Sorghum for biogas in Germany

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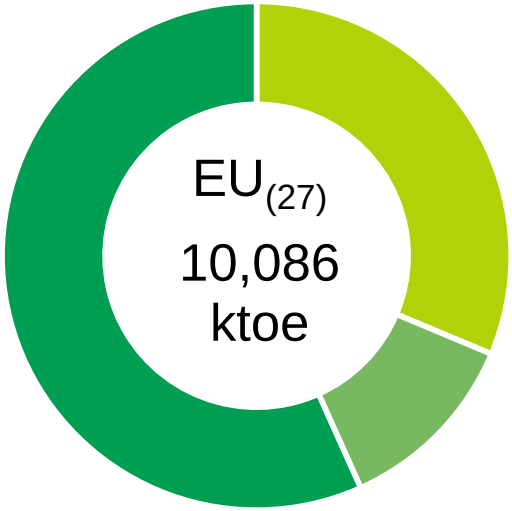
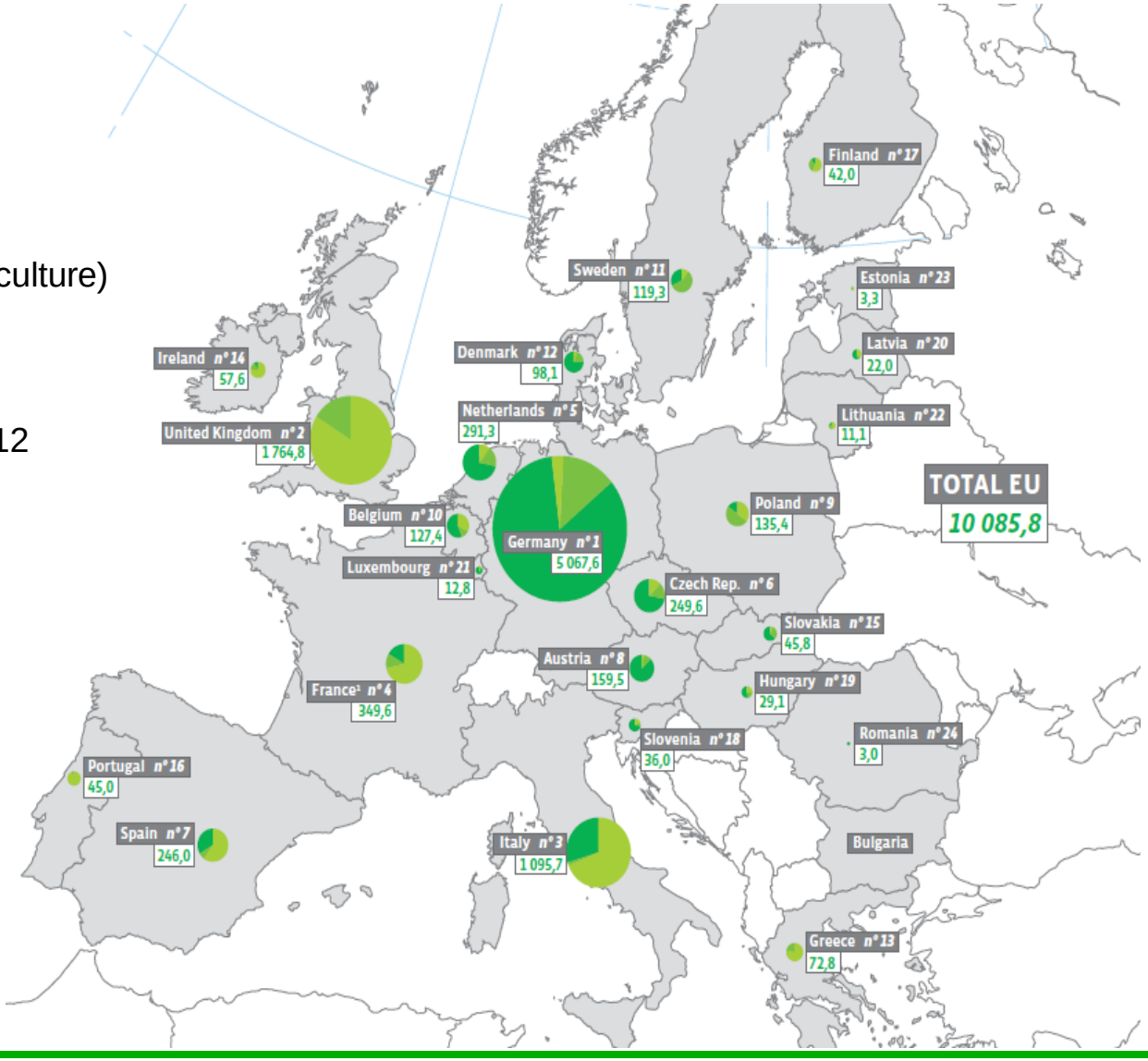
Primary energy production of biogas, 2011

- Landfill gas
- Sewage sludge gas
- Biogas other sources (agriculture)

