Legume based forage production: Possibilities and limitations of a sustainable protein supply based on clovers (Experiences from Northern Germany)

Ralf Loges

Grass and Forage Science/Organic Agriculture, University of Kiel, 24118 Kiel, Germany

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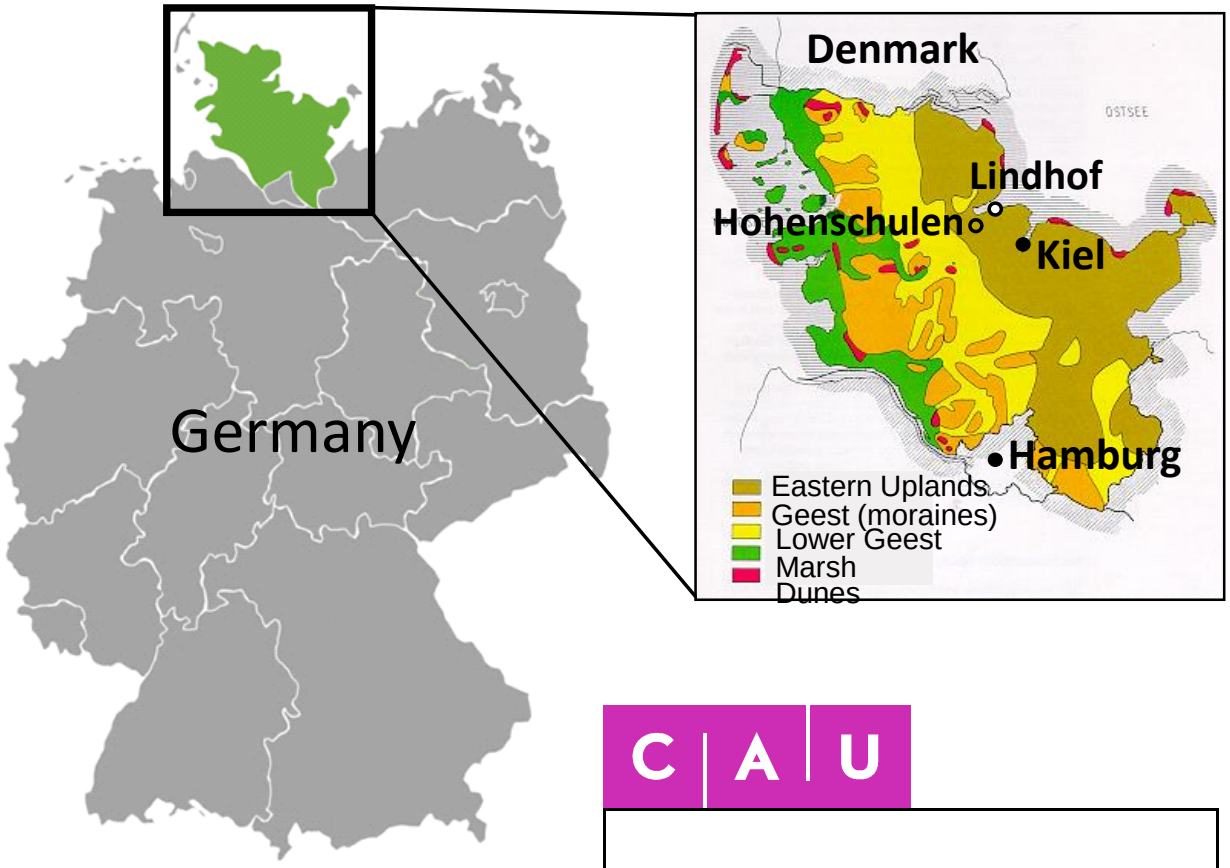


Dr. Ralf Loges
Institute of Crop Science and Plant Breeding
- Grass and Forage Science/ Organic Agriculture
+49 431 880-4654
rloges@gfo.uni -kiel.de

Christian-Albrechts-Universität zu Kiel
Faculty of
Agricultural and Nutritional Sciences

Outline of the webinar

Background and introduction

Possibilities of integrating legumes into forage production

Focus Today: Grass clover leys (arable forage production)

- Presentation of legume species (commonly used in Germany)
- Yield performance and forage quality
- Production technology: sowing, management, fertilization, conservation

Potential Focus next time

white clover based permanent grassland

- Potential and challenges

Conclusions and Outlook

Current challenges in agricultural production:

High purchase prices for
- Energy and fuels,
- synthetic fertilizers and
- concentrates

- climatic change leads to more extreme weather conditions
longer drought periods are more likely and
we have to learn to cope with them in forage production
- decrease in biodiversity

in combination with
decreasing milk prices

And there is pressure from agricultural policy

German Climate Protection Act 2021: Reduction of GHG by 65% by 2030, neutrality in 2045
German Agriculture: Reduction of GHG emissions to 56 million tons of CO_2eq

Farm to Fork Strategy: Aim: Making the European food system more sustainable
Implementation of Sustainable Development Goals/ SDGs:
Food security and sustainable production, by 2030 through:

- **Reduction of chemical-synthetic pesticides by 50%**
- **Reduction of nutrient losses by at least 50%**
- **Reduction of fertilizer use by at least 20% while maintaining soil fertility**
- Reduction in the use of antibiotics in animal husbandry 50%
- Increase in organic farming to a share of 25%

Implementation at national level of the following guidelines

- **EU Nitrate Directive,**
- **EU Directive on National Emission Ceilings (NERC)**

- **Increased demands for public services in CAP** (Common Agricultural Policy)**,**
- **Demands on more biodiversity, more diversified crop rotations**
- **Silage maize year after year without break will no longer be possible in future**

- **Grass clover could be an alternative for arable forage production**

Possibilities of integrating legumes into forage production

- **Grass clover leys (arable forage production)**
- **Grain legumes/pulses grown in monoculture or mixture** for
  a) home grown concentrates or
  b) harvested as whole-crop silage
- **white clover based permanent grassland**
- **Utilisation of clovers or grain legumes**
  as cover- (catch-)crops between 2 main crops

Advantages of grass-clover and alfalfa production

- **Main nitrogen source in organic farming**
- **both crops are rich in crude protein, and for ruminants a real alternative to soy imports**
- **higher crude protein yields compared to grain legumes**
- **high contents of calcium and magnesium** physiological ideal feed minerals delivered by forage (es **Alfalfa**)
- **high palatability + high passage rate = high Dry matter intake** (ETTLE et al. (2012) **and**
- **(ideal alfalfa fed as hay is optimal for rumen function and digestion** many German farms with high yielding cows import alfalfa hay)

More advantages of grass-clover and alfalfa production

Taking also into account its crop rotation value, grass clover represents a very cost-effective way of producing protein-rich fodder on the farm

a) through **several years of usability of the same sowing,**

b) due to **low maintenance**

c) through **self-sufficiency with N**

(has a positive effect on the climatic relevant emissions)

d) due to high crop rotation value (extremely important for organic farming)

due to **large amounts of crop residues**

as well as **mitigation of pest and weed pressure**

(for alfalfa and red clover in particular))

More advantages of grass-clover and alfalfa production

- **Some legume species** such as red clover and alfalfa and alsike clover are deep-rooting and therefore **very tolerant of drought** (eine gute Vorwinterentwicklung vorausgesetzt)

- **Grass clover and field grass are considered ideal crops with regard to soil protection aspects, due to::**

a) clearly largest humus formation (CO_2-sequestration in soil) **also compared to grain legumes and oils seed rape**

b) lowest susceptibility to erosion bzw.

c) Promotion of soil life and biological activity

d) Improving soil structure and stability

(might be crucial in heavy rain events).

Factors influencing yield, forage quality and amount of N_2-fixation of grass clover swards under given site conditions

- **Sward composition**
  - Legume species and -variety
  - Companiongras species and -variety
  - composition of seed mixture
- **Defoliationsystem and –intensity**
- **Sward age**
- **Sward establishment**
- **Fertilisation**

Effect of Lergume species

Brief characterization of the most important clover species

Red clover (RC) *(Trifolium pratense)*:

e

- **Highest productive clover species in ley farming under conditions of Northern Germany**

Duration limited to: max 2 production years sometimes 3 years

- **Draught tolerant deep rooting**,

- **High share of rumen stable protein**

Used for: cutting for conservation,

- **Not resistant for grazing**
- **moderate soil requirements**
  > 600mm precipitation
- not suitable for peat, or light sandy and wet clayic soils
  (Ideal-Soil-pH 6-6,5)

Mainly grown in mixture with grasses

Alfalfa LZ (Medicago sativa)

Very deep rooting, highest yielding legume on better soils under dryer conditions (of Southern Germany)

High Protein contents

Rich in Minerals (Ca, Mg….), When fed as hay, ideal feed structure component for the rumen

Soil quality requirements: higher as Red clover: **deep loamy sand-, sandy loam and loam soils (pH > 6).**

•Used for: cutting for conservation,

• **Not really resistant for grazing**

Mainly grown in mixture with grasses

(Recommendation: to use coated seeds with alfalfa specific: Rhizobium bacteria)

White clover (Trifolium repens)

Clover with extremely good forage quality (at the same time: very high crude protein and energy concentrations) but only moderate protein stability

