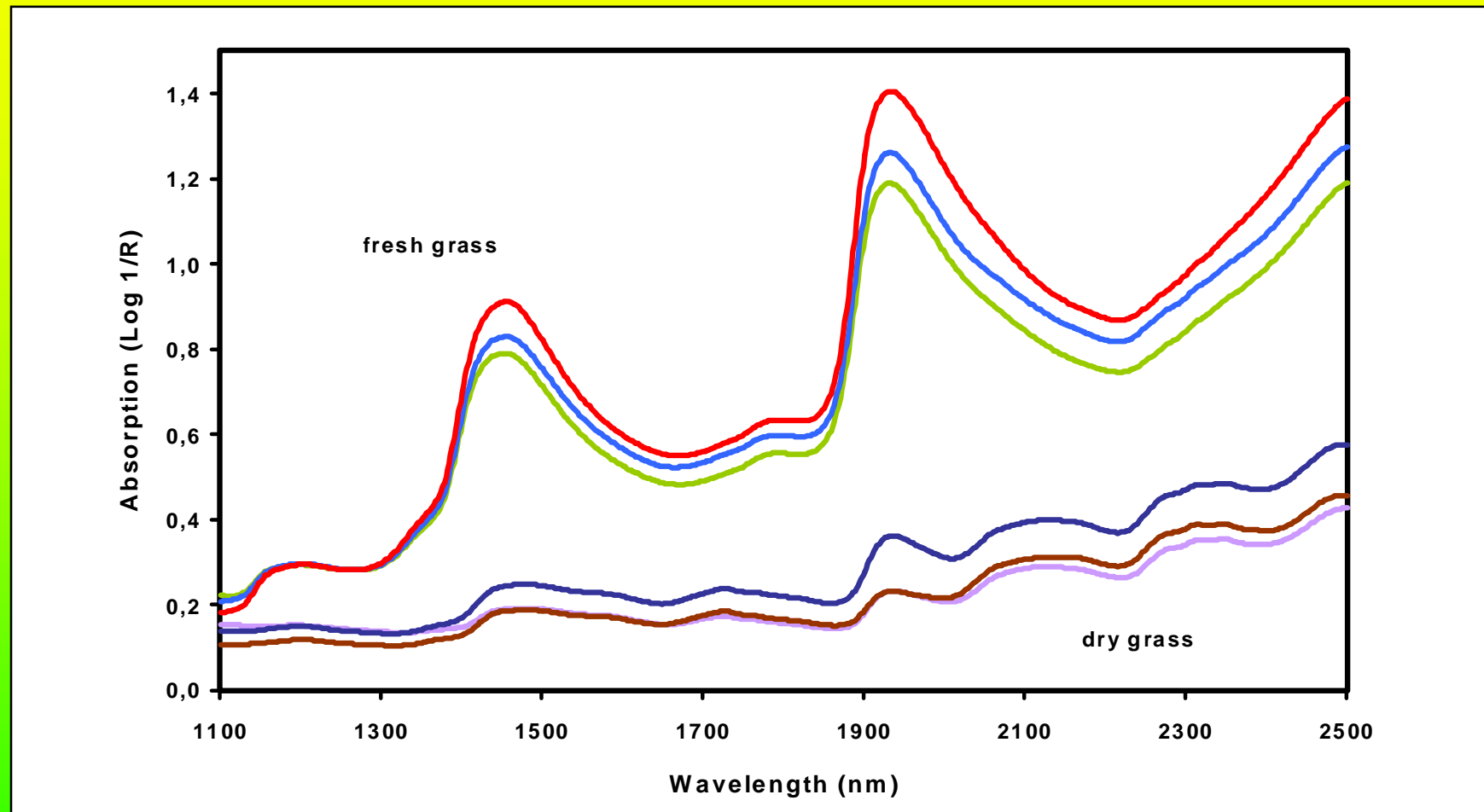
- *Trifolium repens*
- *Trifolium pratense*
- *Medicago sativa*
- *Lotus corniculatus*
- *Galega orientalis*