unit: ktoe

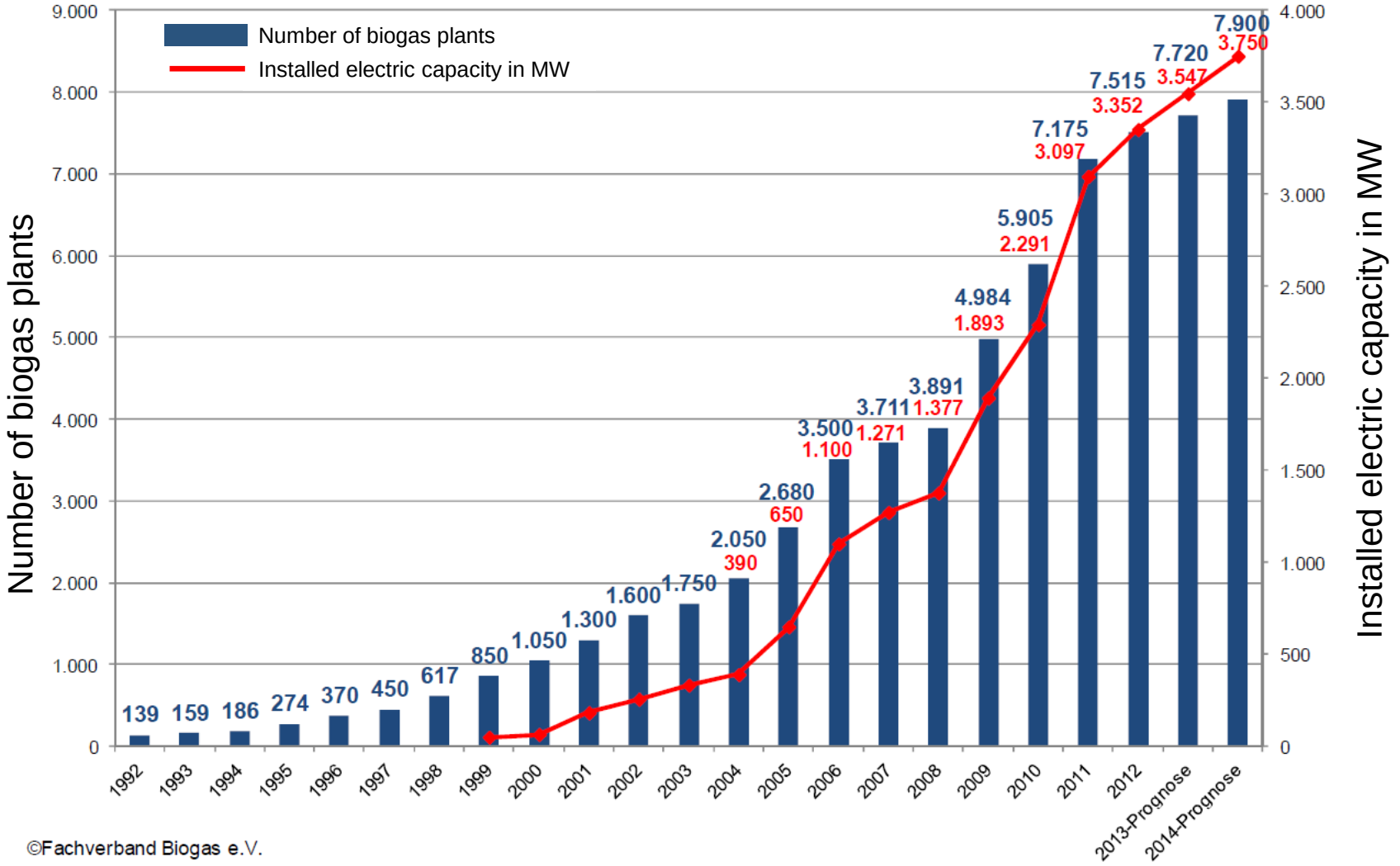
Source: EURObservER 2012





Farmyard biogas plants in Germany

Development of the biogas market in Germany

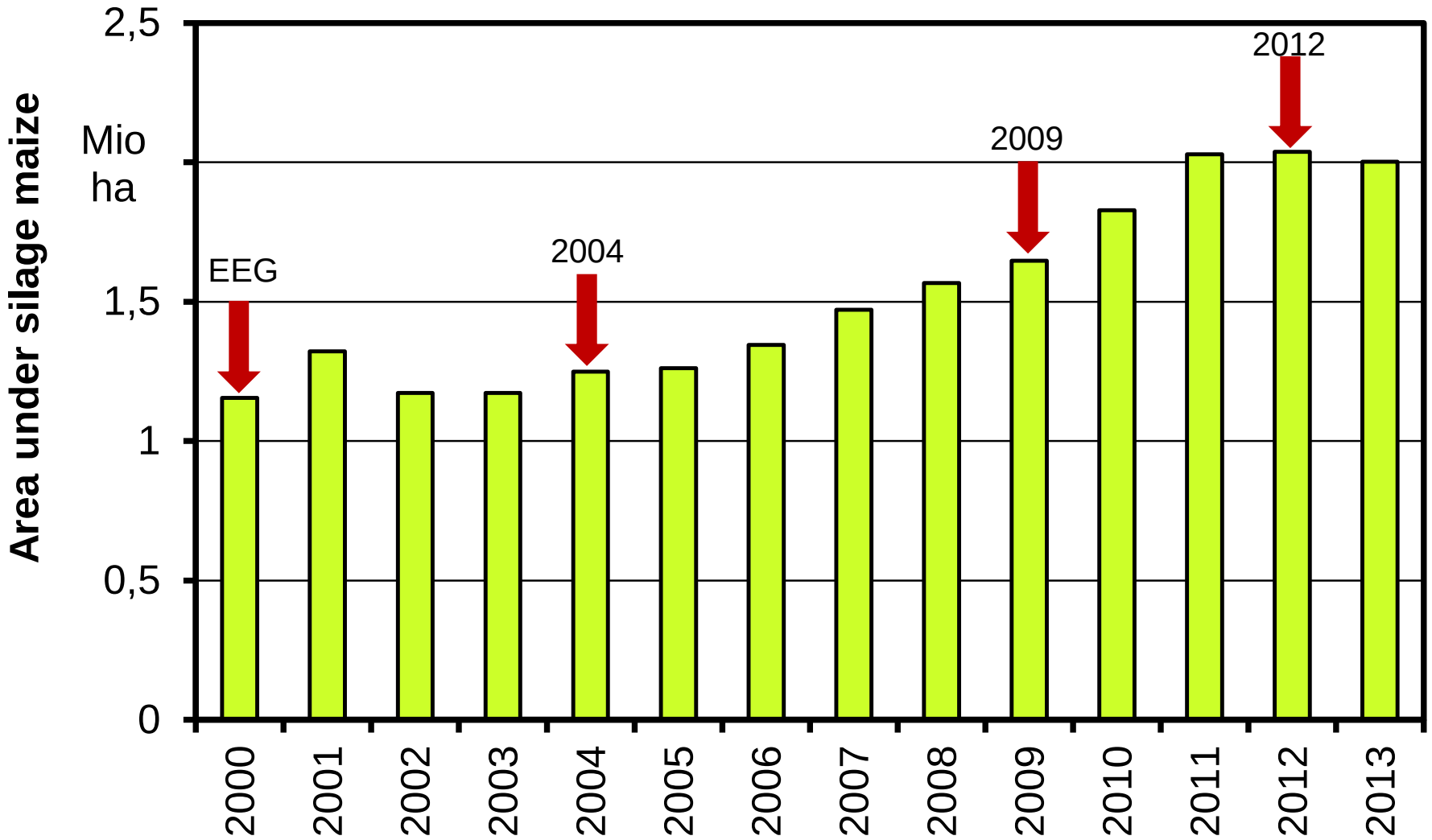


Feed in tariffs for biogas according to EEG

Feed In Tariff (€-Cent/kWh)	2000	2004	2009	2012	2014*)
Basic tariff					
≤ 75 kWel. & min. 80 % liquid manure				25,00	23,73
≤ 150 kWel.		11,50	11,67	14,30	13,66
≤ 500 kWel.	10,23	9,90	9,18	12,30	11,78
≤ 5000 kWel.	9,20	8,90	8,25	11,00	10,55
Bonus					
Energy crops (≤ 500 kWel.)		6,00	7,00	6 (I) / 8 (II)	
Energy crops (≤ 750 kWel.)				5 (I) / 8 (II)	
Energy crops (≤ 5000 kWel.)		4,00	4,00	4 (I) / 8 (II)	
Material of landscape work			2,00		
liquid manure ≥30% (≤ 150 kWel.)			4,00		
liquid manure ≥30% (≤ 500 kWel.)			1,00		
Innovative systems engineering		4,00	2,00		
Permissible value FDA (≤ 500 kWel.)			1,00		
CHP		2,00	3,00		