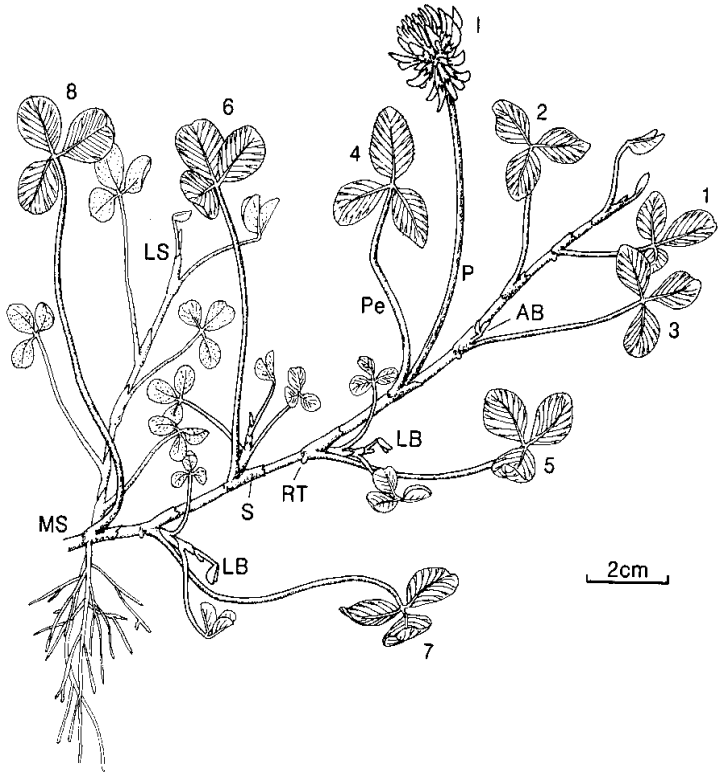
Extremly tolerant for grazing but **shallow rooted** and not very tolerant for summer draught, but recovers fast when rain comes back

Used in grazed or longer lasting leys. It is the main legume species in perma-nent grassland (under German conditions)

Comparatively low requirements with respect to soil (not well adapeted to very light sandy or very heavy clay soils

Soil-pH: 5,5-7.

Grown in mixture with grasses



Comparison of the yield potential of the (from my point of view) most important species

Alfalfa, Red clover und white clover
here grown as pure stand or in mixture with Perennial Ryegrass

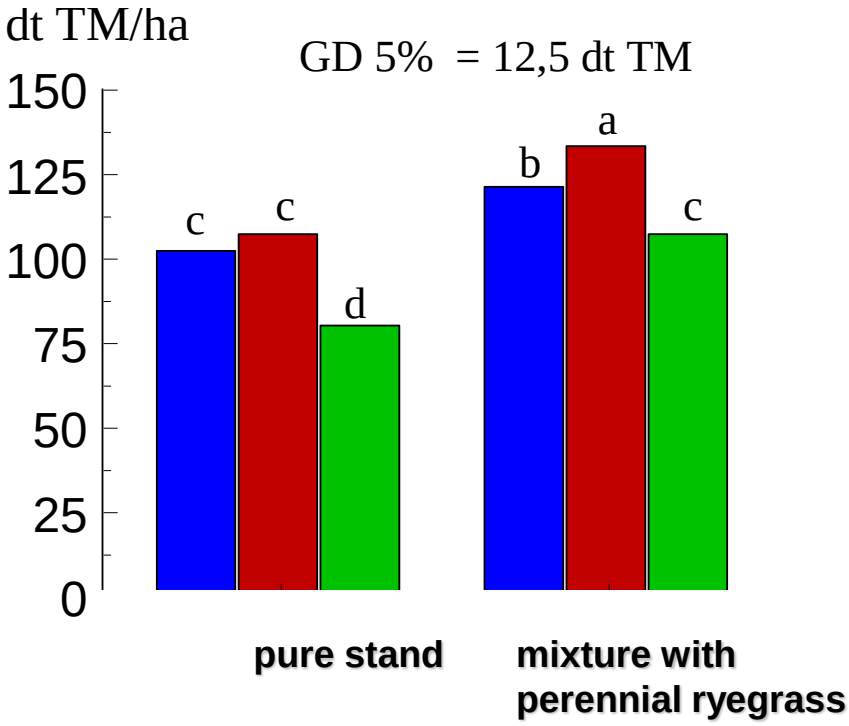
and here compared to varied fertilised Perennial ryegrass
a) 0 kg, b) 100 kg, c) 200 kg, d) 300 kg, e) 400 kg N ha^{-1}

under Northern German conditions at a location with evenly spraed precipitation on loamy sandy soil

Defoliation: 4-cuts for silage

Drymatter yield and Legume content

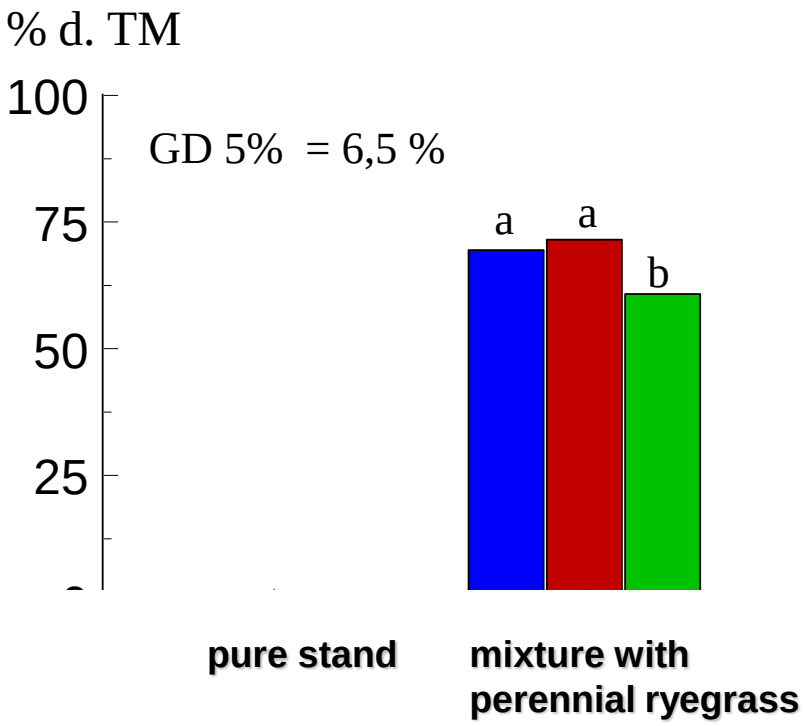
deciton/ha



F-Test

TM-Ertrag	Pr > F
Leg-Art	0.0001***
Saatmischung	0.0001***
Leg*Misch	0.3698 (ns)

% of Drymatter



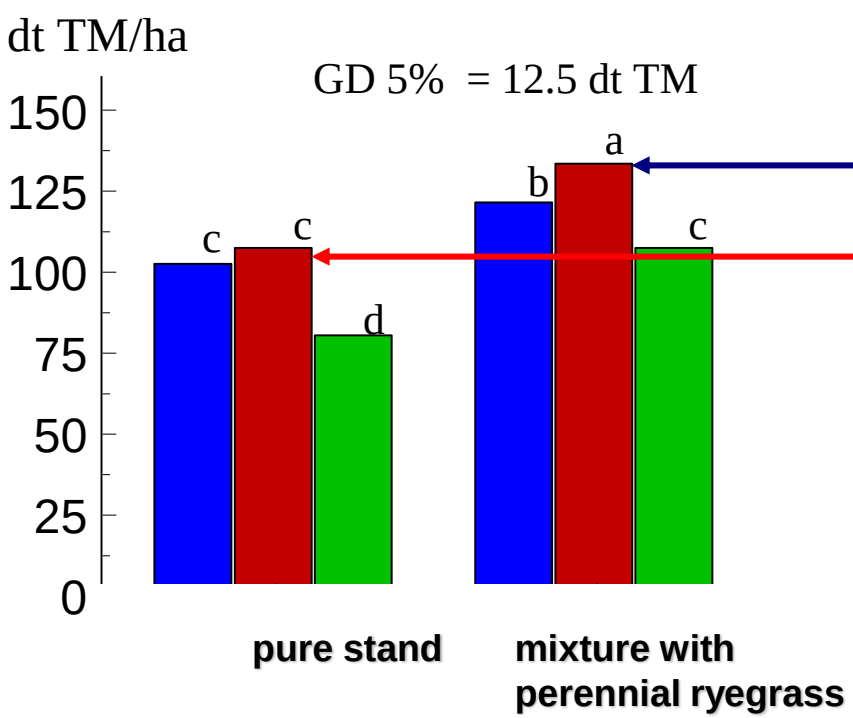
F-Test

Leg-Anteil	Pr > F
Leg-Art	0.0002***

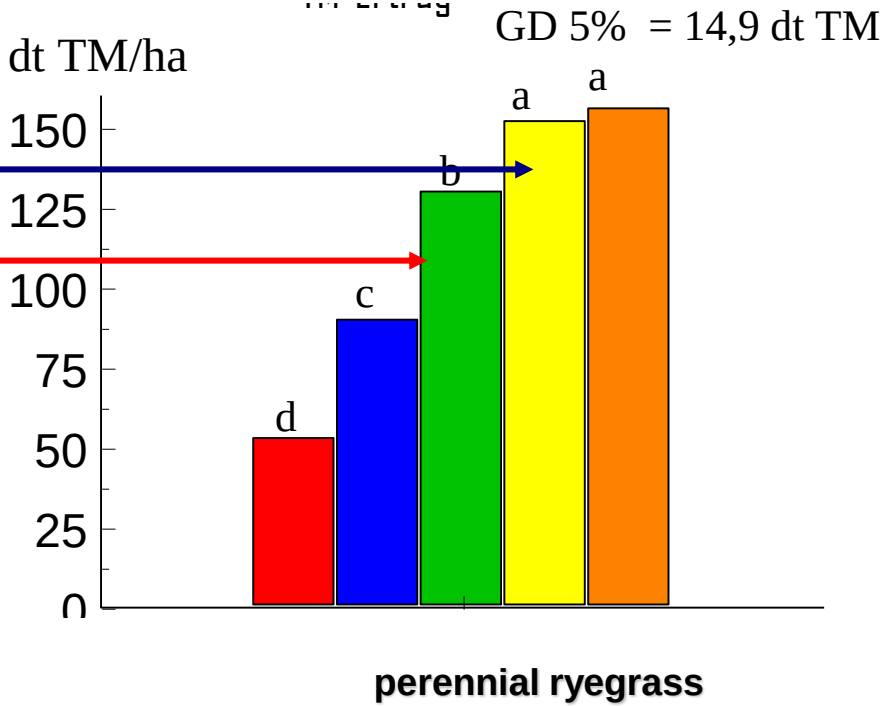
Leguminosenart: Rotklee **Red clover** Luzerne **Alfalfa** Weißklee **White clover**