# Calibration Examples

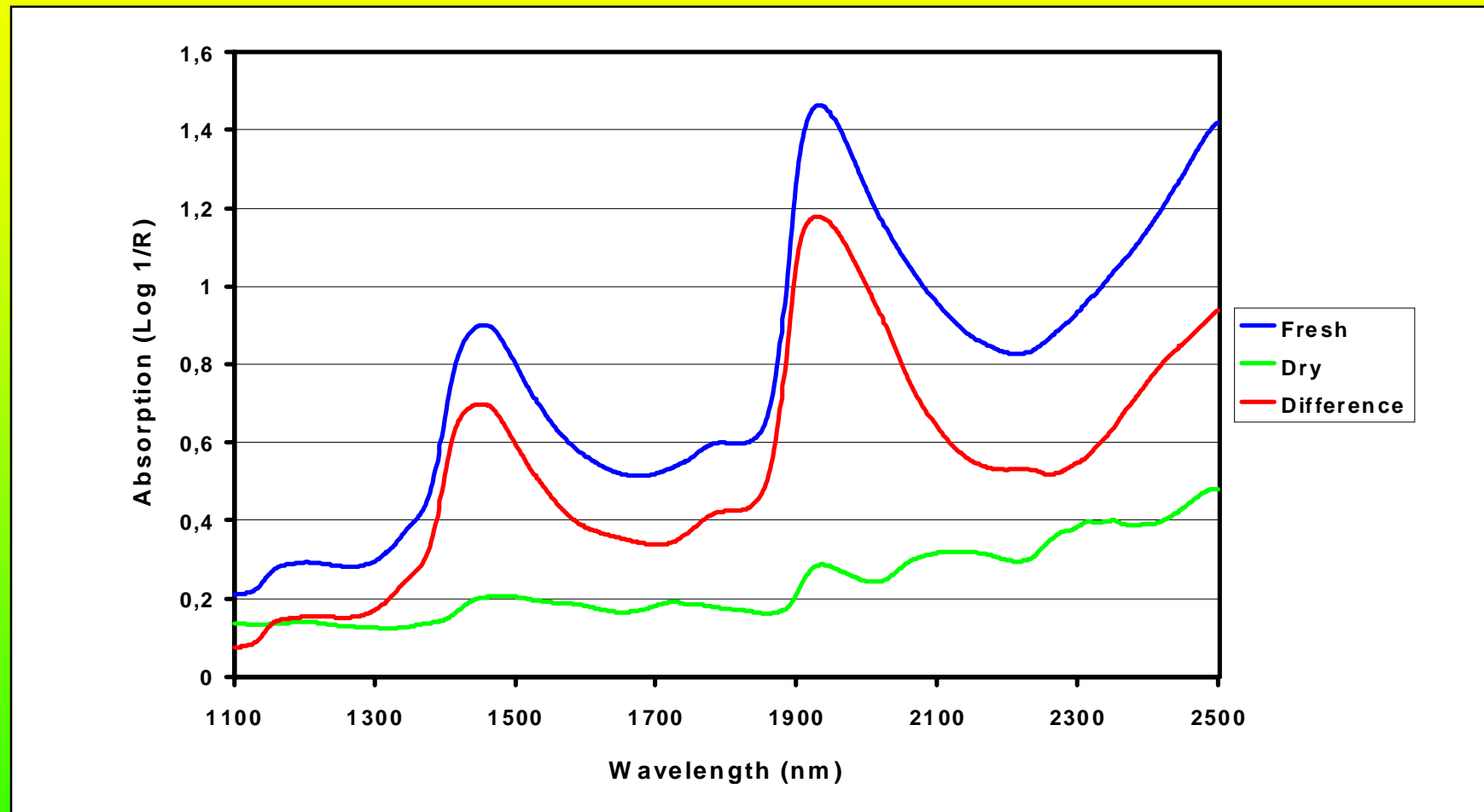


# Spectral Differences between Dry and Fresh Grass Samples





# Difference Spectrum of Fresh vs. Dry Grass





# Chemometric Software

- WinISI II V1.0
  - Global Calibrations
    - Regression types
      - Partial Least Squares (PLS)
      - Principle Component (PCR)
      - Step-up
      - Modified Stepwise (MSR)
    - Cross Validation
  - Local Calibrations
  - Neural Networks



## **Examples of Calibrations for Fresh and Dry Grasses (NIRSystems and ZEISS)**

- Calibrations on the NIRSystems 6500
  - Calibration Results with Fresh Forages
  - Comparison of Calibrations with Dry Samples on NIRSystems 6500 vs. ZEISS MMS-NIR 1.7
- Calibrating the portable ZEISS MMS-NIR 1.7
  - Regression Analysis of NIR Absorption vs. Dry Matter Concentration in Fresh Grass on NIRSystems 6500 vs. ZEISS MMS-NIR 1.7