*) Still “White paper”, Implementation planned on 1st August 2014

Development of the area under silage maize in Germany



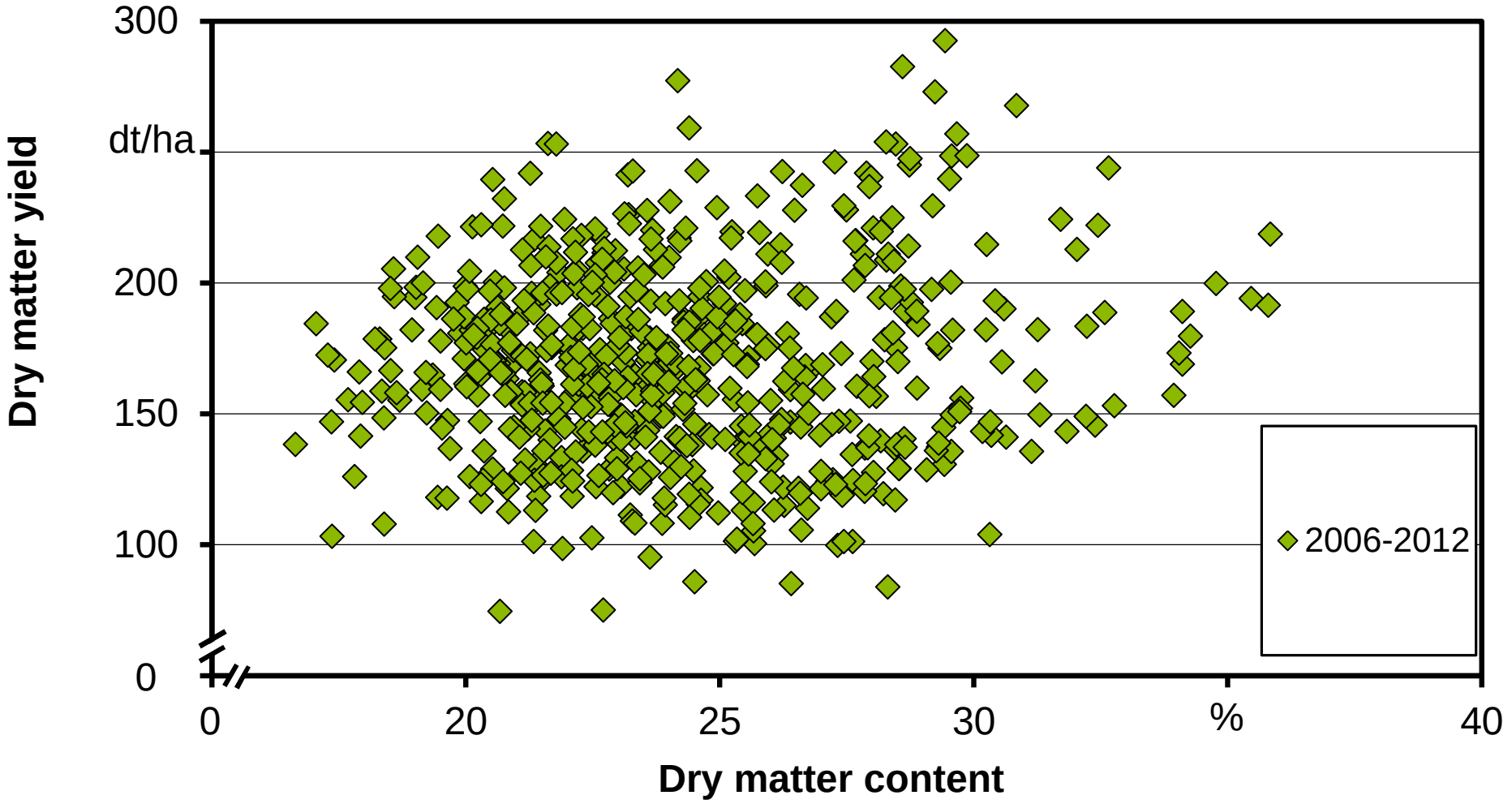
Source: DMK and Federal Statistical Office, updated: April 2014

Recent problems in energy crop cultivation

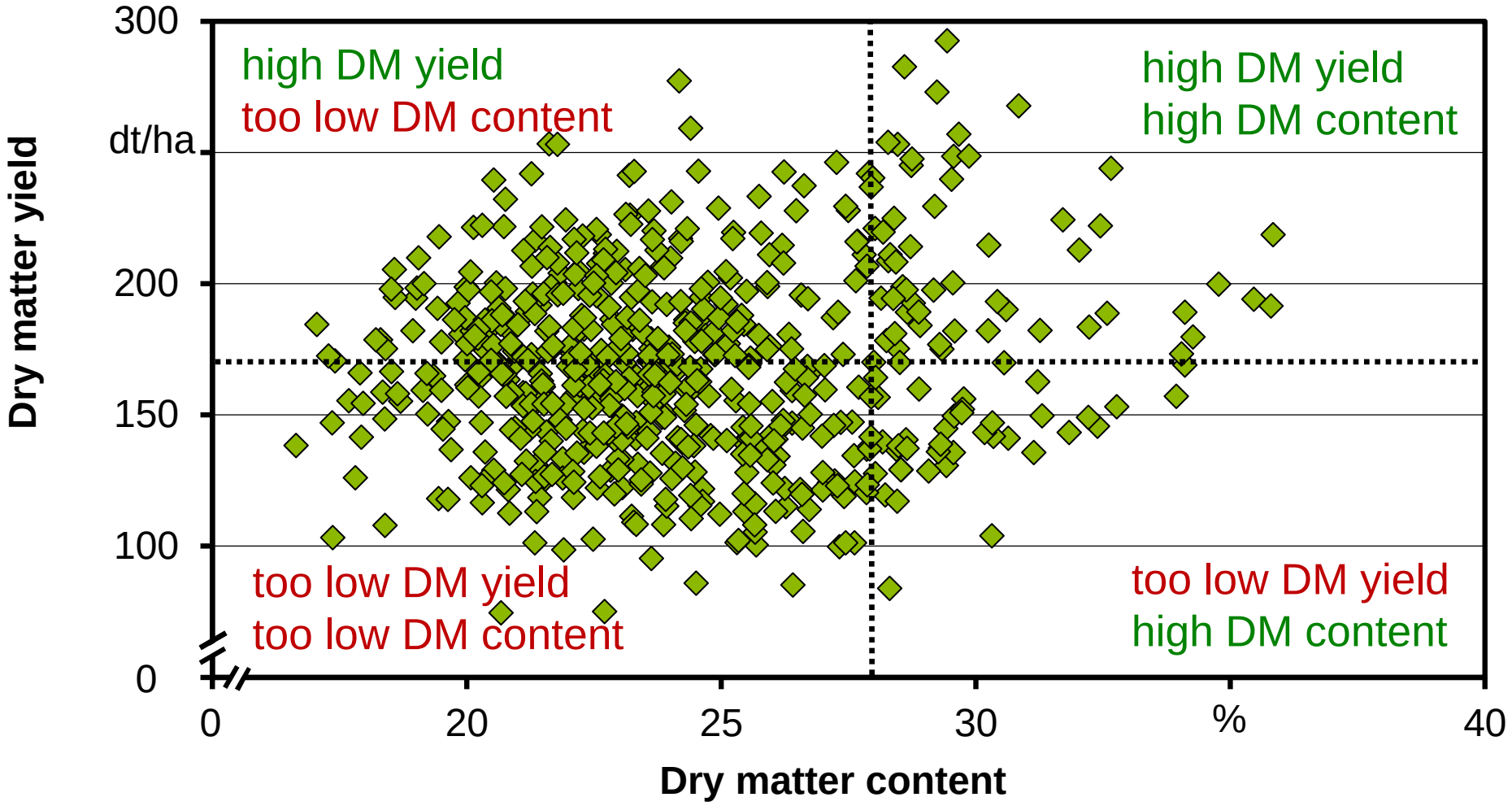
Foto: K. Gehring, LfL

- Increased maize cultivation
  - Public perception: „Maize encroachment“
  - Dense crop rotations with impacts on occurrence of pests and diseases, soil structure, organic matter content….
  - Spreading of *Diabrotica virgifera virgifera* LeConte, that had been classified as quarantinea pest until spring 2014
- Demands for diversification of crop rotations
  - Cultivation of alternative crops
    - *Sorghum*: drought resistant, vigorous
  - Mixed cropping of two and more partners
  - Intercropping / Catch cropping