Comparison of dry matter yields to perennial ryegrass

Deciton DM /ha



Deciton DM /ha



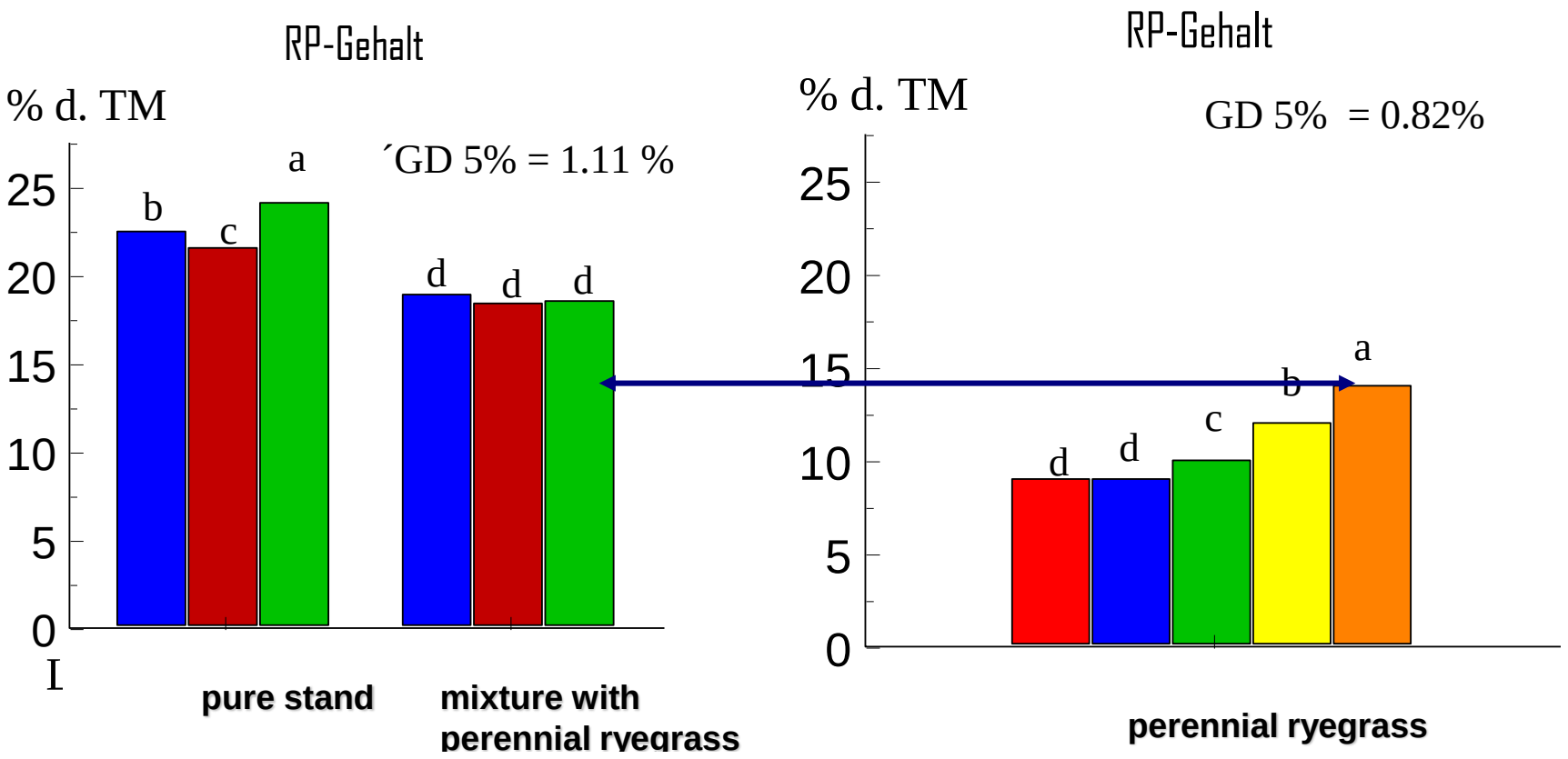
Legume species

- Alfalfa
- Red clover
- White clover

N-Fertilisation of Perennial ryegrass

- 0 kg N/ha
- 100 kg N/ha
- 200 kg N/ha
- 300 kg N/ha
- 400 kg N/ha

Comparison of crude protein contents in % of DM to perennial ryegrass



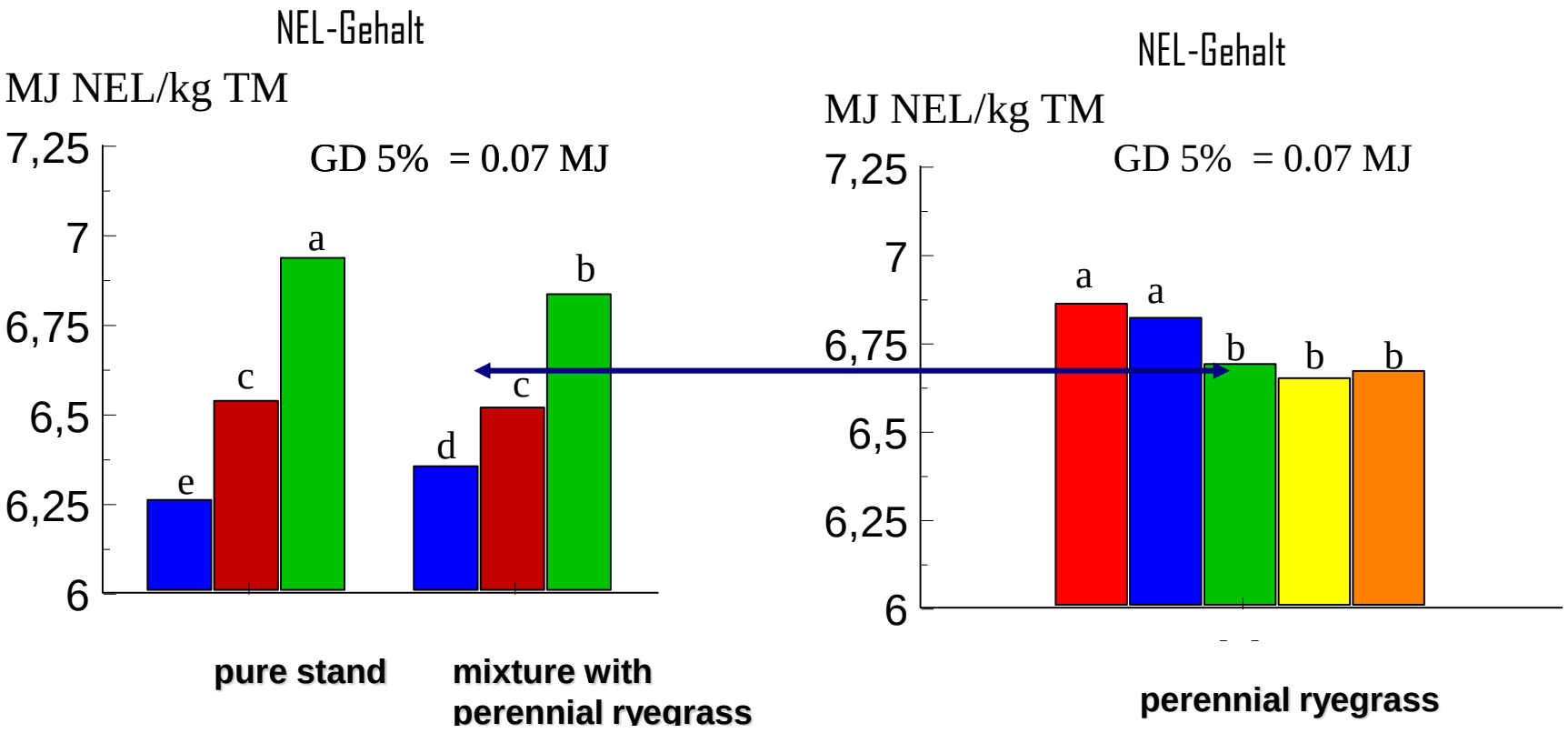
Legume species

- Alfalfa
- Red clover
- White clover

N-Fertilisation of Perennial ryegrass

- 0 kg N/ha
- 100 kg N/ha
- 200 kg N/ha
- 300 kg N/ha
- 400 kg N/ha

Comparison of net energy contents contents in MJ NEL per kg drymatter to perennial ryegrass



