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Evaluation of genotype and environmental variation in fibre and water soluble carbohydrate content of silage maize using a model-assisted approach

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Problem

- Weather conditions are a main determinant of yield and quality performance of forage maize in marginal regions
- Few comparative studies available concerning the impact of hybrid and environment on content of structural and water soluble carbohydrates

Objective

- Quantify the genotypic and environmental variation in fiber components (NDF, ADF, cellulose, hemicellulose) and water soluble carbohydrates by means of a simulation study for marginal regions of northern Germany

Material and Methods

- Three-year field experiment (2001-2003) conducted at the experimental farm 'Hohenschulen' of the University of Kiel, northern Germany
- Climate: daily mean temperature of 8.7° C and 759 mm average annual rainfall; soil: pseudo-gleyic sandy loam
- Two hybrids, Oldham (early) and Fuego (mid-early), harvested 6 times throughout the vegetation period
- Contents of NDF, ADF, cellulose, hemicellulose, and water soluble carbohydrates (WSC) estimated by near-infrared reflectance spectroscopy (NIRS)
- Mechanistic FOPROQ (Herrmann et al., 2005) and FONSCH (Wulfes et al., 1999) models adapted for predicting seasonal changes of dry matter, fiber, and WSC content, respectively, based on 3-year field trial
- Long-term simulation study (Kiel, 1976-2005) conducted to comprehensively quantify the environmental impact on fiber and WSC content for marginal regions of northern Germany

Results

- Contents of dry matter, fiber, and WSC reasonably well estimated for both cultivars, explaining 73 to 96 percent of variation (Table 1, Figs. 1 and 2)
- Seasonal changes in fiber and WSC content mainly determined by impact of temperature and radiation; influence of soil water negligible
- Field trial data showed similar impact of year and hybrid on variation of NDF, ADF, and hemicellulose, while for cellulose and WSC variation of hybrid doubled that of year (not presented)

Table 1. Results of model calibration for contents of dry matter, NDF, ADF, cellulose, hemicellulose, and water soluble carbohydrates (g kg^{-1} dry matter)

	Oldham (early)		Fuego (mid-early)	
	RMSE	R^2	RMSE	R^2
Dry matter	21.9	0.96	23.0	0.94
NDF	18.9	0.83	14.6	0.89
ADF	9.2	0.89	8.8	0.93
Cellulose	10.4	0.84	9.0	0.92
Hemicellulose	9.7	0.73	6.5	0.75
WSC	26.0	0.84	24.5	0.89

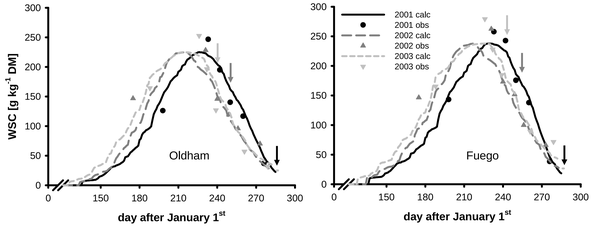

Fig. 1. Observed (symbols) and calculated (lines) data of water soluble carbohydrates (WSC) in the whole-plant of hybrids Oldham and Fuego (2001-2003). Arrows indicate silage maturity in corresponding years (~320 g DM kg^{-1})

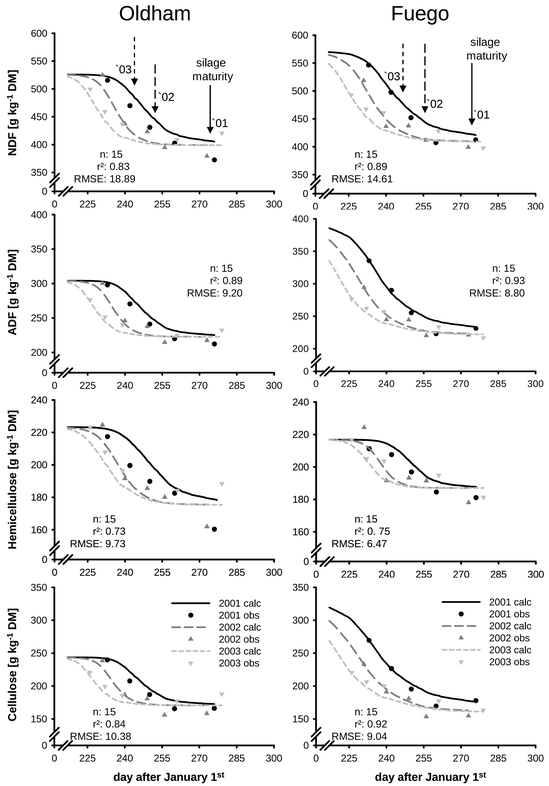

Fig. 2. Observed (symbols) and calculated (lines) data of fiber constituents of hybrids Oldham and Fuego (2001-2003). Arrows indicate silage maturity in corresponding years (~320 g DM kg^{-1})

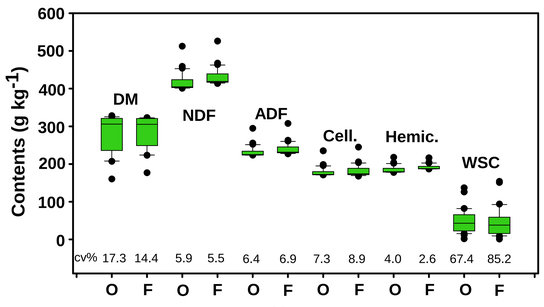

Fig. 3. Results of simulation study (1976-2005) for contents of dry matter, NDF, ADF, cellulose, hemicellulose, and water soluble carbohydrates for hybrids Oldham (O) and Fuego (F); box-plots with 10, 25, 50, 75 and 90% quantiles, and outliers (●)

- Long-term simulation study (1976-2005) revealed strong impact of weather conditions on contents of dry matter and water soluble carbohydrates, while cell wall constituents showed much less environmental variation (Fig. 3)

Conclusions

- For marginal regions of silage maize production in northern Germany the study documents a larger contribution of environmental conditions than hybrid to variation in structural and non-structural carbohydrates
- Model applications may supplement a harvest time prognosis tool (MAISPROG) implemented in Germany, where prognosis is based on dry matter content only; this, however, will re-quire further model validation under a wider range of environmental conditions

References

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