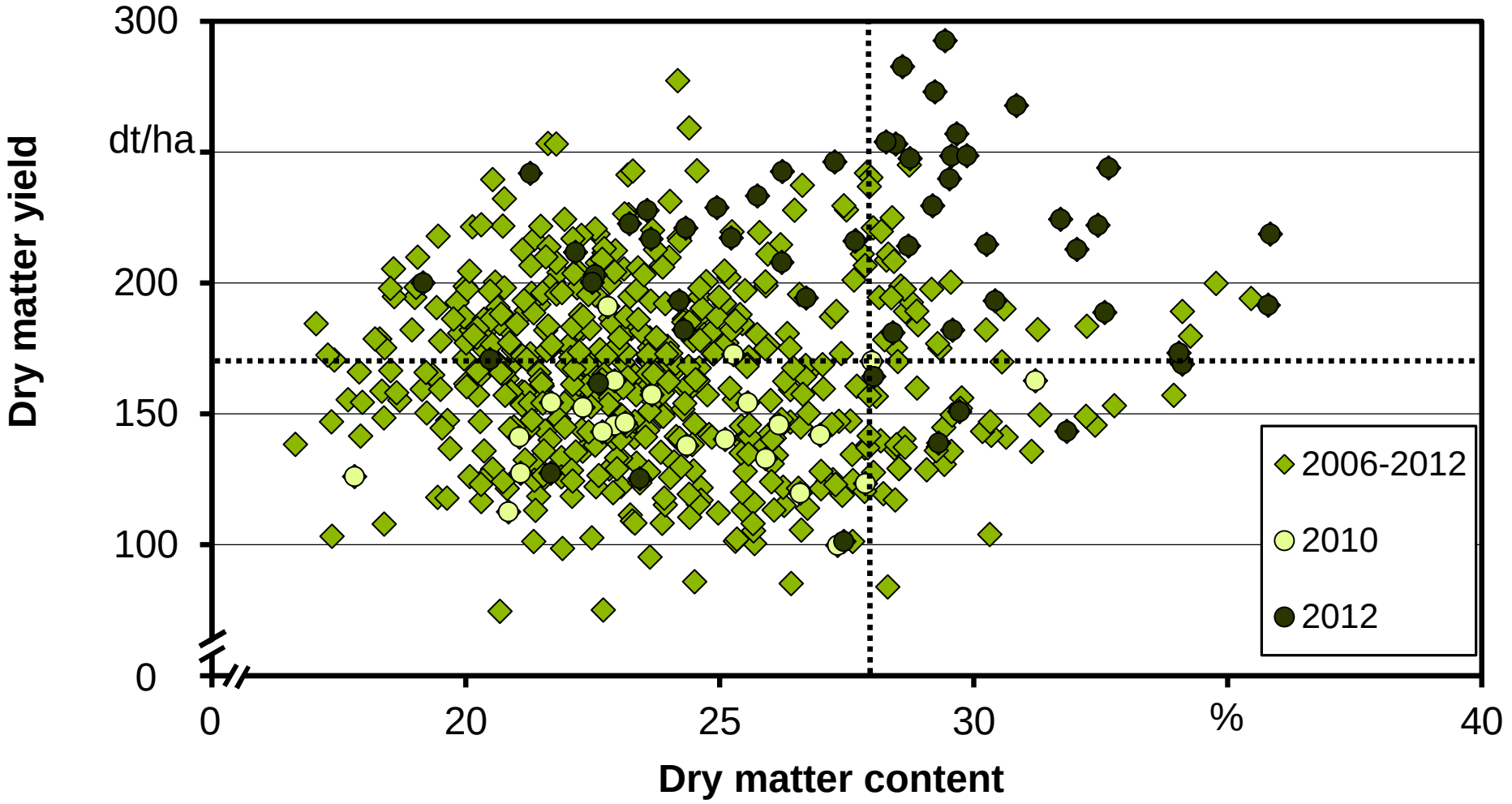
Sorghum screening in Straubing, Lower Bavaria