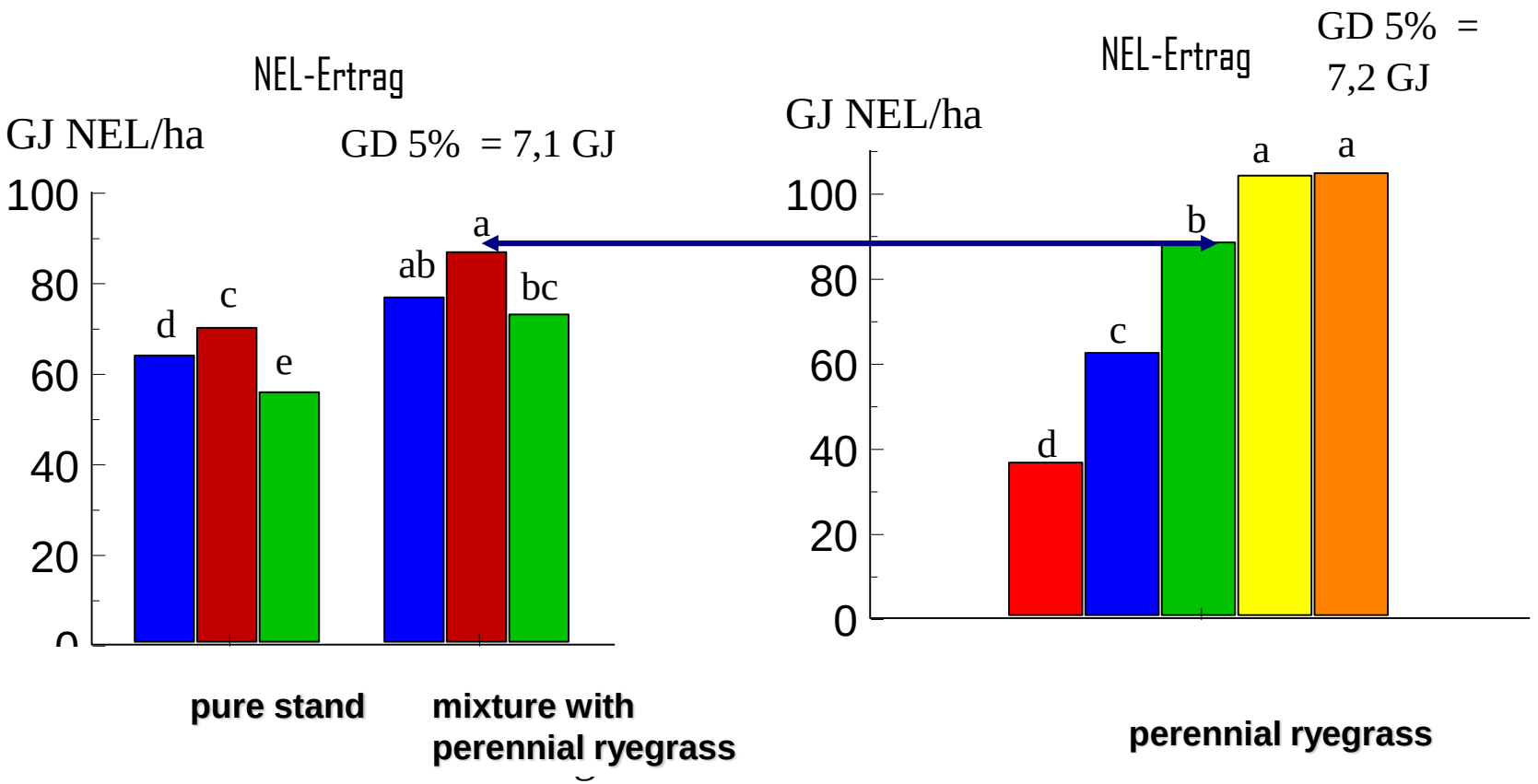
Legume species

- Alfalfa
- Red clover
- White clover

N-Fertilisation of Perennial ryegrass

- 0 kg N/ha
- 100 kg N/ha
- 200 kg N/ha
- 300 kg N/ha
- 400 kg N/ha

Comparison of net energy yields in GJ NEL per hectar drymatter to perennial ryegrass