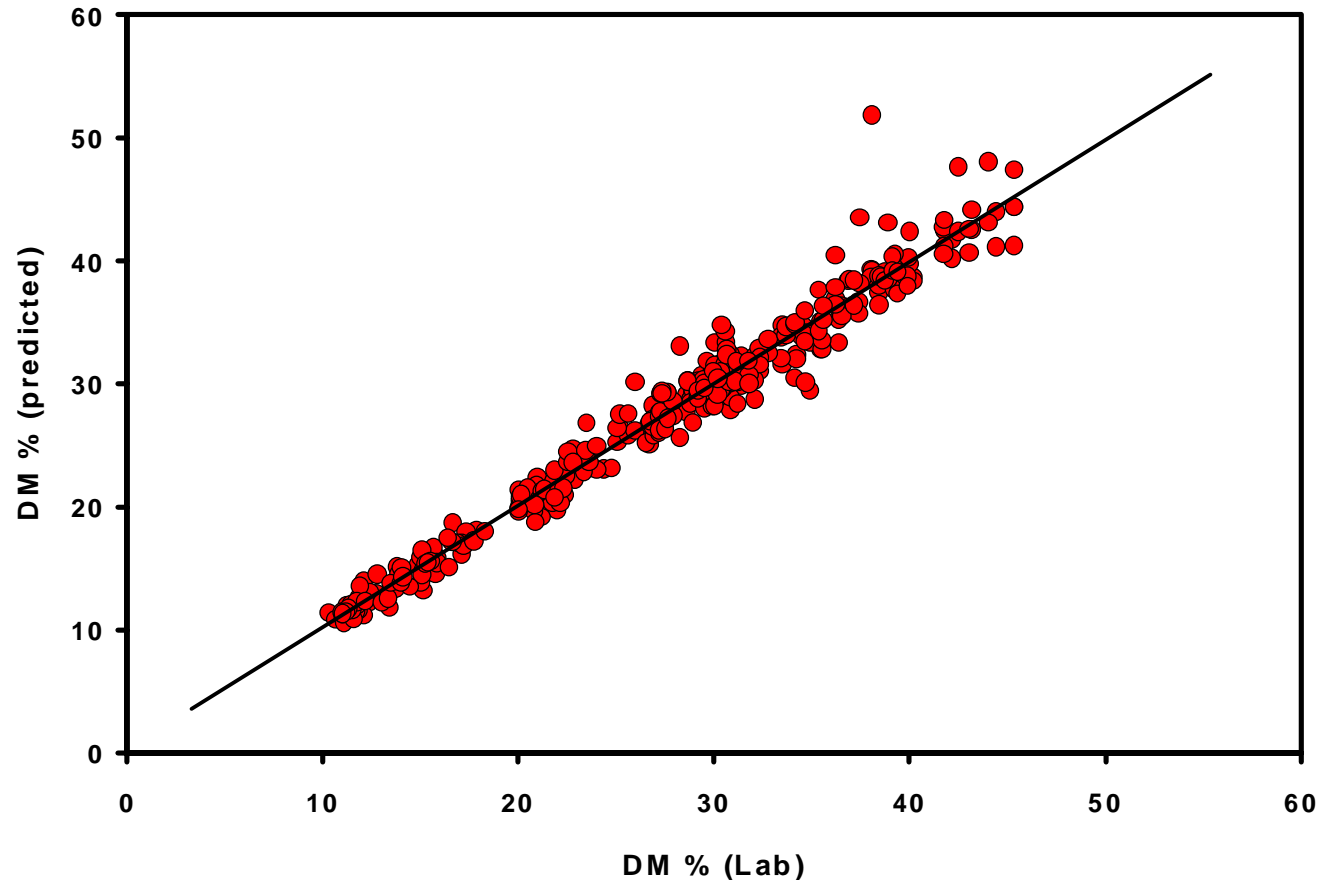


## Selection of Fresh Forage Calibrations on the NIRSystems 6500: Results

- Dry Matter DM %
  - Standard Error (SE): 1,13
  - R<sup>2</sup>: 0,99
- Crude Protein CP (% of DM)
  - SE: 1,56
  - R<sup>2</sup>: 0,92
- Water Soluble Carbohydrates WSC (% of DM)
  - SE: 0,88
  - R<sup>2</sup>: 0,94