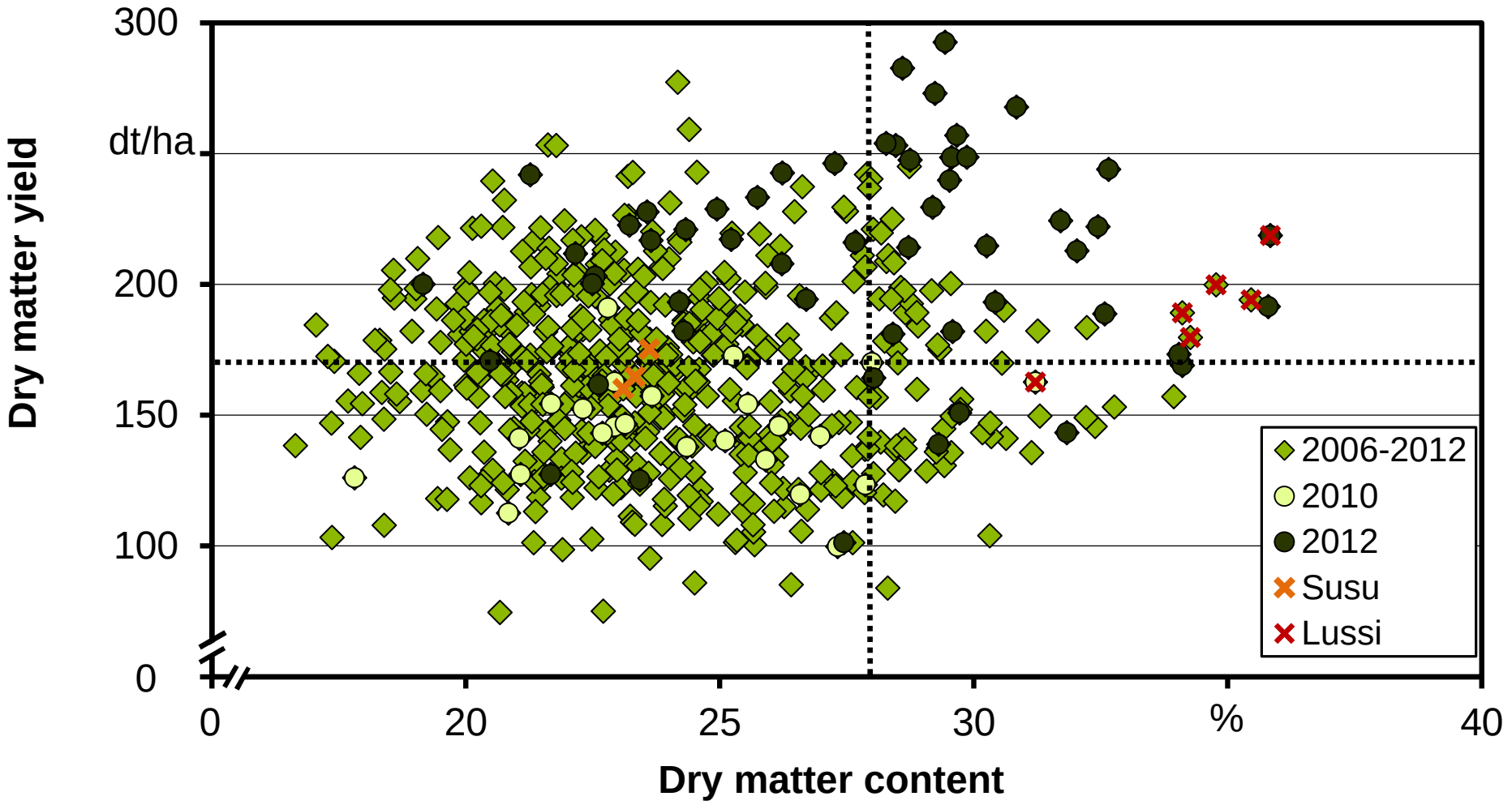
Sorghum screening – yield expectations



Sorghum screening – effect of the weather

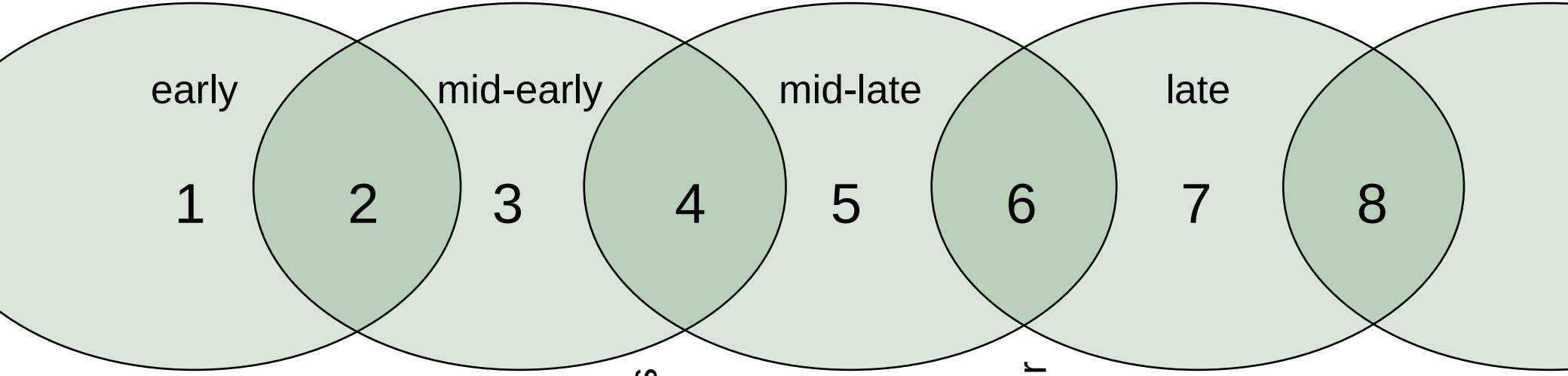


Sorghum screening - effect of the cultivar



Sorghum maturity groups – preliminary model

Maturity groups



cultivars	Lussi	KWS Sole	**KWS Freya** KWS Santos	KWS Zerberus Amiggo KWS Tarzan	**Herkules** Goliath Biomass 150	KWS Bulldozer	**Jumbo** Sisco BMR	BMR Gold

Maturity groups – caloric demand

Caloric demand (growth degree units, GDU) to reach the maturity sufficient for ensilage of Sorghum (DM content od 28 %), based on a basic temperature of 10 °C*)

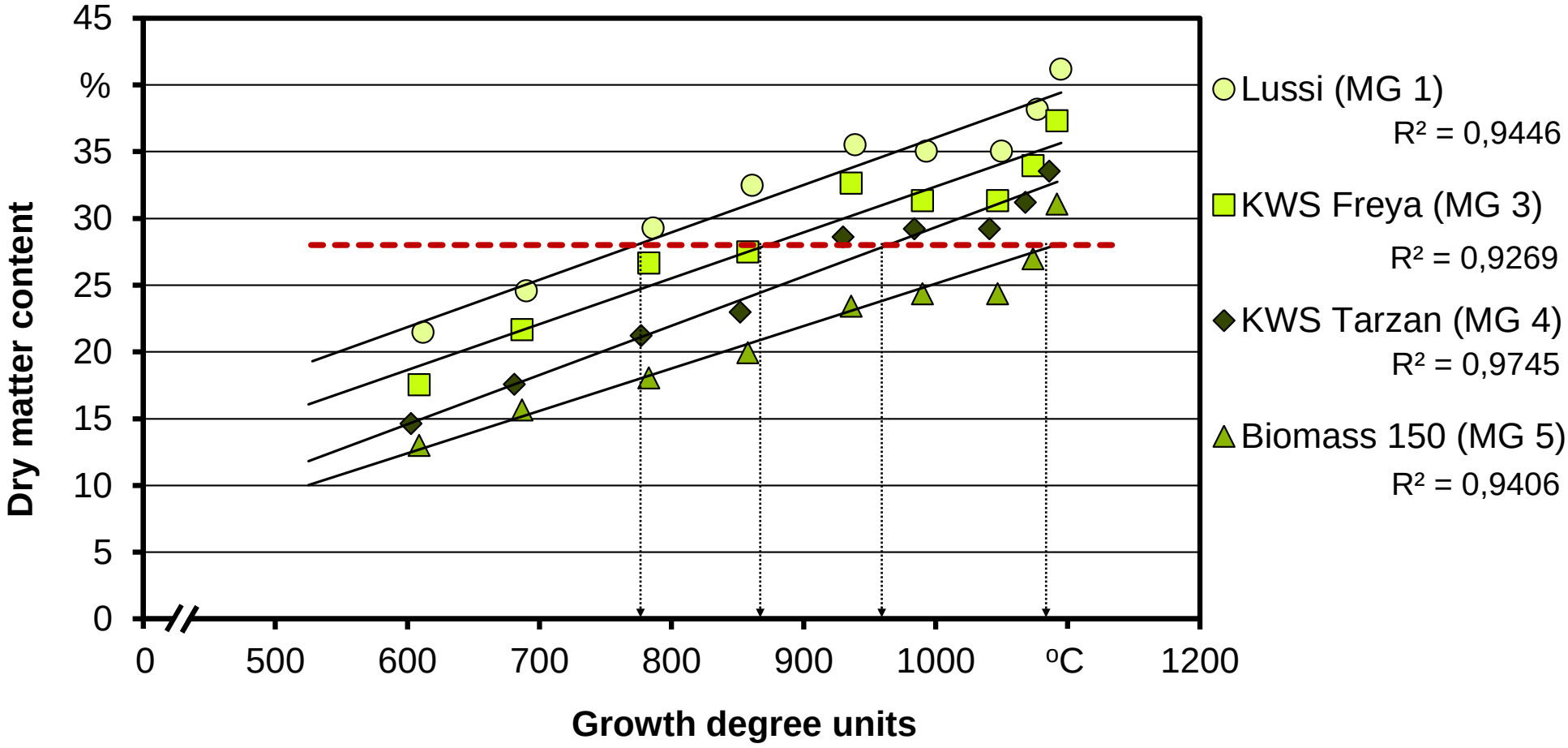
- **Early maturity group: up to 800 °C**
- **Mid-early maturity group: 800 to 900 °C**
- **Mid-late maturity group: 1000 to 1100 °C**
- **Late maturity group: more than 1200 °C**

Deviations possible due to weather conditions; larger differences in case of:

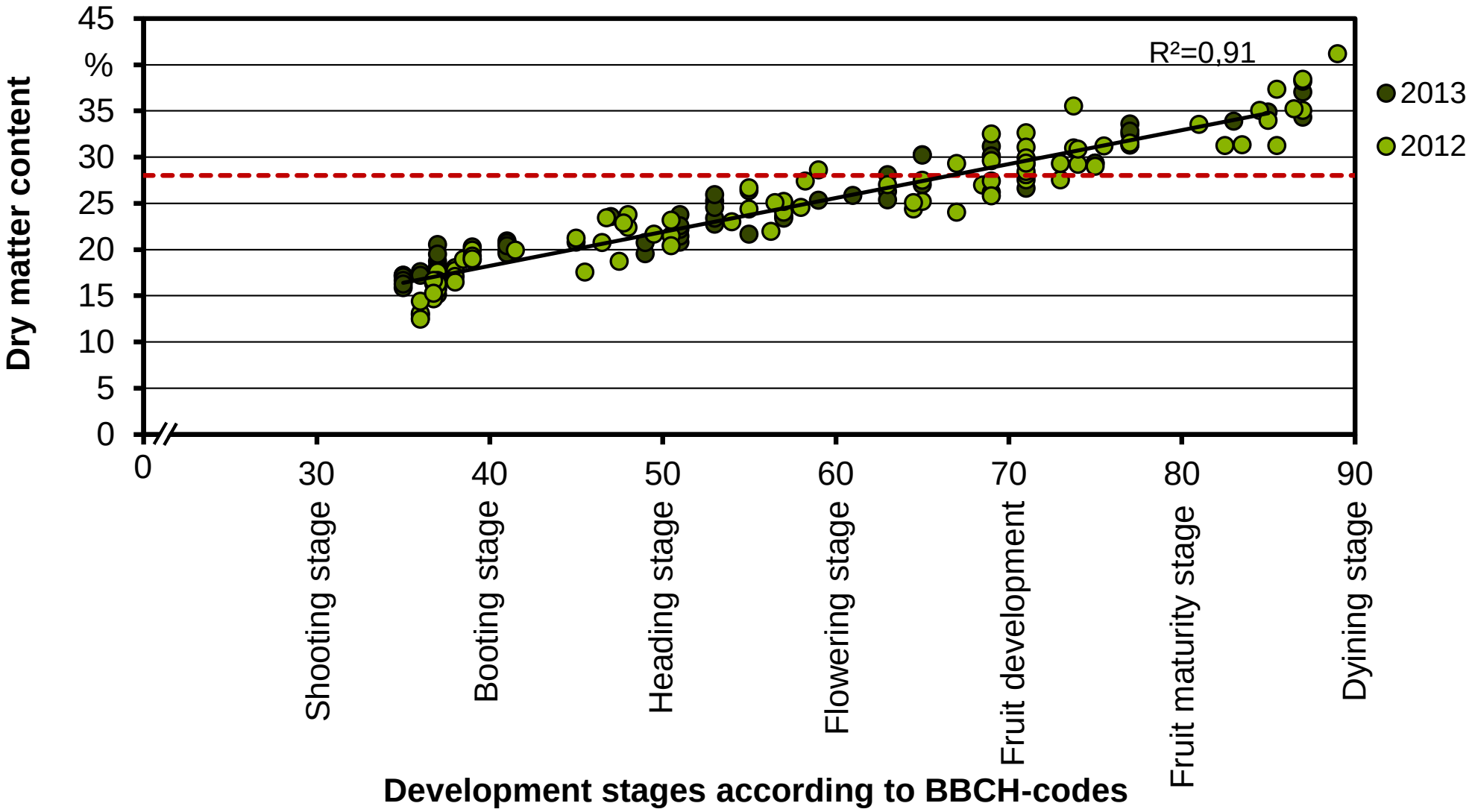
- Water deficiency (accelerated maturity)
- Long lasting raining periods (delayed maturity)