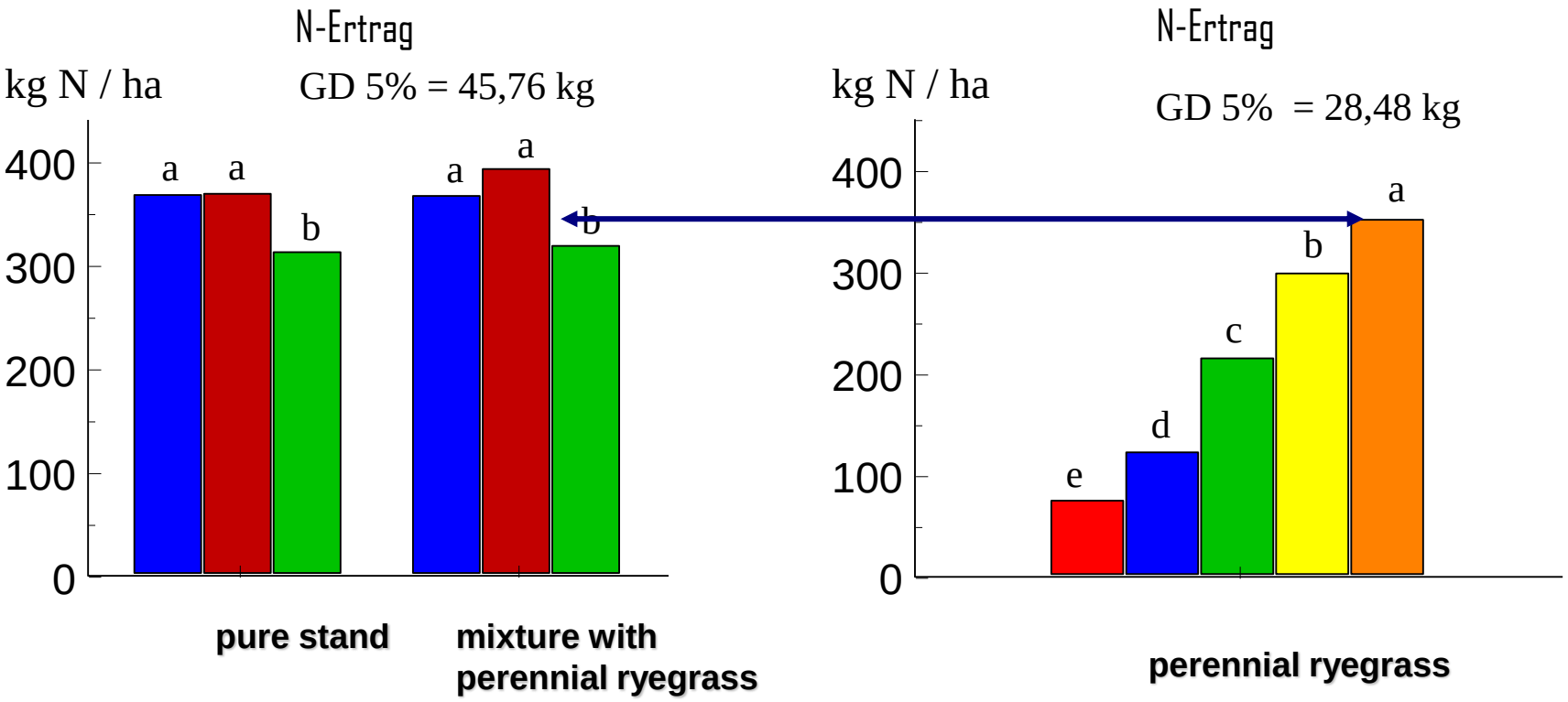
Legume species

- Alfalfa
- Red clover
- White clover

N-Fertilisation of Perennial ryegrass

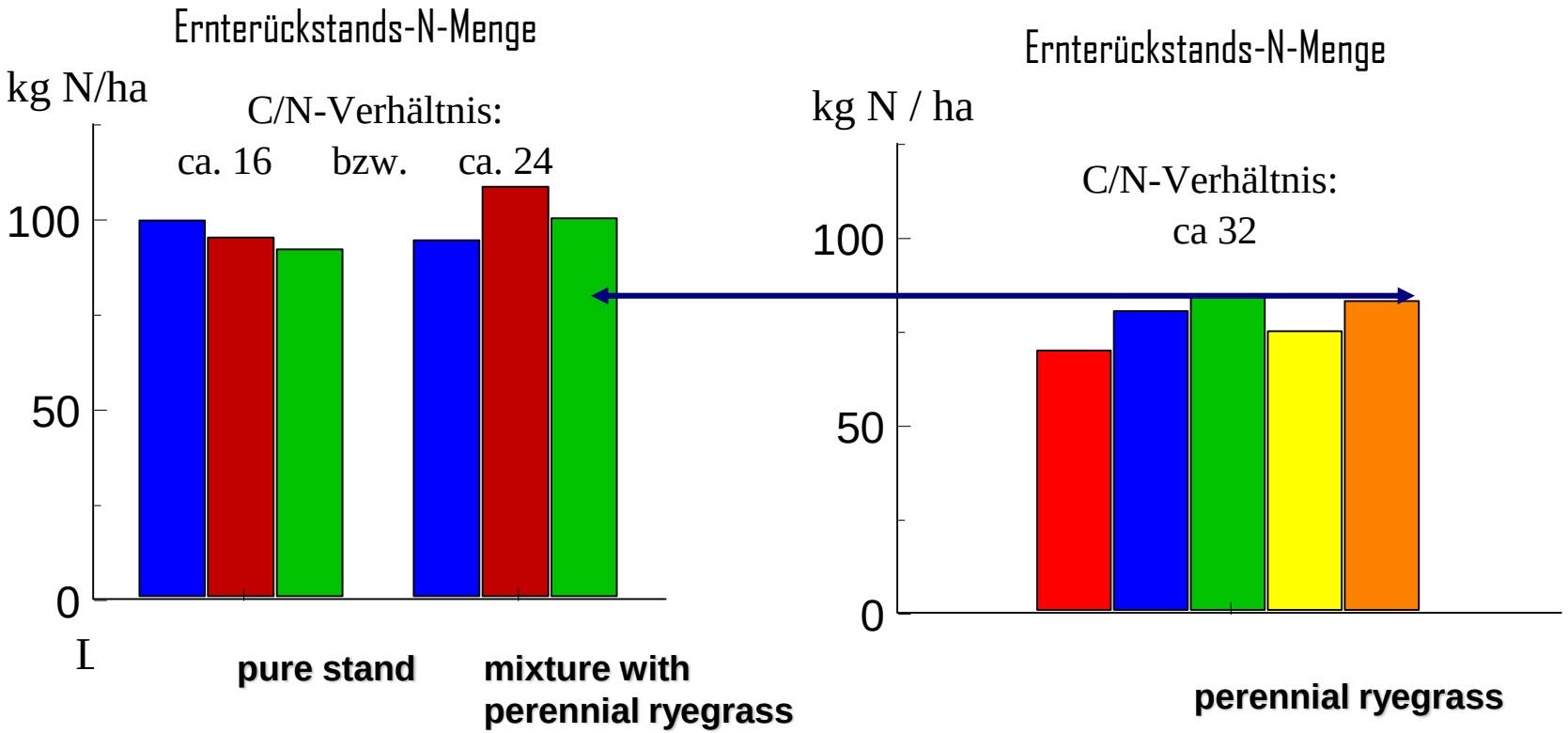
- 0 kg N/ha
- 100 kg N/ha
- 200 kg N/ha
- 300 kg N/ha
- 400 kg N/ha

Comparison of Nitrogen yields in kg N/ per hectare



- An N yield of 300 kg N/ha corresponds to a protein yield of 1875 kg/ha
- 350 kg N/ha would be approx. 2200 kg protein/ha
- With 5 tonnes/ha peas with 22% Crude protein harvest 1100 kg/ha

N-amounts (kg N/ha) in Crop residuals and C to N-Ratio



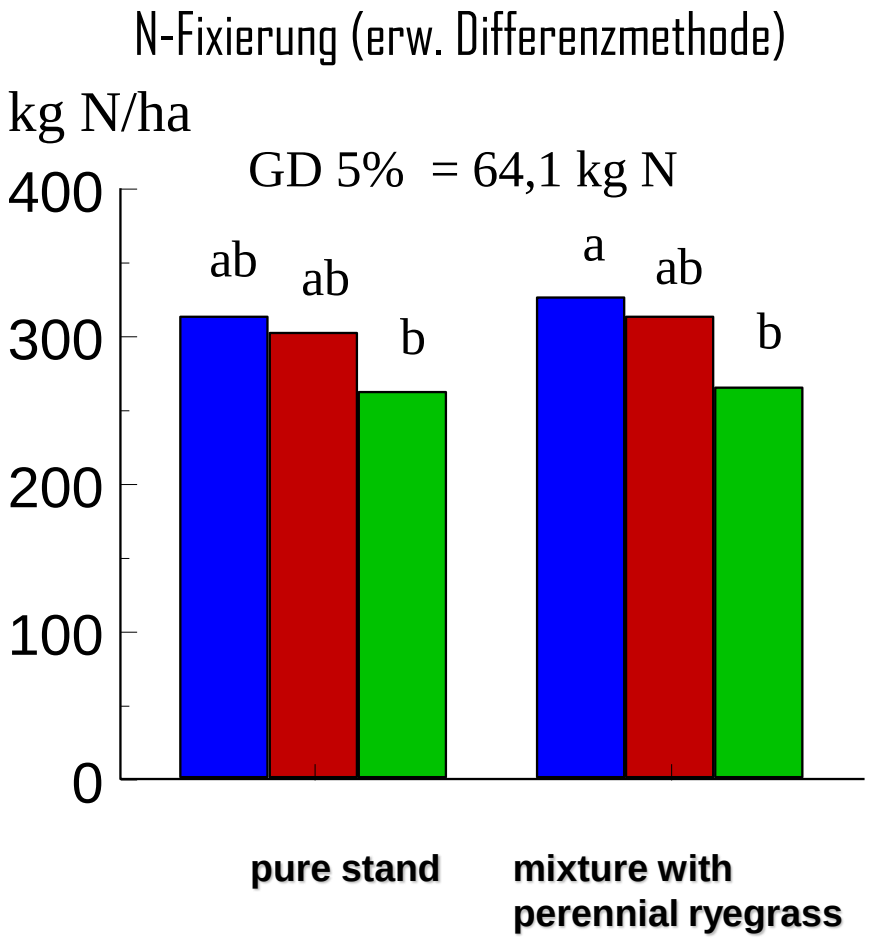
Legume species

- Alfalfa
- Red clover
- White clover

N-Düngung Dt. Weidelgras:

- 0 kg N/ha
- 100 kg N/ha
- 200 kg N/ha
- 300 kg N/ha
- 400 kg N/ha

N_2-Fixation of Grass clover leys



Leguminosenart: Rotklee Luzerne Weißklee

Red clover **Alfalfa** **White clover**

Mineralstoffgehalte von Leguminosenbeständen

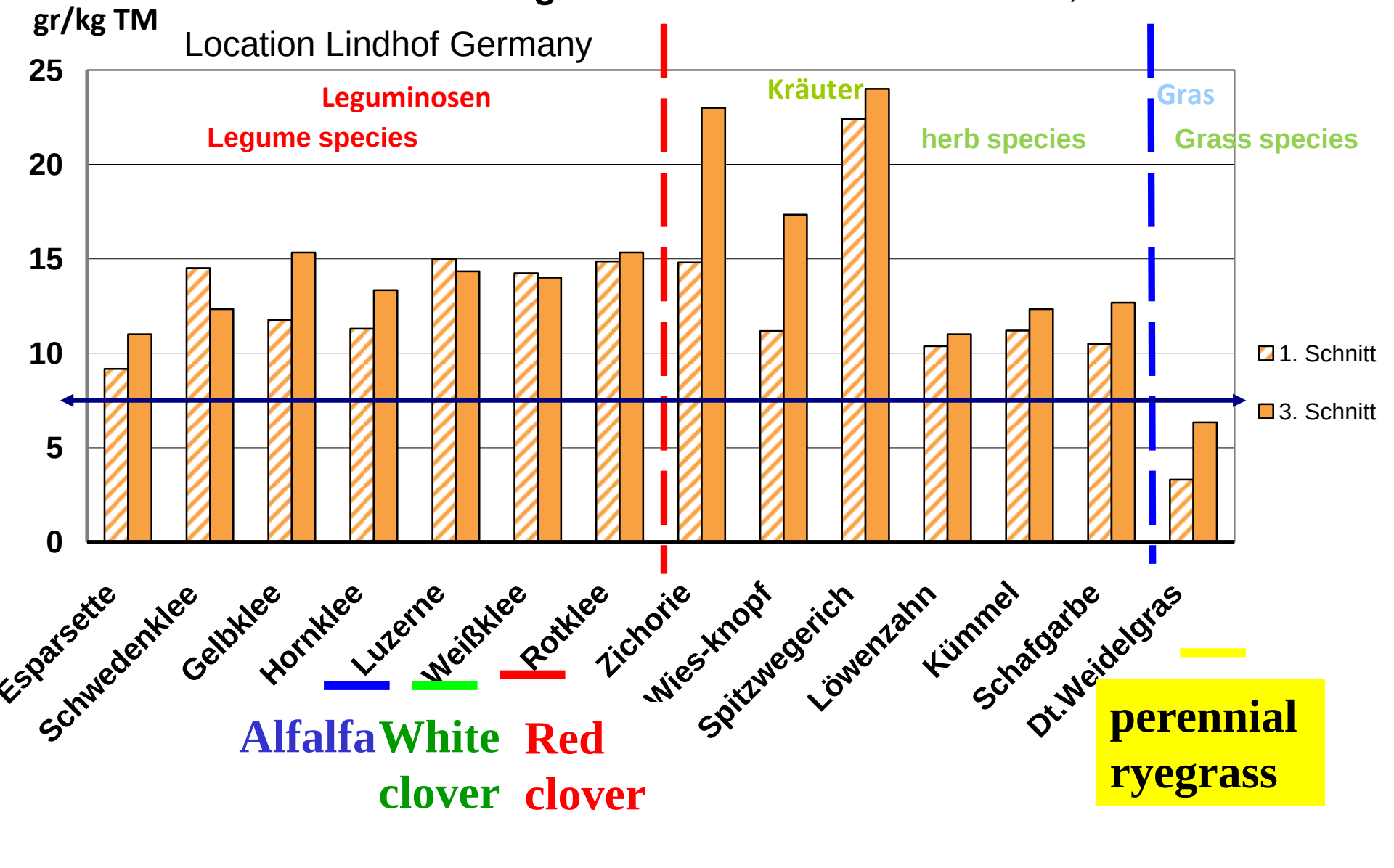
hier Fokus auf die zweiwertigen Kationen,

Diese korrespondieren extrem stark mit der Kationenaustauschkapazität, die in Leguminosenfutter sehr hoch ist,

und sich z.B. im Falle der Luzerne extrem günstig auf das Pansenmileu auswirkt,

das ist einer der Gründe ist warum Hochleistungsmilchviehbetrieb auf Luzerne zurückgreifen

Calcium content in gr per kg of DM (average of 1 and 3rd cut)



Quality of Protein?