# Dry Matter Calibration of Fresh Forages (NIRSystems 6500)



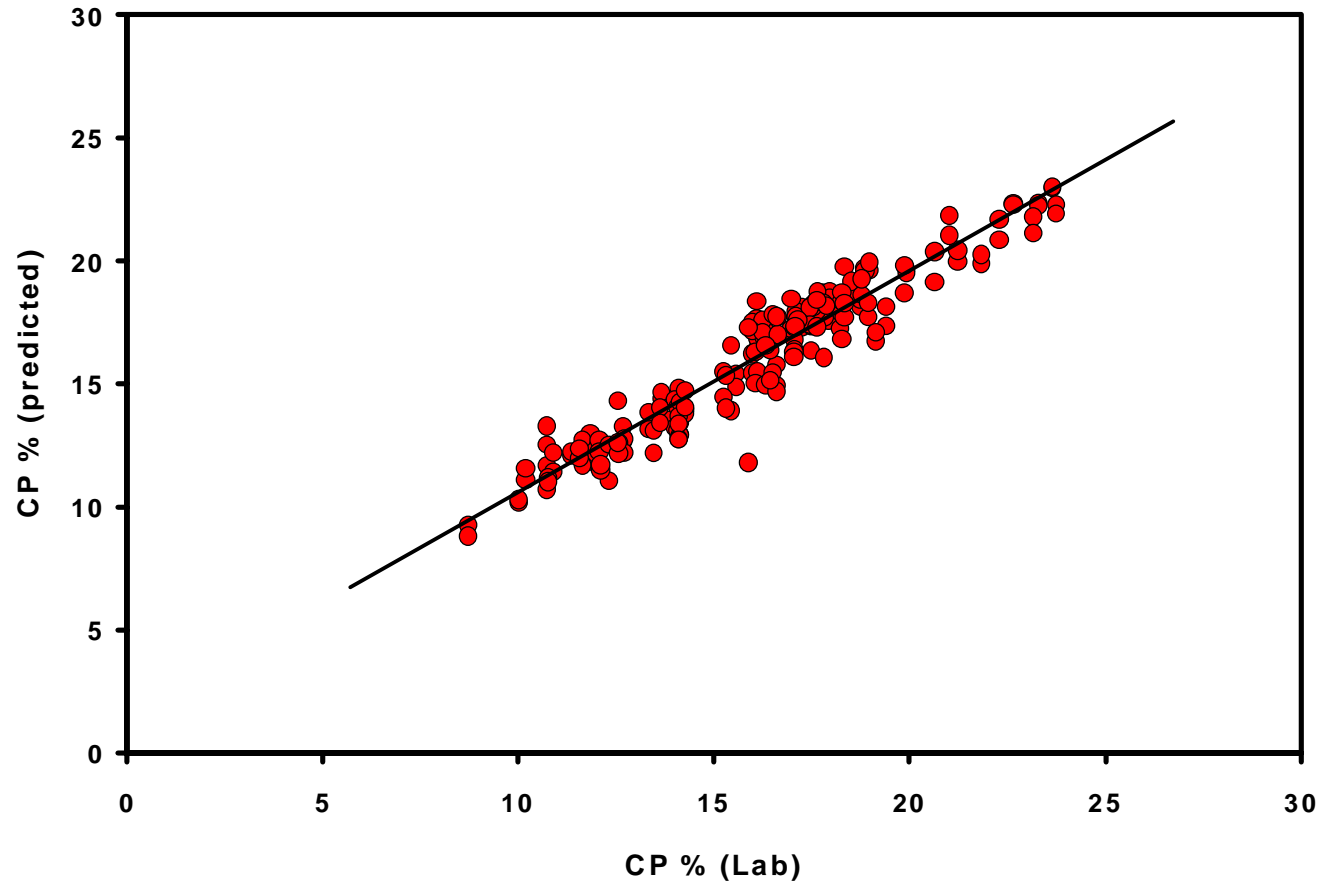
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# Protein Calibration of Fresh Forages (NIRSystems 6500)