*) source: Gerik, T.; Bean, B.; Vanderlip, R.: Sorghum growth and development, 2003

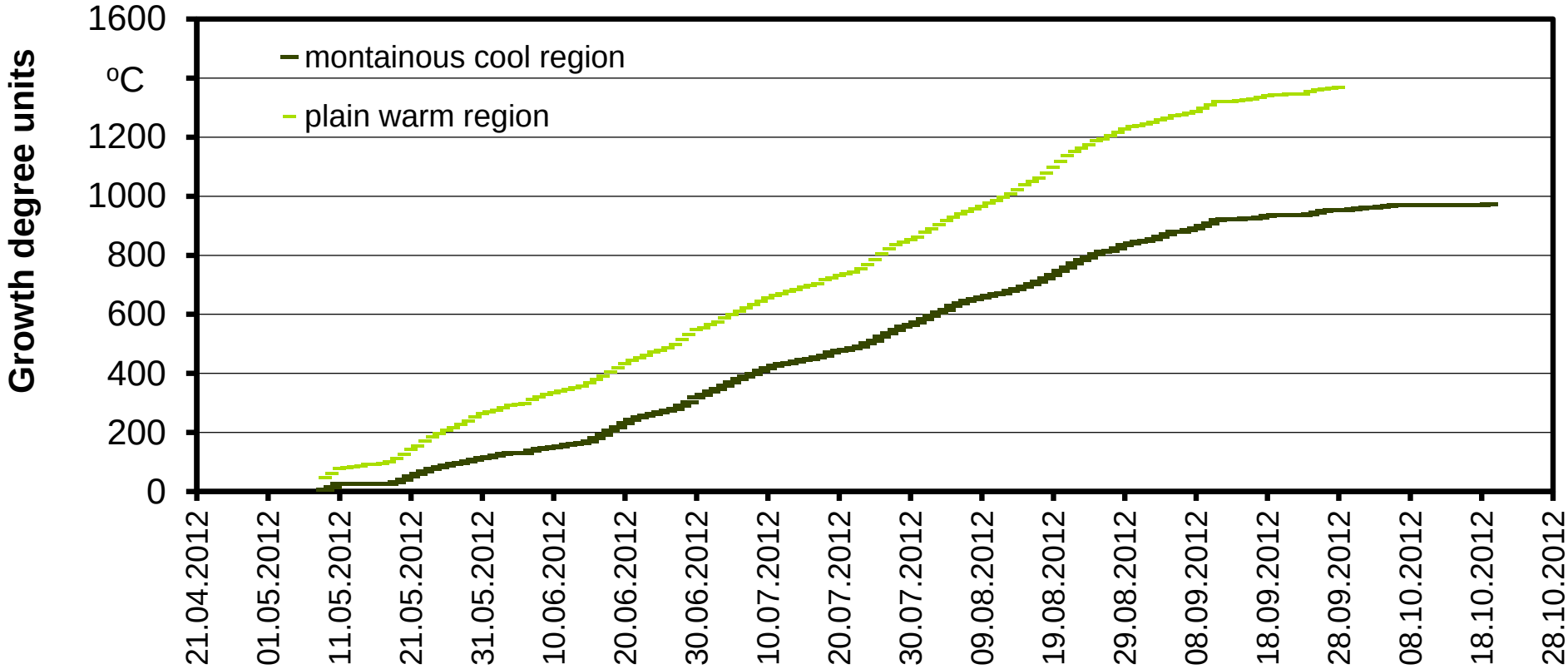
Dependence of dry matter content from GDU



Relationship between DM-content and development stages



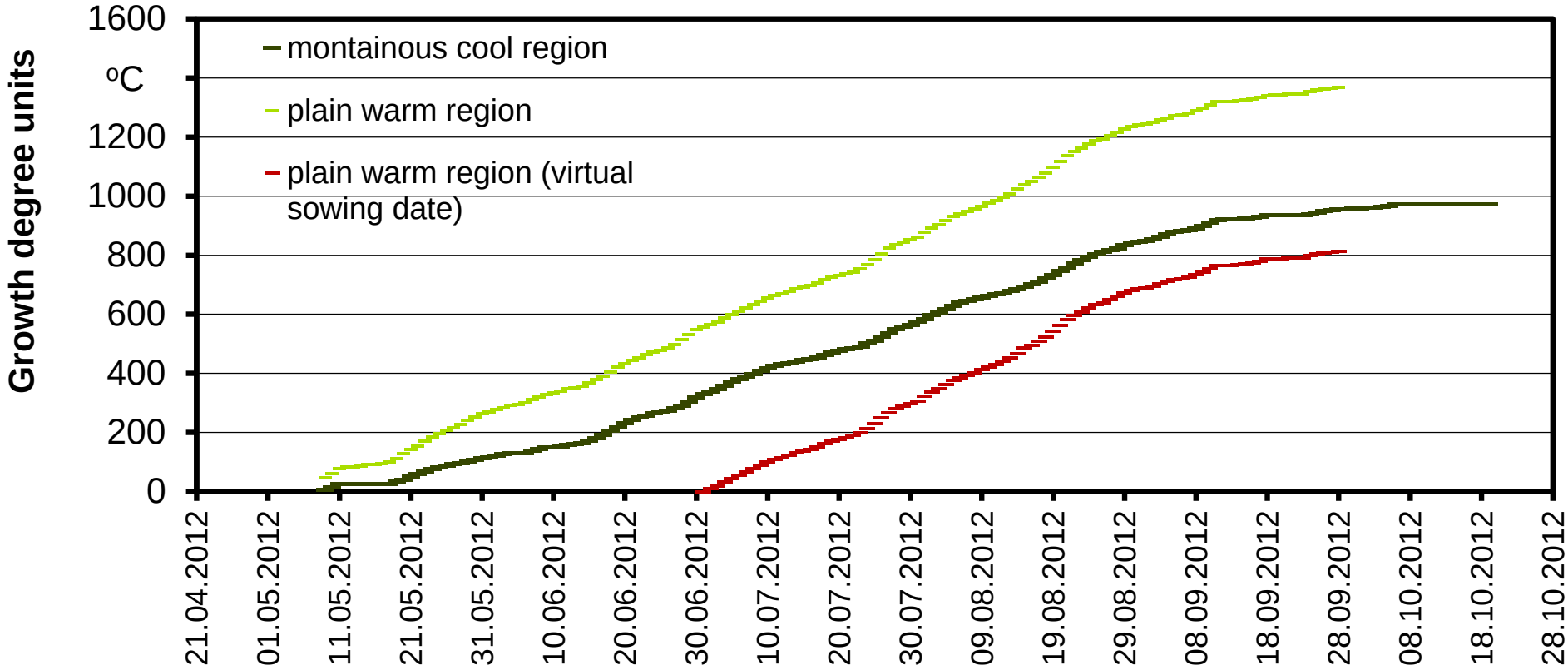
Suitability of Sorghum as main crop



Recommendation:

