Economic and environmental advantages of *Miscanthus* cultivation on marginal lands – lessons learnt from the MISCOMAR project

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Project objectives

- investigate the field performance of novel, stress tolerant *Miscanthus* hybrids in comparison to the standard genotype *Miscanthus* x *giganteus* (*M*×*g*) on economically marginal: high clay content (Unterer Lindenhof, Germany), nutrient depleted (Lincolnshire, UK) and heavy metal (HM) contaminated soils (Katowice, Poland)
- quantify the impacts of *Miscanthus* production on soil parameters and quantify any beneficial effects for soil fertility and crop production
- identify utilization options for biomass from novel *Miscanthus* hybrids and study the impact of varying environmental conditions, *e.g*. HM contamination, on potential *Miscanthus* end uses
- develop concepts for the integration of *Miscanthus* into existing landscapes, crop rotations and farming systems

Yield

Fig. 1. The Miscomar trial in UK.

Field test results on *Miscanthus* biomass production on marginal land in United Kingdom (Figure 1), Germany and Poland showed that yield potential of seed-based hybrids is often in same range as standard *M*×*g* (Figure 2). It was also shown that most of the next generation hybrids are very suitable for climate conditions in Poland and Germany, giving high yield both at green and brown harvest. Seeded hybrids have the advantage that they can be rapidly and cheaply scaled up to thousands of hectares.

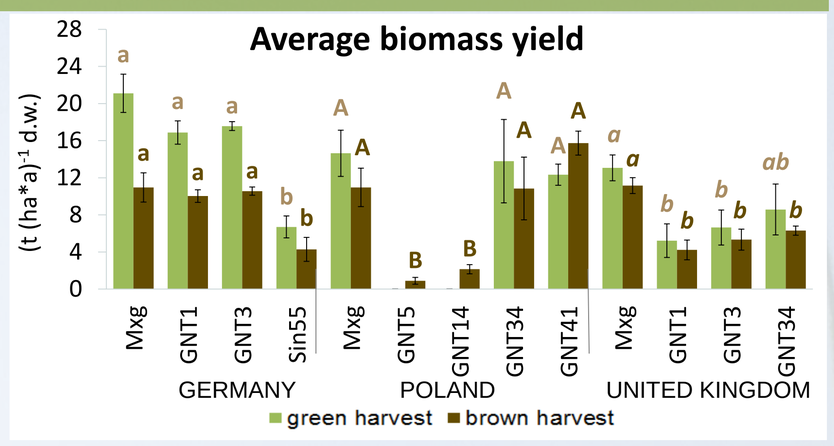

Fig. 2. Green and brown average yield (third growing season).

Biomass quality

Both *Miscanthus* seed-based hybrids and standard *M*×*g* showed heavy metal phytostabilisation in the soil due to very low uptake of lead, cadmium and zinc to aboveground part of plants. Moreover it was also found that metal uptake by seed-based hybrids are significantly lower in comparison to *M*×*g* especially in green harvested plants (Figure 3).
Moreover it was shown, that presence of heavy metals in the soil did not affect plant physiological parameters.