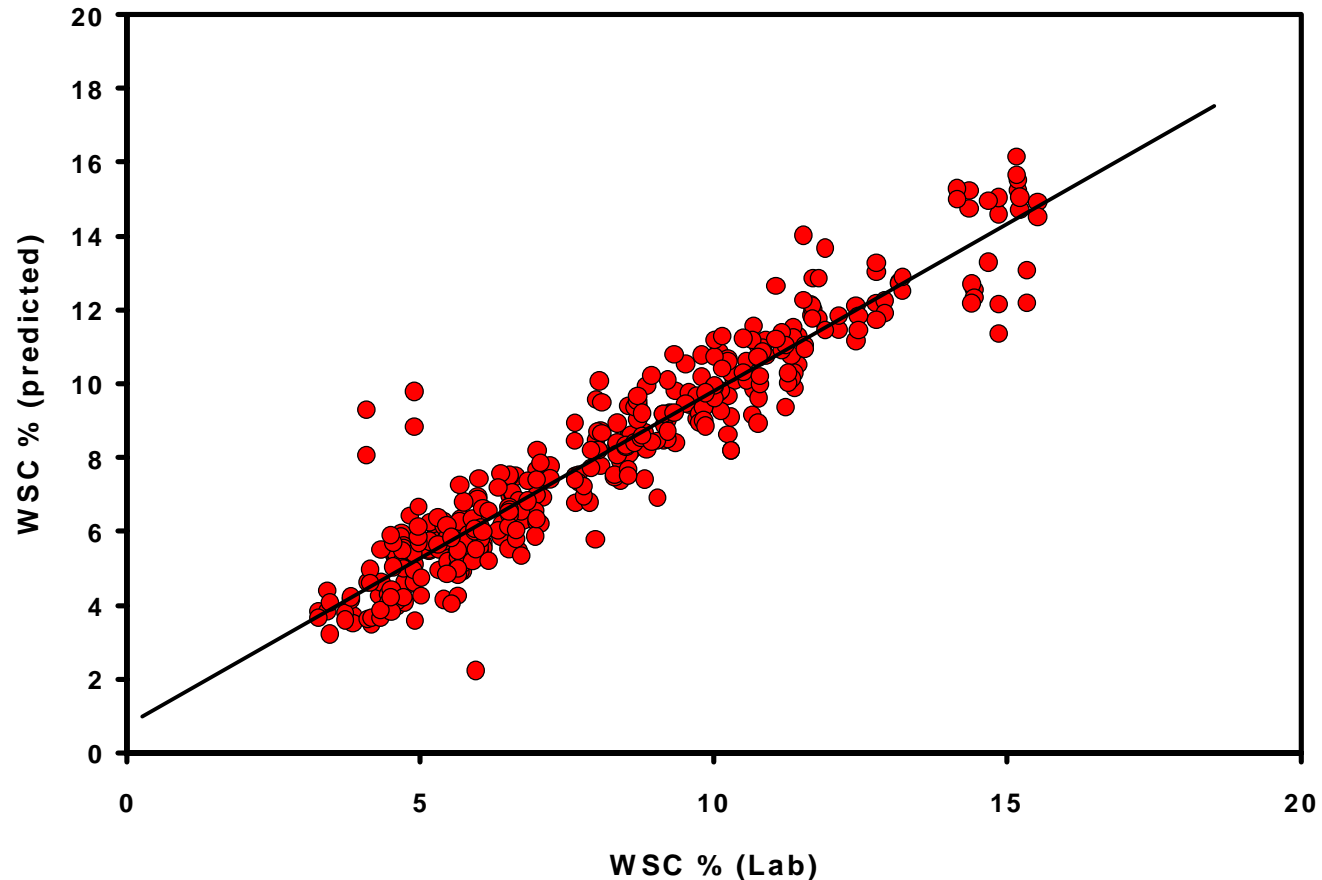


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# Carbohydrate Calibration of Fresh Forages (NIRSystems 6500)



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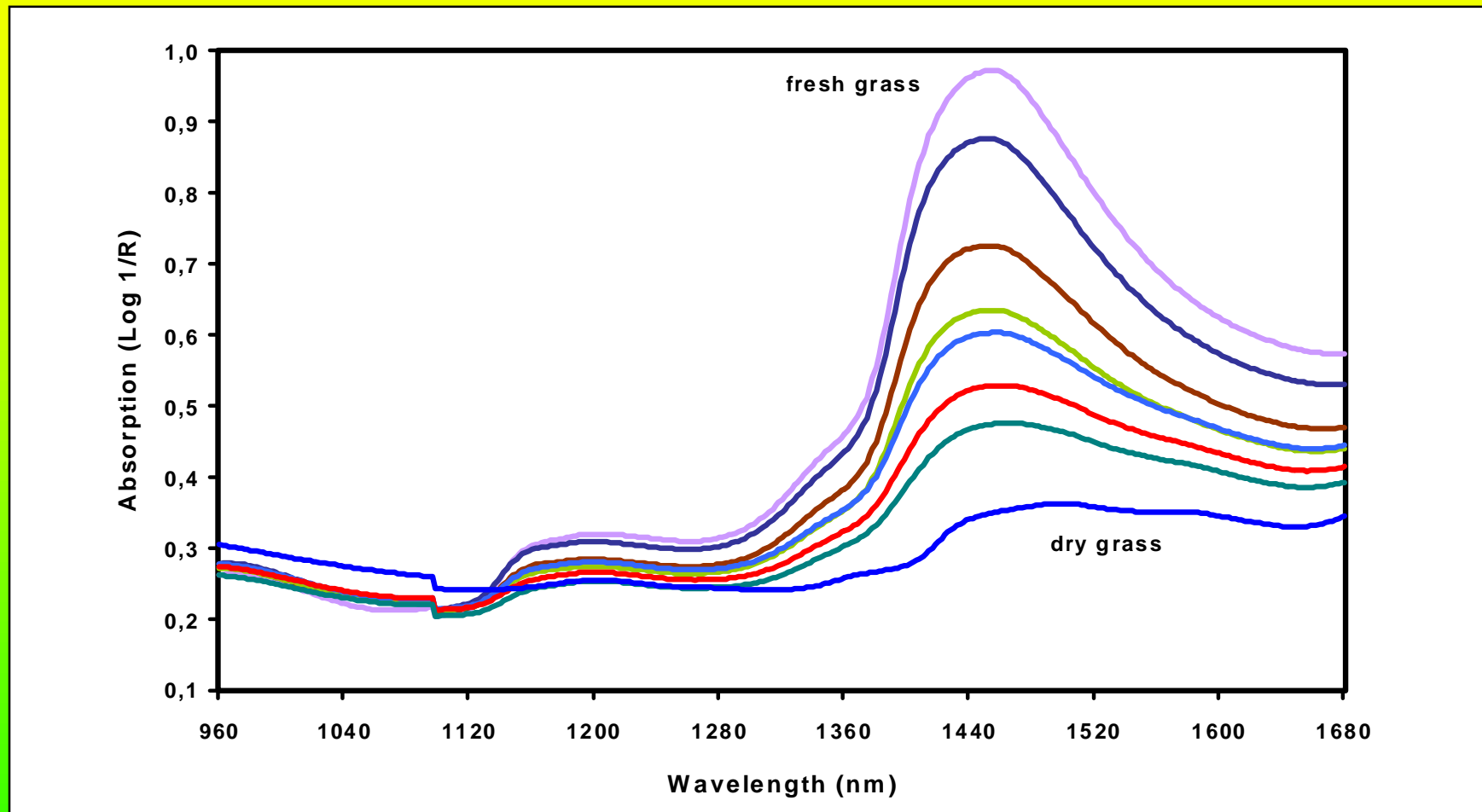