- In cool regions cultivars of maturity group up to 3 as main crops with sowing dates until middle of May
- In warm regions cultivars of maturity group 5 as main crops with sowing dates until middle of May

Suitability of Sorghum as catch crop



Recommendation:

- In warm regions cultivars of maturity group of 3 as catch crop after green rye until middle June and cultivars of maturity group of 1 after whole plant silage rye until end of June possible

Harvest of Sorghum

Methane potential and methane yield of Sorghum

Species	Cultivar	Maturity group	Year	DM-yield in dt/ha	Methane potential in Nl/kg DM		Methane yield based on HBT Nm³/ha
					Calculated according to Weißbach*	Measured with HBT**	
S. bic. x *S. sud.*	Lussi	1	2011	180	281	296	5,314
			2012	219	252	289	6,312
S. bic. x *S. sud.*	KWS Freya	3	2011	177	283	284	5,014
			2012	222	257	292	6,474
*S. bic*olor (forage type)	Biomass 150	5	2011	237	259	292	6,913
			2012	273	260	285	7,771
S. bicolor (grain type)	GK Emese	3	2011	135	314	290	3,905
			2012	182	335	309	5,618
Maize	Agro Gas	S280	2011	265	351	335	8,891
			2012	237	357	337	7,964
Maize	Slagado	S220	2011	227	362	346	8,633
	Saludo	S220	2012	244	358	351	8,576

* Calculation of fermentable organic dry matter (FODM) based on crude fiber content (XF) and crude ash content (XA):
FODM = 984-(XA)-0,47(XF)-0,00104(XF)² with Methane (Nl/kg DM) = 0,42 * FODM
** HBT = Hohenheim Biogas Test, very small scale batch test

Male sterility in Sorghum induced by low temperature

No anther formation

No grain formation

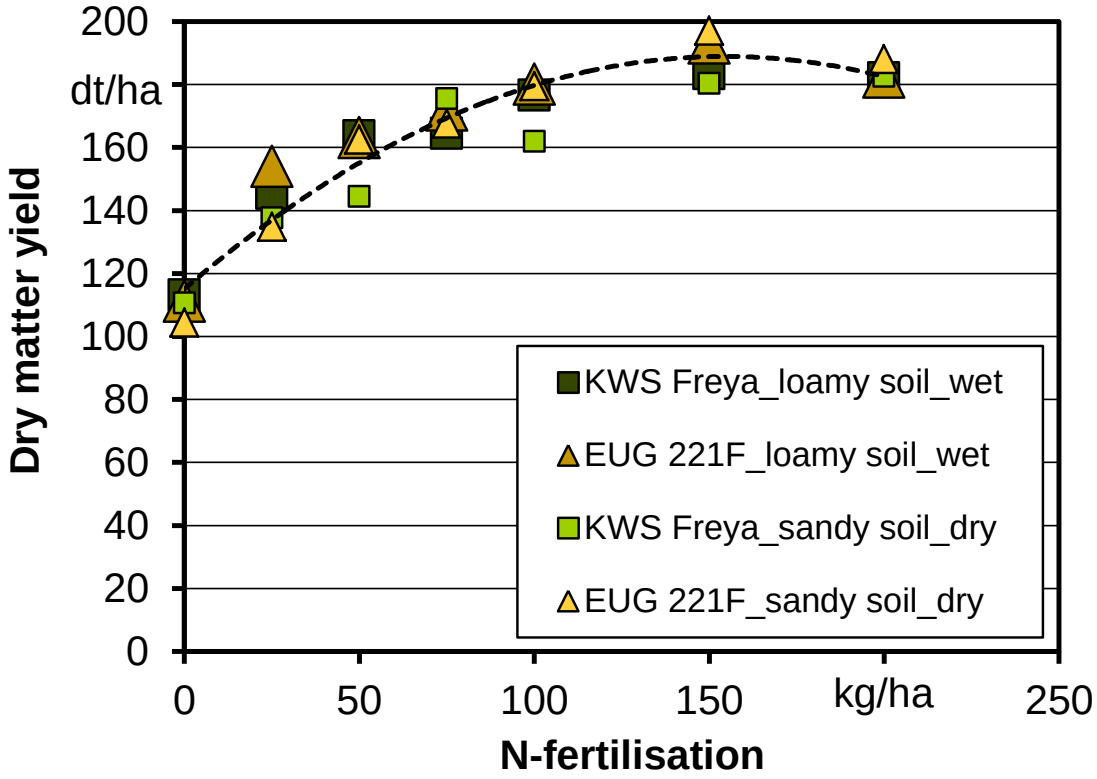
Aim of the cultivation-related field experiments

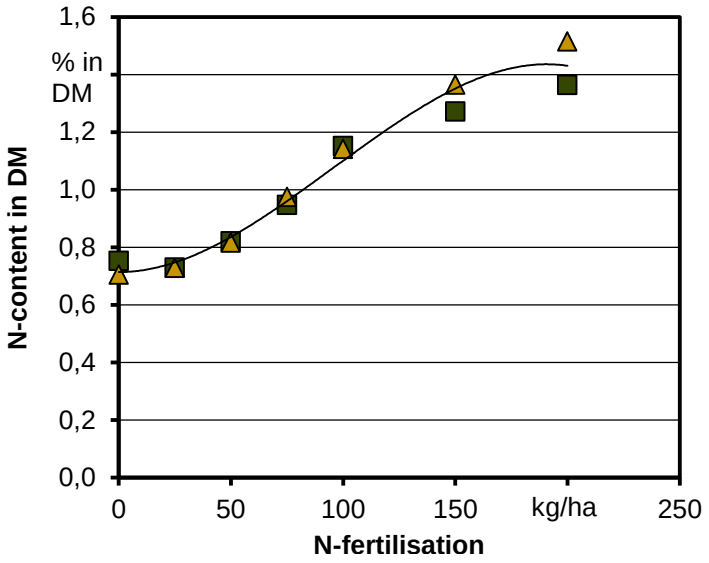
…is not simply to adopt the technology for growing maize but to grow Sorghum even more efficiently.