Protein quality/ Protein stability

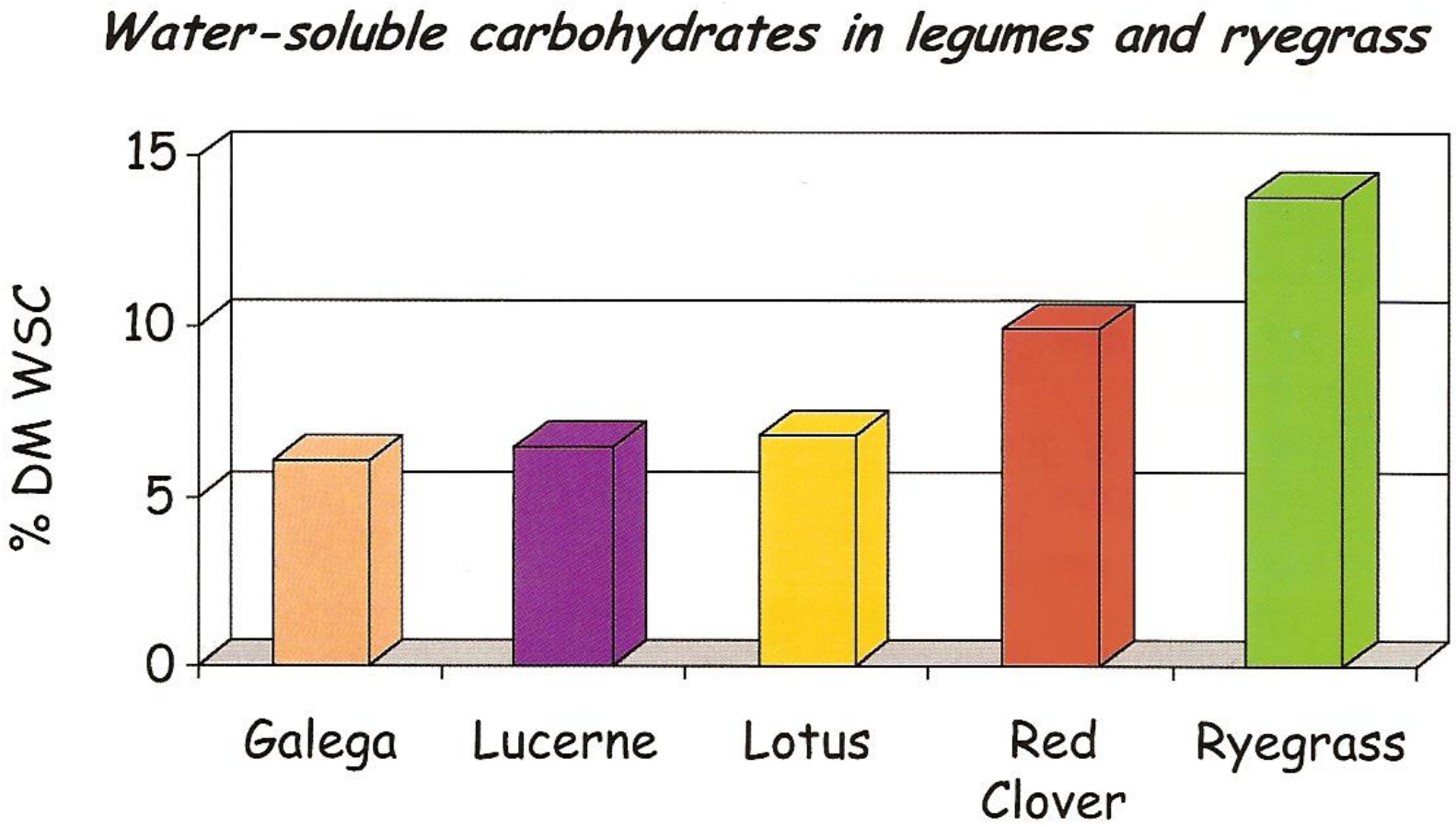
	Tannin-equivalent	XP degradation in vitro, %/h	UDP, % 1)
Alfalfa	0,0	23,7	19,2
White clover	0,0	26,9	17,5
Red clover	0,0	15,0	27,2
Birdsfoot trefoil	7,0	18,6	23,0
Sainfoin	14,6	5,4	49,5

Broderick and Albrecht, 1997

For Comparison:

Soybean-Meal UDP-Content of 35 % and Grass of 20%

Ensiling grass clover



Galega Luzerne Hornschotenklee Rotklee Dt. Weidelgras

(Dewhurst, 2003)

Effect of ensiled mixture of legume and grass on forage quality of legumes/grass silage
(test site Lindhof, 1998, on average over 2 growths
and as a means of the two legume species red clover and alfalfa
Means with the same letters are not significantly different))

Silage mixture Siliermischung	DM-contet %	XP-contet (% d. TM)	Net-Energy contet (MJ NEL · kg^{-1})	Crudefibre contet (% d. TM)	Losses during ensiling (%)
100% Leguminose	24.1^{d}	17.2^{a}	5.51^{d}	27.8^{a}	9.51^{a}
67%Leguminosenanteil	27.5^{c}	15.3^{b}	5.87^{c}	26.7^{b}	6.92^{b}
33%Leguminosenanteil	30.1^{b}	13.8^{c}	6.07^{b}	25.6^{c}	6.46^{c}
100% Dt. Weidelgras	34.0^{a}	10.7^{d}	6.36^{a}	24.9^{d}	5.56^{d}
GD 0.05	0.73	0.54	0.09	0.60	0.40

Solution: How to make better silages?

Use of a conditioner under stable weatherconditions

- rapid water release from the red clover stalks when mowing with a conditioner

Fotos:

Dr. Johannes Thaysen, jthaysen@lksh.de

Top grass clover silage quality, when harvested on time

1st cut silage of 2016

Datum 24.10.2016
Kundennr. 5000990

PRÜFBERICHT 574983 - 916360

Auftrag	**574983 Lindhof Heu/Silage**
Analysennr.	**916360**
Probeneingang	**14.10.2016**
Probenahme	**12.10.2016**
Kunden-Probenbezeichnung	**Probe 9/Silage Kleegras**
Futtermittelcode	**Grassilage, 7.01.01**

	Einheit	Ergebnis	Wert i.d.TS	Orientierungswerte in TS	Mittelwerte	Methode
Nährwerte/Inhaltsstoffe						
Trockenmasse	%	**36,5**			51,3	VO(EG) 152/2009, III, A n)
Wasser berechnet	%	**63,5**			48,7	Berechnung n)
Rohasche			**9,0**		10,23	NIR n)
Rohprotein			**14,9**		15,38	NIR n)
Reineiweiß	%	**1,5**	**4,2**		6,39	NIR n)
Rohfaser	%	**7,1**	**19,5**		24,32	NIR n)
Rohfett	%	**1,3**	**3,6**		3,27	NIR n)
NDF	%	**12,8**	**35,2**		49,19	NIR n)
ADF	%	**9,5**	**26,0**			NIR n)
ADF org	%	**8,1**	**22,3**		29,24	NIR n)
Zucker	%	**5,8**	**16,0**		8,89	NIR n)
Cellulase-Test	%	**4,6**	**12,7**		26,86	NIR n)
Berechnete Werte (Nährwerte/Inhaltsstoffe)						
Sand (errechnet)	%	**0,4**	**1,2**		2,45	Berechnung n)
nutzbares Rohprotein	g/kg	**54,6**	**149,5**		129,21	Berechnung GfE 2008 n)
ruminale N-Bilanz	g/kg	**0,0**	**-0,1**		2,21	Berechnung GfE 2008 n)
Anteil Reineiweiß am Rohprotein	%		**28,2**		46,54	Berechnung n)
Anteil Nicht-Protein-N (Fraktion A) am Rohprot	%		**71,8**		53,46	Berechnung n)
ME - Rind			**11,6**		9,8	Berechnung GfE 2008 n)
NEL			**7,1**		5,82	Berechnung GfE 2008 n)
NFC			**37,3**		21,29	Berechnung n)
ELOS	%	**28,6**	**78,3**		62,63	VDLUFA III, 6.6.1 (berechnet) n)
Strukturwert (SW)	/ kg	**0,8**	**2,2**		2,86	Berechnung n)
Mineralstoffe/ Spurenelemente						
Calzium	g/kg	**3,1**	**8,6**		4,61	DIN EN ISO 11885 n)
Phosphor	g/kg	**1,4**	**3,9**		3,74	DIN EN ISO 11885 n)
Natrium	g/kg	**0,2**	**0,6**		1,97	DIN EN ISO 11885 n)
Kalium	g/kg	**11,4**	**31,2**		28,9	DIN EN ISO 11885 n)
Magnesium	g/kg	**0,7**	**1,9**		1,92	DIN EN ISO 11885 n)