# Calibration Comparison of Dry Samples on the NIRSystems and the ZEISS

Equalized Wavelength Range 958-1678 nm			NIRSystems 6500		ZEISS MMS-NIR	
Constituent	n (6500/MMS)	Range (%)	Terms	SE	Terms	SE
Dry Matter	94 / 97	93,8 - 98,7	5	0,43	7	0,46
Crude Protein	92 / 94	8,7 - 23,7	8	0,52	8	0,57
Crude Ash	65 / 64	7,6 - 12,6	6	0,61	5	0,67
Crude Fibre	94 / 94	16,7 - 34,1	8	0,99	8	1,22
WSC	194 / 193	3,3 - 15,5	12	0,63	10	0,87
EULOS	93 / 93	116,5 - 388,3	8	15,99	8	19,21



# Spectra of Fresh Grass with Different Dry Matter on the NIRSystems 6500

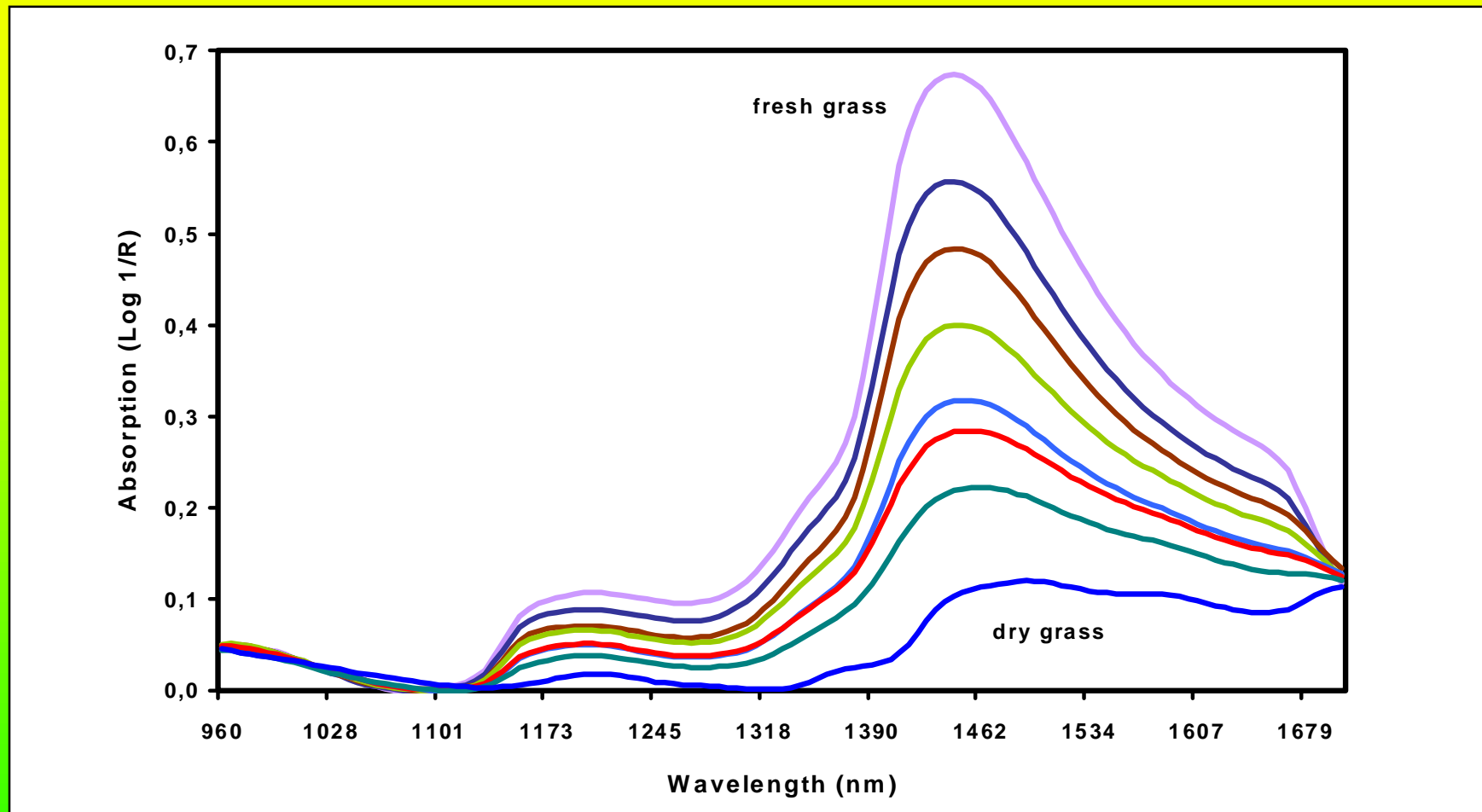


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# Spectra of Fresh Grass with Different Dry Matter on the ZEISS MMS-NIR 1.7



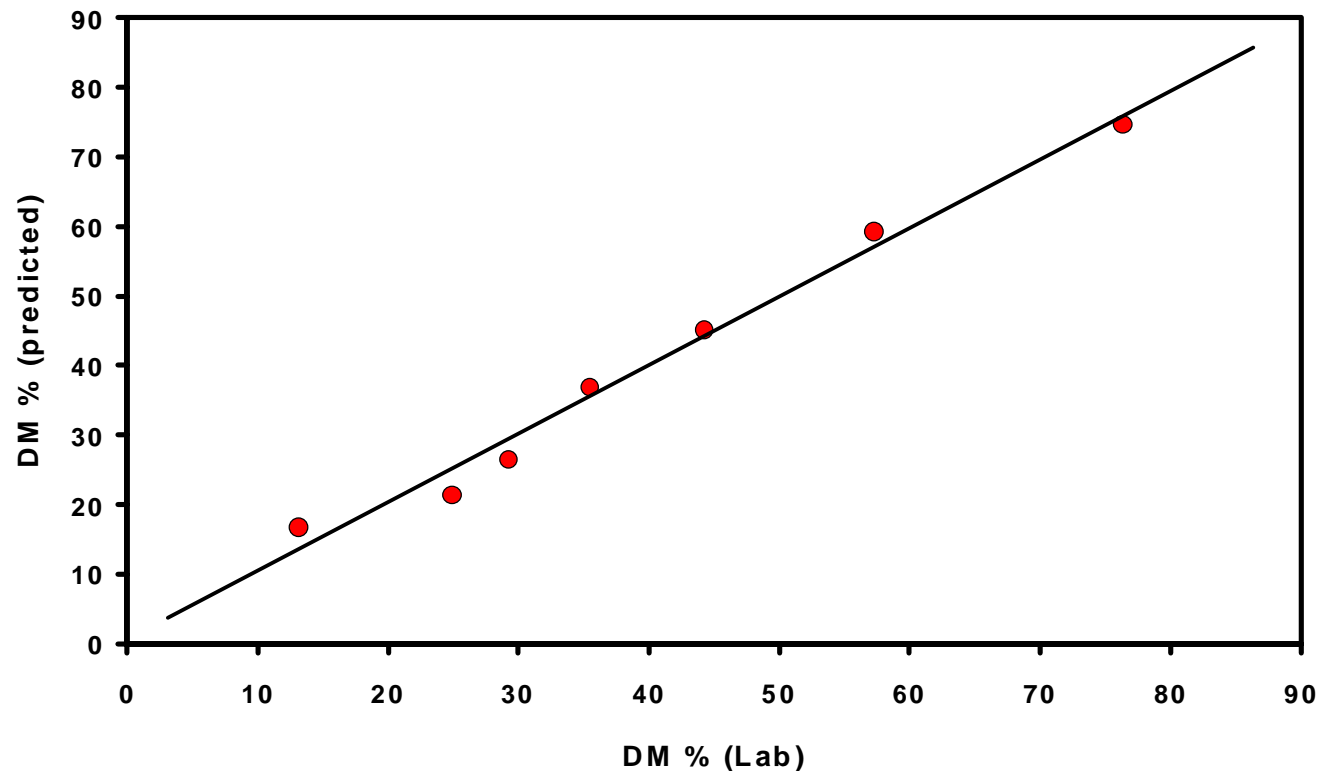
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# Dry Matter 1 - Term - Regression (NIRSystems 6500)