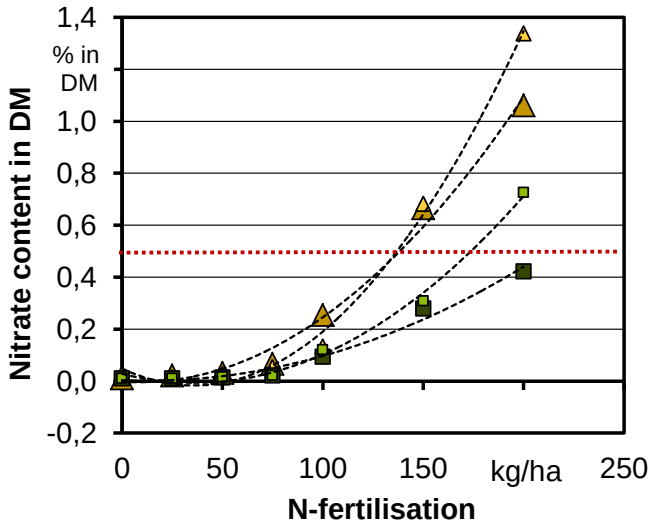
Thus the strategies for fertilizing, soil preparation, sowing and designing the crop rotation must have the presumed higher nutrient and water efficiency of sorghum as well as its suitability for catch cropping in view.

→ extensive instead of intensive

Effect of fertilisation on Sorghum







With an $N_{min.}$ depot in soil of
50 kg/ha give additional 100 kg/ha
and restrict total available N at
150 kg/ha

critical value in forage

above critical value:
EUG 221F _AHO at 137 kg N/ha
EUG 221F_SR at 138 kgN/ha
KWS Freya_AHO at 174 kg N/ha

Problems to solve

Early maturing cultivars

Slow development in early stages

Lodging

Field emergene

Thank you for your attention

Head of department
Dr. Maendy Fritz

Technical assistance:
Michael Kandler
Benno Sötz
Andreas Trauner

Funding: Bavarian State Ministry for Food, Agriculture and Forestry

Sweet Sorghum for ethanol; problems of storage

		Fresh material		Silage				
Formic acid	Removal of silage effluent	DM content %	Sugar content in %	DM content %	Sugar content in %	Ratio of silage effluent (SE) %	Loss of sugar without SE %	Loss of sugar with SE %
without	yes	20.9	34.0	17.7	0.0	15	100.0	97.7
0,5 %	yes	20.6	34.8	19.9	17.8	20	61.6	41.5
1,0 %	yes	20.8	34.6	21.5	29.3	20	30.8	7.0
1,0 %	no	22.6	35.2	22.2	33.7	9	14.8	2.5

Source: TFZ report number 30, 2012

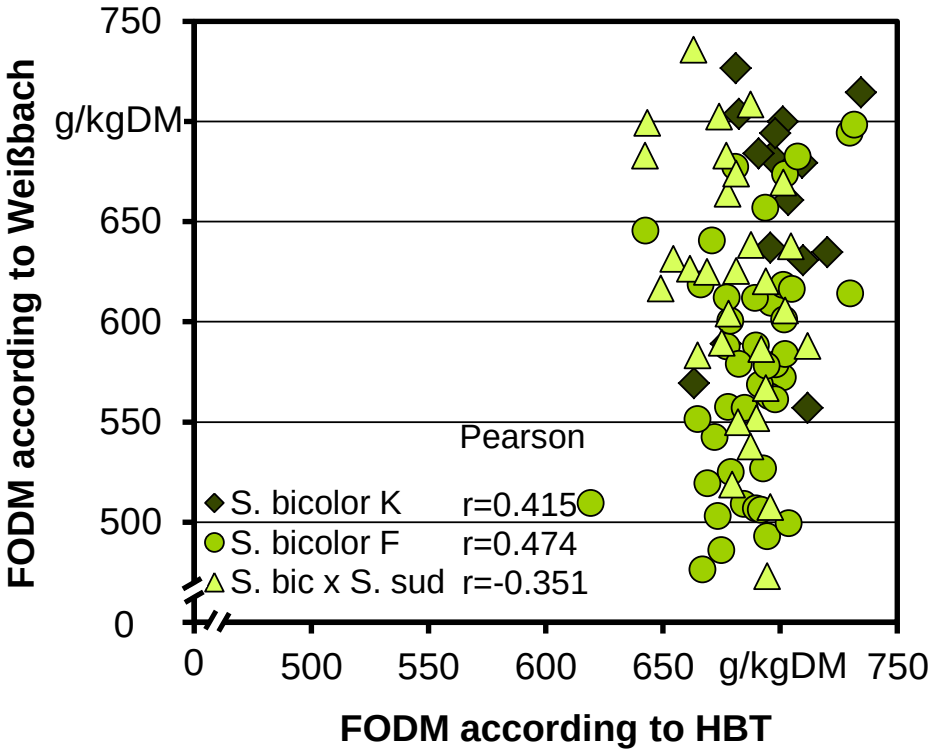
Sweet Sorghum for ethanol; costs

Position	Specific costs in €/l
Cultivation of sweet sorghum	0.468
Harvest, preservation and storage (ensiling)	0.412
Extraction of juice	0.459
Fermentation, destillation, dehydration	0.164
Bagasse usage as fuel	-0.064
Specific costs in total	1.439

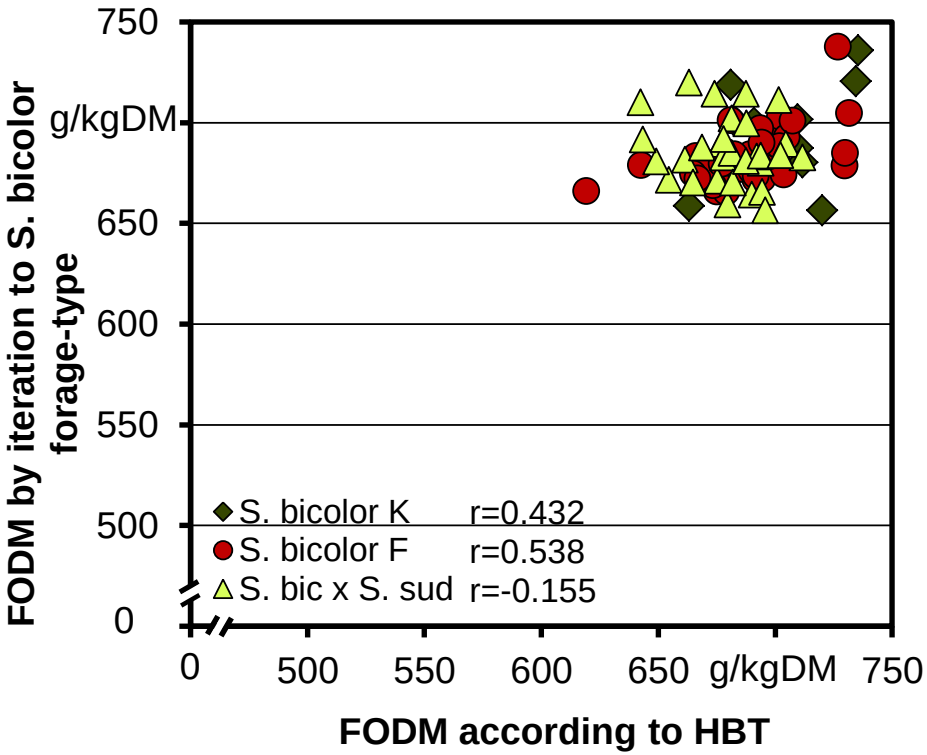
- Specific costs for the position“ harvest, preservation and storage (ensiling)”: 1,108 €/ha
- Thereof for
  - formic acid: 359 €/ha
  - storage silage effluent: 61 €/ha

Source: TFZ report number 30, 2012

Adaptation of the Weißbach-EROM-model for maize to sorghum (preliminary results)



Original Weißbach-EROM-model in comparison to the adjusted HBT data (abscissa). For that, the HBT data were calculated from the methane potentials in Nl/kg DM to the fermentable organic dry matter (FODM) using the “Weißbach-factor” of 0.42.



Result of iteration of the original EROM-model to the HBT data set of *S. bicolor* forage-type. While the original model underestimated nearly ¾ of the cultivars, the new algorithm shows a higher precision.

Effect of tillage on Sorghum yield, results of 2012