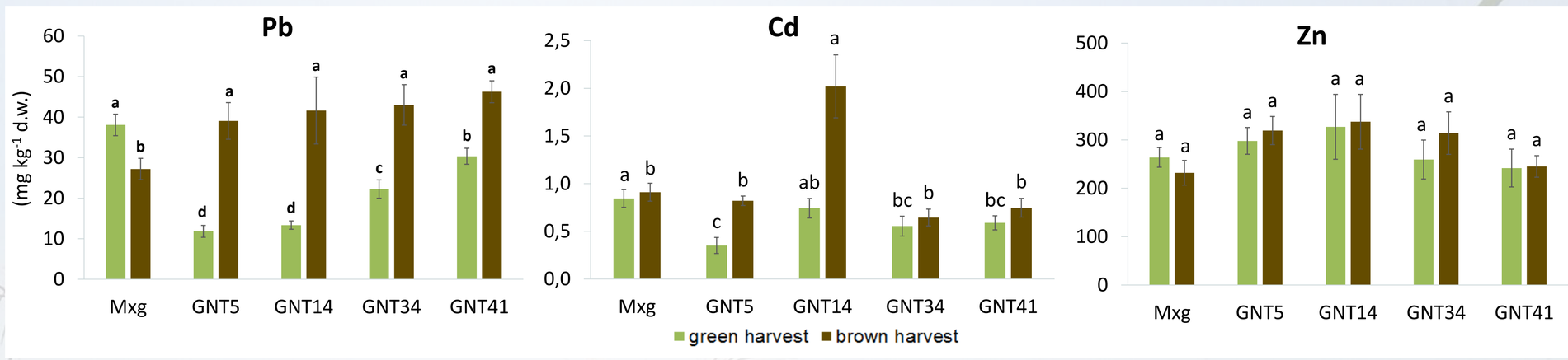

Fig. 3. Heavy metal concentration in *Miscanthus* aboveground biomass cultivated in Poland.

Utilization options

Anaerobic digestion

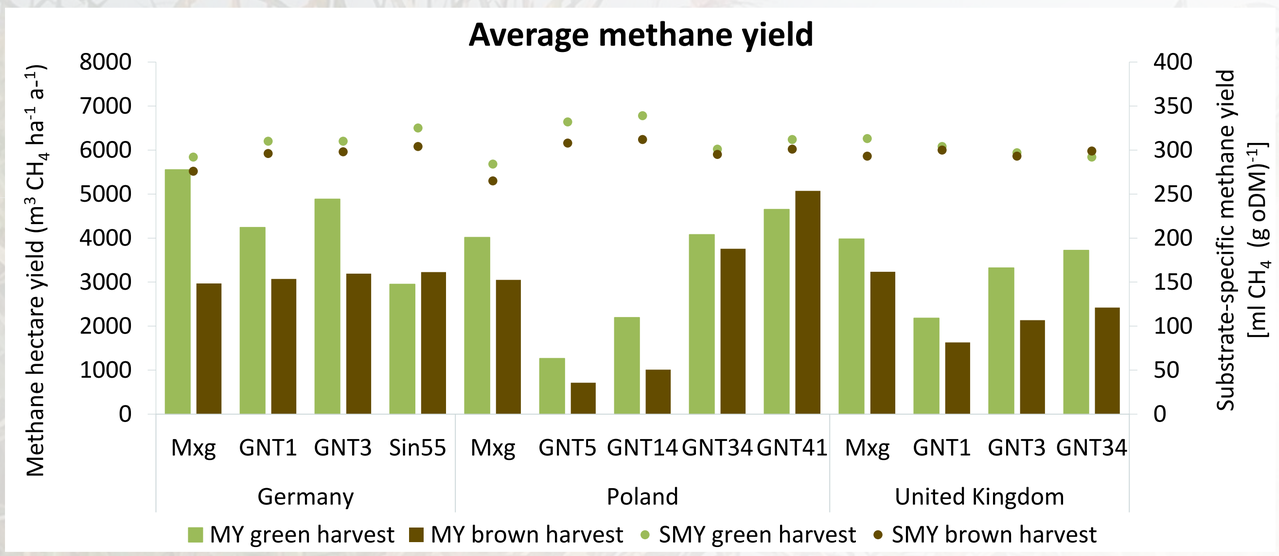

Fig. 4. Methane yield ha^{-1} (bars) and substrate specific methane yield (dots) of green and brown harvests of *Mxg* and hybrids, averaged over two growing seasons.

Novel genotypes in Germany and Poland had higher average substrate specific methane yields than standard cultivar *Mxg,* whilst the opposite was true in the UK. Analyses indicated an impact of dry matter yield, but not substrate specific methane yield, on methane yields per hectare. In Germany and in the UK, the methane yield ha^{-1} of *Mxg* was higher than for novel genotypes, whilst in Poland novel genotypes GNT41 and GNT34 had higher methane yields ha^{-1} than *Mxg*. The highest methane yield was obtained from green *Mxg* biomass harvested from the German site (Figure 4).