Wavelength: 1582 nm



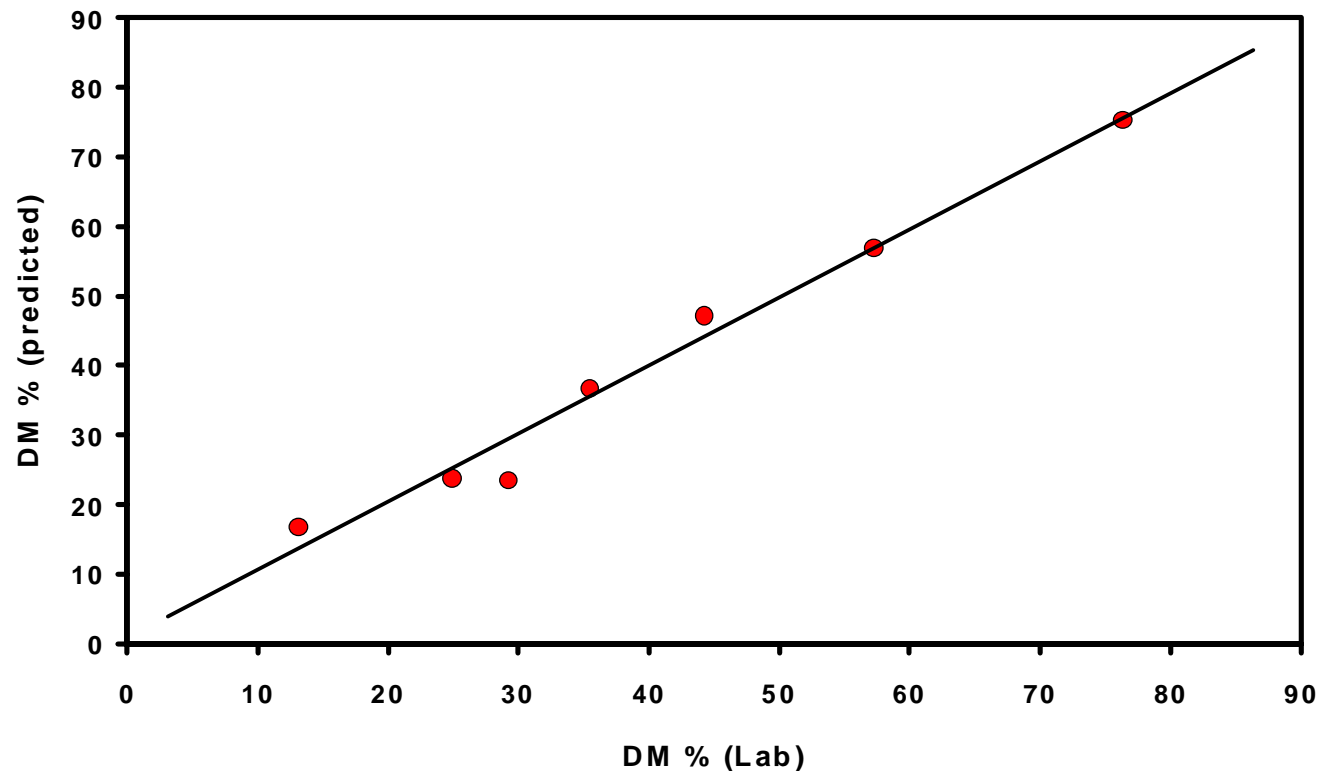
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# Dry Matter 1 - Term - Regression (ZEISS MMS-NIR 1.7)

Wavelength: 1558 nm



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# Prospects

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# Measurement and Data Handling

- Construction of Instruments
  - Modular Construction
  - Portability / Ruggedness
  - Miniaturization
  - Data Point Standardization
- Sample Presentation
  - in line / on line
  - Reflectance / Transmittance
  - Size of Measurement Area



# Measurement and Data Handling

- Standard Data Format
- Transferability of Spectra
- Identification Routines
- Quantification Routines