XP- Crude-Protein Content (% of DM)

Metabolisable -Energy (MJ/ kg DM)

Net-Energy for lactation (MJ/ kg DM)

Top grass clover silage quality, when harvested on time

PRÜFBERICHT 777247 - 927446

1st cut silage of 2017

Auftrag	777247 Ralf Loges
Analysennr.	927446
Probeneingang	24.07.2017
Probenahme	22.05.2017
Kunden-Probenbezeichnung	Grassilage 4 Schnitt-Nr.:1 Dannenkuhl Tierart:Milchkuh
Futtermittelcode	Grassilage 1.Schnitt, 7.01.01

	Einheit	Ergebnis	Wert i.d.TS	Orientierungswerte in TS	Mittelwerte	Methode
Nährwerte/Inhaltsstoffe						
Trockenmasse	%	36,2			34,78	VO(EG) 152/2009, III, A
Wasser berechnet	%	63,8			65,22	Berechnung
Rohasche			9,3		9,48	NIR
Rohprotein			16,8		14,8	NIR
Reineiweiß	%	2,2	6,2		5,28	NIR
Rohfaser	%	7,2	20,0			VO(EG) 152/2009, III, I
Rohfett	%	1,4	3,8		3,1	NIR
NDF	%	11,8	32,5		51,79	NIR
ADF	%	9,1	25,2		33,99	NIR
ADF org	%	8,0	22,1		30,22	NIR
Zucker	%	4,5	12,3		4,79	NIR
Cellulase-Test	%	3,7	10,3		26,53	NIR
Berechnete Werte (Nährwerte/Inhaltsstoffe)						
Sand (errechnet)	%	0,5	1,5		1,77	Berechnung
nutzbares Rohprotein	g/kg	56,0	154,7		131,22	Berechnung GfE 2008
ruminale N-Bilanz	g/kg	0,8	2,1		2,67	Berechnung GfE 2008
Anteil Reineiweiß am Rohprotein	%		36,9		35,96	Berechnung
Anteil Nicht-Protein-N (Fraktion A) am Rohprotein	%		63,1		64,04	Berechnung
ME - Rind			11,8		9,92	Berechnung GfE 2008
NEL			7,3		5,9	Berechnung GfE 2008
NFC			37,6		20,82	Berechnung
ELOS			80,4		64,09	VDLUFA III, 6.6.1 (berechnet)
Strukturwert (SvV)	/ kg	0,8	2,3		3	Berechnung
Mineralstoffe/ Spurenelemente						
Calzium	g/kg	3,3	9,0		4,97	DIN EN ISO 11885 (E 22)
Phosphor	g/kg	1,3	3,5		3,49	DIN EN ISO 11885 (E 22)
Natrium	g/kg	0,1	0,4		2,35	DIN EN ISO 11885 (E 22)
Kalium	g/kg	11,6	32,1		23,7	DIN EN ISO 11885 (E 22)
Magnesium	g/kg	0,5	1,5		1,86	DIN EN ISO 11885 (E 22)

XP- Crude-Protein Content (% of DM)

Metabolisable -Energy (MJ/ kg DM)

Net-Energy for lactation (MJ/ kg DM)

Erläuterung: Substanz: OS=Originalsubstanz, TS=Trockensubstanz

3rd Cut Grass-clover silage

Datum 24.10.2016
Kundennr. 5000990

PRÜFBERICHT 574983 - 916355

Auftrag	**574983 Lindhof Heu/Silage**
Analysennr.	**916355**
Probeneingang	**14.10.2016**
Probenahme	**12.10.2016**
Kunden-Probenbezeichnung	**Probe 4/Silage Kleegras**
Futtermittelcode	**Grassilage, 7.01.01**

	Einheit	Ergebnis	Wert i.d.TS	Orientierungswerte in TS	Mittelwerte	Methode
Nährwerte/Inhaltsstoffe						
Trockenmasse	%	**30,6**			51,3	VO(EG) 152/2009, III, A n)
Wasser berechnet	%	**69,4**			48,7	Berechnung n)
Rohasche			**8,7**		10,23	NIR n)
Rohprotein			**14,4**		15,38	NIR n)
Reineiweiß			**5,2**		6,39	NIR n)
Rohfaser	%	**6,8**	**22,3**		24,32	NIR n)
Rohfett	%	**0,9**	**3,1**		3,27	NIR n)
NDF	%	**12,9**	**42,0**		49,19	NIR n)
ADF	%	**9,3**	**30,5**			NIR n)
ADF org	%	**8,4**	**27,4**		29,24	NIR n)
Zucker	%	**2,4**	**8,0**		8,89	NIR n)
Cellulase-Test	%	**6,3**	**20,5**		26,86	NIR n)
Berechnete Werte (Nährwerte/Inhaltsstoffe)						
Sand (errechnet)	%	**<0,4**	**0,9**		2,45	Berechnung n)
nutzbares Rohprotein	g/kg	**42,2**	**137,9**		129,21	Berechnung GfE 2008 n)
ruminale N-Bilanz	g/kg	**0,3**	**1,0**		2,21	Berechnung GfE 2008 n)
Anteil Reineiweiß am Rohprotein	%		**36,1**		46,54	Berechnung n)
Anteil Nicht-Protein-N (Fraktion A) am Rohpro	%		**63,9**		53,46	Berechnung n)
ME - Rind			**10,6**		9,8	Berechnung GfE 2008 n)
NEL			**6,4**		5,82	Berechnung GfE 2008 n)
NFC			**31,8**		21,29	Berechnung n)
ELOS	%	**21,7**	**70,8**		62,63	VDLUFA III, 6.6.1 (berechnet) n)
Strukturwert (SW)	/ kg	**0,8**	**2,6**		2,86	Berechnung n)
Mineralstoffe/ Spurenelemente						
Calzium	g/kg	**3,1**	**10,2**		4,61	DIN EN ISO 11885 n)
Phosphor	g/kg	**0,9**	**3,1**		3,74	DIN EN ISO 11885 n)
Natrium	g/kg	**0,2**	**0,6**		1,97	DIN EN ISO 11885 n)
Kalium	g/kg	**8,4**	**27,3**		28,9	DIN EN ISO 11885 n)
Magnesium	g/kg	**0,6**	**2,1**		1,92	DIN EN ISO 11885 n)

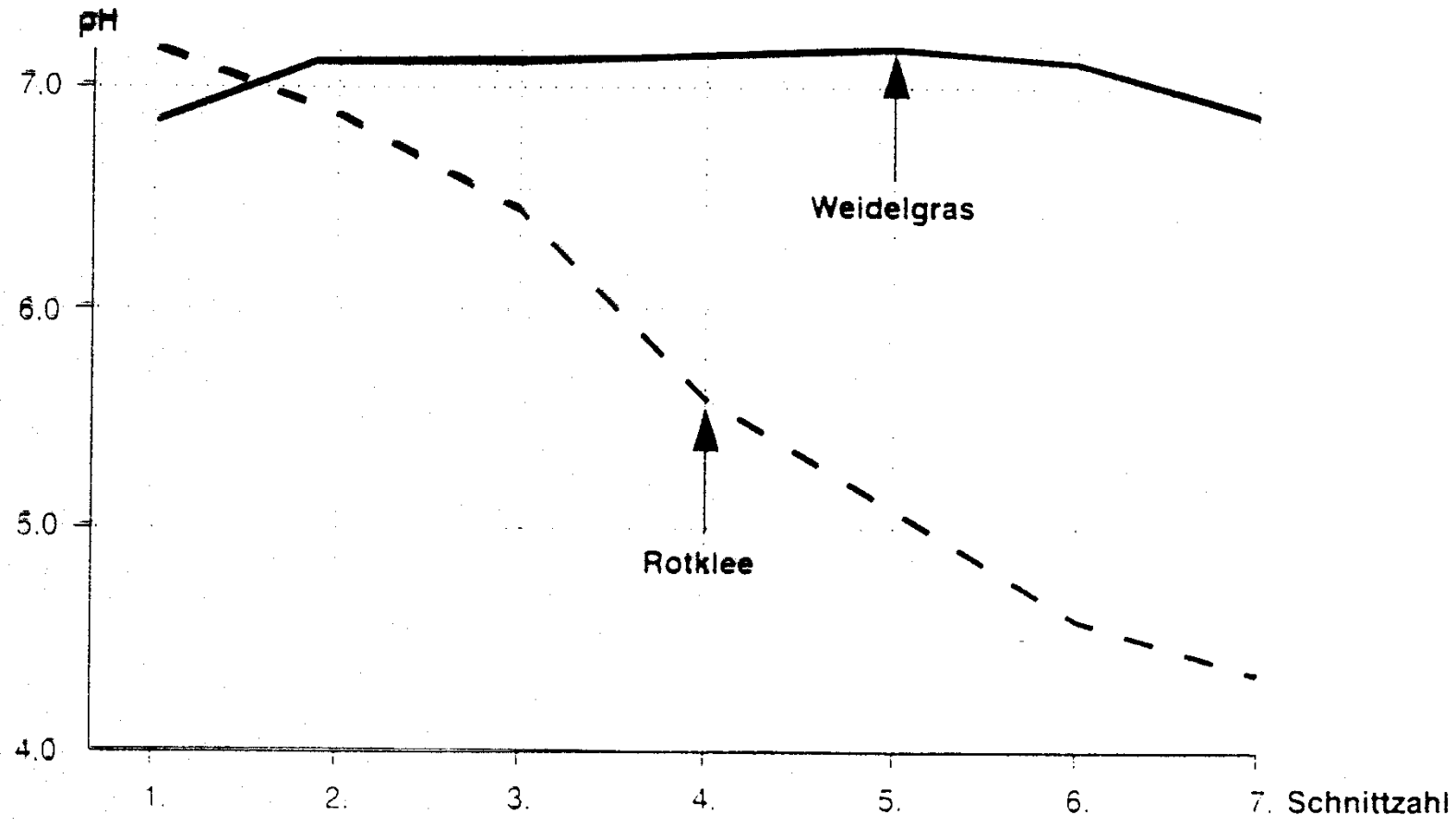
XP- Crude-Protein Content (% of DM)

