# Suitability of Perennial Grasses and Legume-Grass-Mixtures for Methane Production

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## Introduction

The crop production for energy purposes in the North-Eastern German Plain is restricted by water supply. In other German regions (precipitation >600 mm per year) *Lolium* species can result in potential methane yield per hectare similar to maize which is recommended for biogas production. The objective of this paper is to evaluate dry matter yield and methane output of perennial forage crops under water limited conditions.

Furthermore the fermentability of this green forage should be estimated with nitrate content in addition to the dry matter content and WSC/BC ratio (Kaiser *et al.*, 2002, Kaiser and Weiß 2007).

In green forage with nitrate content <4,4 g $NO_3$ kg$^{-1}$ DM the risk for producing silages containing butyric acid is extremely high.

## Materials and Methods

### *Field trials*

**Cutting management**

Early first cut: Inflorescenses just visible, four or five harvests per year

Late first cut: Early flowering stage, three or four harvests per year

Split block designed trials, four replicates, experimental station in Berge (Federal state Brandenburg, precipitation of 502 mm per year), 2006 - 2008

Table 1. Forage crops and sowing rates

| Forage crops | Composition | Sowing rate kg ha$^{-1}$ |
|---|---|---|
| 1 Grass mixture | *Festulolium/Lolium multiflorum* | 15/20 |
| 2 Grass mixture | *Lolium perenne/L. x boucheanum/L. multiflorum* | 15/10/10 |
| 3 Red clover/grass | *Trifolium pratense/Lolium perenne/L. x boucheanum/L. multiflorum* | 10/10/7.5/7.5 |
| 4 Red clover/grass | *Trifolium pratense/Festulolium/Phleum pratense* | 12/8/2 |
| 5 Alfalfa/grass | *Medicago varia/Festulolium/Phleum pratense* | 18/8/2 |
| 6 Alfalfa/red clover/grass | *Medicago varia/Trifolium pratense/Festulolium/Phleum pratense* | 12/2/8/2 |

**N-Fertilisation**

Grass mixtures: Early first cut 240 kg ha$^{-1}$ yr$^{-1}$

Late first cut 190 kg ha$^{-1}$ yr$^{-1}$

Legume-grass-mixtures: no fertilisation

**Evaluation/Calculation**

Potential methane yield:

Calculation using dry matter yield and specific methane yield (standard gas volume) per kg organic DM according to Schattauer and Weiland (2006)

Threshold values of ensiling material, low or free in nitrate:

$DM_{min}$ = 680 – 64 (g $NO_3$ kg$^{-1}$ DM) – 71 WSC / BC (Kaiser *et al.*, 2002, Kaiser and Weiß, 2007)

## Results

### *Biogas production*

**Dry matter yield**

Figure 1. Annual dry matter yield of forage crops at different stand ages from 2006 to 2008 (values followed by the same letters are not significantly different at α < 0.05 of *Newman-Keuls test*).

**Potential methane yield**

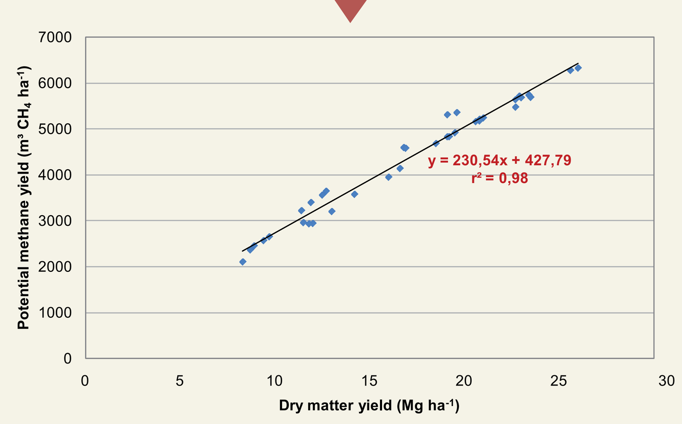


Figure 2. Annual dry matter yield and potential methane yield of forage crops

Alfalfa-grass-mixtures exhibited a significantly higher annual dry matter yield and potential methane yield than the pure grass mixtures if a late first cut was applied. This result was explained by advantages of alfalfa-grass-mixtures in persistence, winter hardiness and drought tolerance compared with *Lolium* species. An early cutting to improve forage quality resulted in a lower annual dry matter yield of alfalfa-grass-mixtures.