Combustion

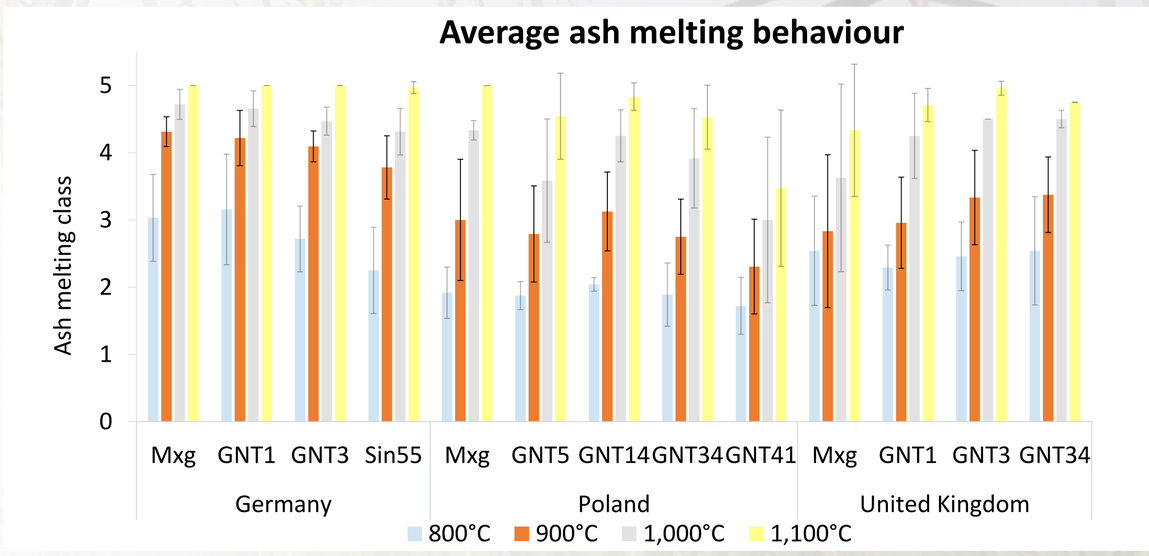

Fig. 5. Ash melting classes (1-2: no sintering; 4-5: molten) at four temperatures for brown harvested *Mxg* and hybrids, averaged over two growing seasons.

Combustion analyses demonstrated improved ash melting behavior in novel genotypes in Poland and Germany than the standard cultivar *Mxg* (Figure 5). Biomass ash fusion classes tended to be lowest from Poland and highest from Germany and demonstrated that contaminated soils at Poland did not negatively affect ash melting behavior.

Integrating *Miscanthus* into farming systems

	Biomass management	Production cost of 1t *Miscanthus* [€ (t DM)$^{-1}$]	Selling prices [€ ha^{-1}]
green harvest (October)	anaerobic digestion	55	2,000
brown harvest (March)	animal beeding	64	8,100
	combustion	47	800

Different spring crops as barley, ryegrass, rapeseed, maize after *Miscanthus* removal requires less fertilization to growth as a consequence of *Miscanthus* residues decomposition.

Findings

***Miscanthus*:**

1. **Feasible** for **marginal** and **contaminated** sites
2. **High phytostabilization potential** with limited metal removal
3. **HM contaminated biomass** suitable for **AD** and **combustion**,
   - BUT: residue/flue gas management
4. **Crops after *Miscanthus*** removal requires **less fertilization**

Seed-based *Miscanthus* hybrids:

1. **Cost reduction** compared to the propagation via rhizomes
2. **High multiplication** rates for **rapid upscaling**
3. **Fast propagation** → faster deployment
4. **Breeding** can improve biomass quality and quantity → opens up **novel utilization pathways**

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