### *Fermentability*

**Nitrate content**

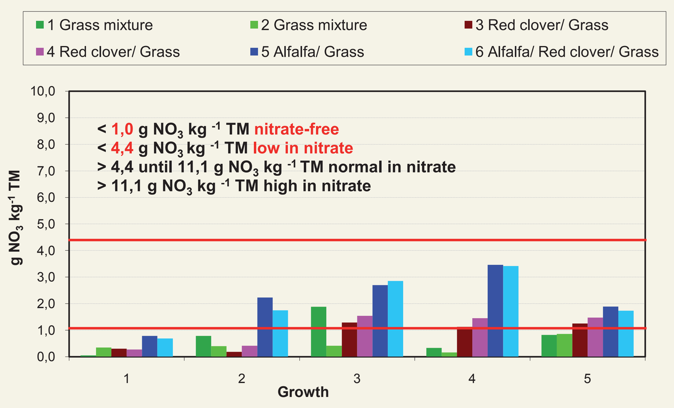

Figure 3. Content of Nitrate, 1. - 5. Growth, Early first cut

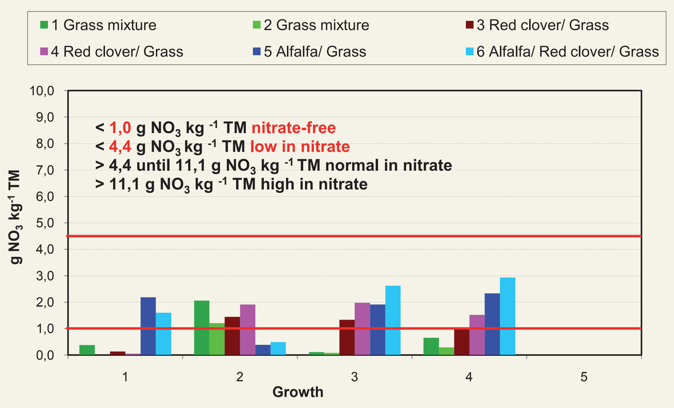

Figure 4. Content of Nitrate, 1. - 4. Growth, Late first cut

Nitrate concentration in forages was very low regardless of nitrogen fertilization level, forage species and cutting frequency.

**Minimum of dry matter content for butyric acid-free silages**

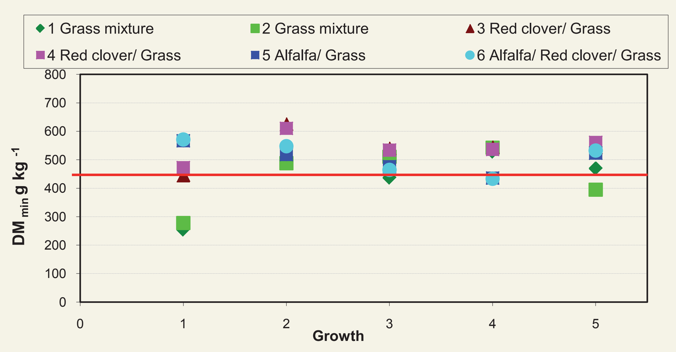

Figure 5. Minimum of DM content (Model of Kaiser and Weiß) $DM_{min}$ = 680 - 64 g $NO_3$ kg$^{-1}$ DM - 71 WSC/ BC 1. - 5. Growth, Early first cut

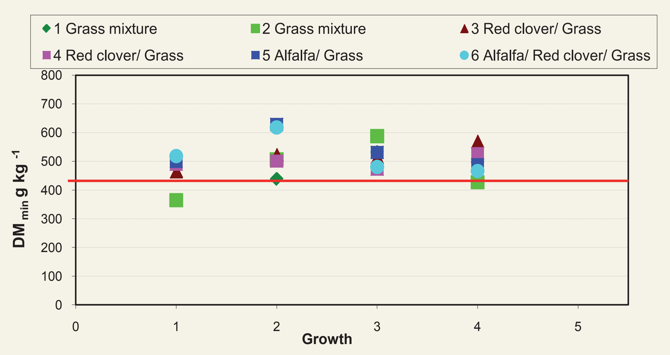

Figure 6. Minimum of DM content (Model of Kaiser and Weiß) $DM_{min}$ = 680 - 64 g $NO_3$ kg$^{-1}$ DM - 71 WSC/ BC 1. - 4. Growth, Late first cut

As low nitrate levels are common in most perennial grasses and grass-legume-mixtures and wilting alone is not sufficient to prevent clostridial activity and butyric acid production even in forages with high DM level at ensiling (<30 %), the strategic use of silage additives is recommended.

## Conclusions

Under water limited conditions alfalfa-grass-mixtures yield higher in dry matter and methane per hectare than pure grass mixtures if a reduced level of cutting frequency is applied. In addition to maize alfalfa-grass-mixtures could be used as a substrate for biogas production.

Most forage crops show particularly low contents of nitrate. For quality assurance of silages wilting to 350 – 400 g DM kg$^{-1}$ in combination with strategic use of silage additives is recommended.

## Acknowledgements

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