Metabolisable -Energy (MJ/ kg DM)

Net-Energy for lactation (MJ/ kg DM)

Erläuterung: Substanz: OS=Originalsubstanz, TS=Trockensubstanz
n) Nicht akkreditiert

Changes in pH-Value under ryegrass (Weidelgras) and red clover (Rotklee) after seven harvests, in a pot-experiment on a loam soil when not limed (Mengel und Steffens 1982)



Effekte der Schwefeldüngung - 2010

Sulfur maybe important

ohne Schwefeldüngung mit Schwefeldüngung

without **and with Sulfur**

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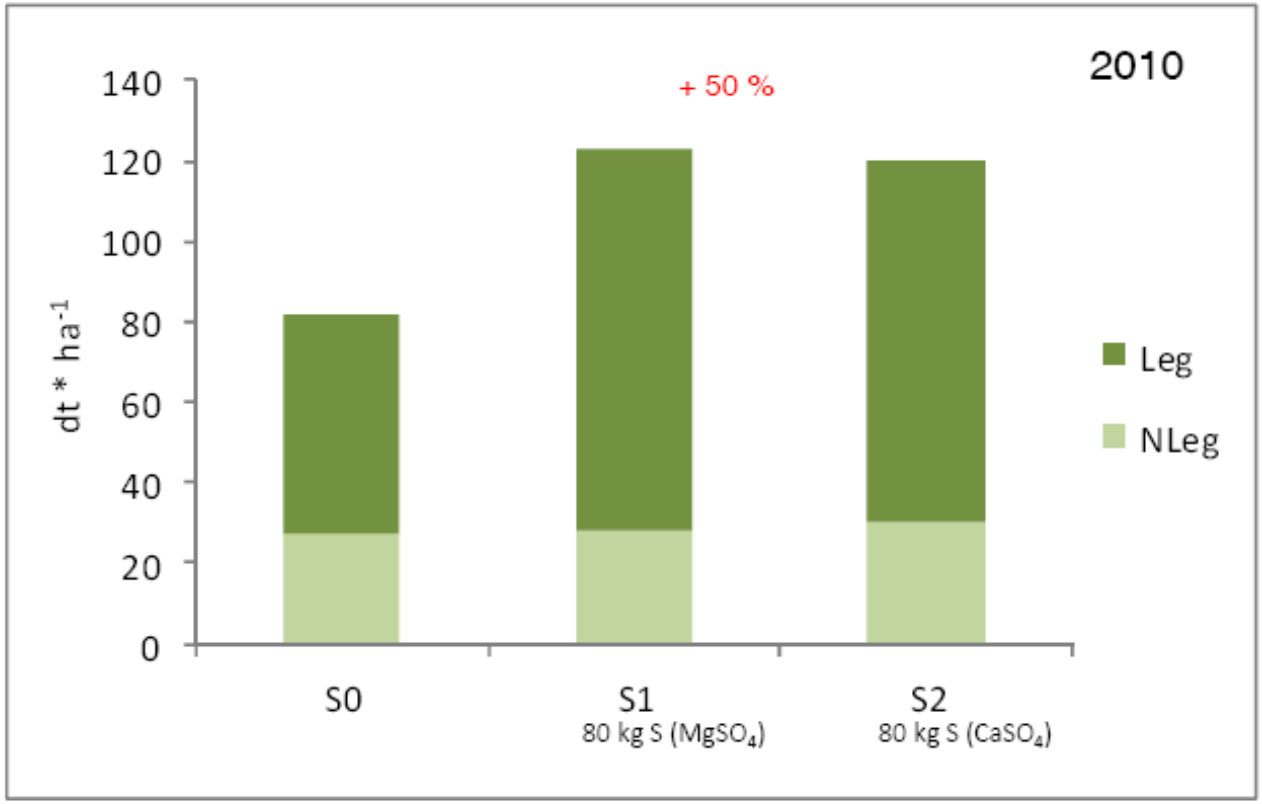
Nach K. Becker 2013

Jahrestrockensubstanzerträge in dt * ha^{-1}

Futterleguminosen-Grasgemenge Gladbacherhof

Dry Mater yields in decitonnes grass/alfalfa



without **and with Sulfur**

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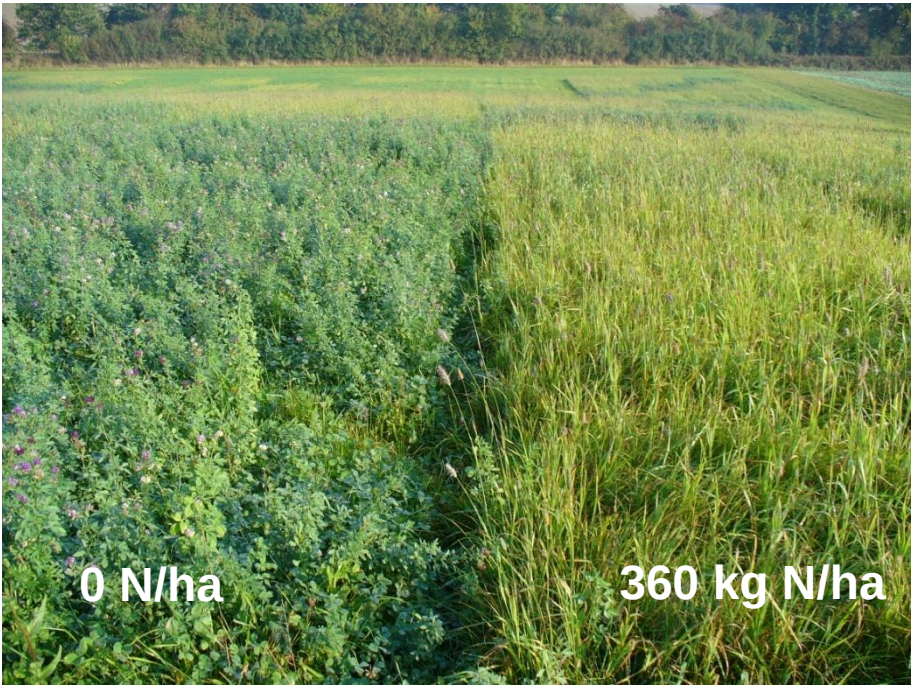
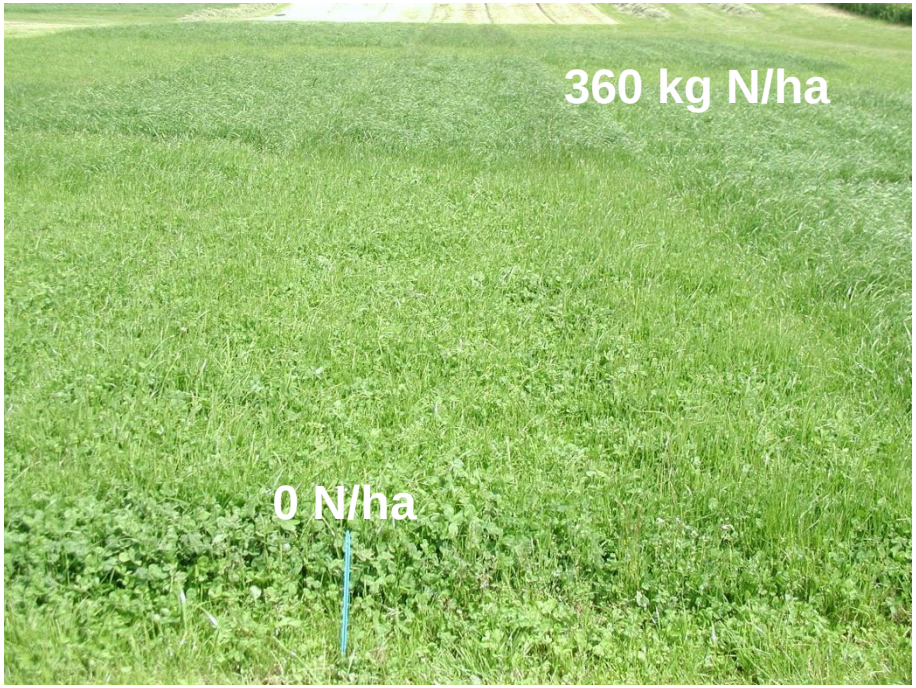
Interaction of defoliation system and Nitrogen fertilisation after 1 Year on botanical composition of the same seed mixture consiting of Alfalfa, White clover, Perennial Ryegrass. and cocksfoot

3-Cut-System,

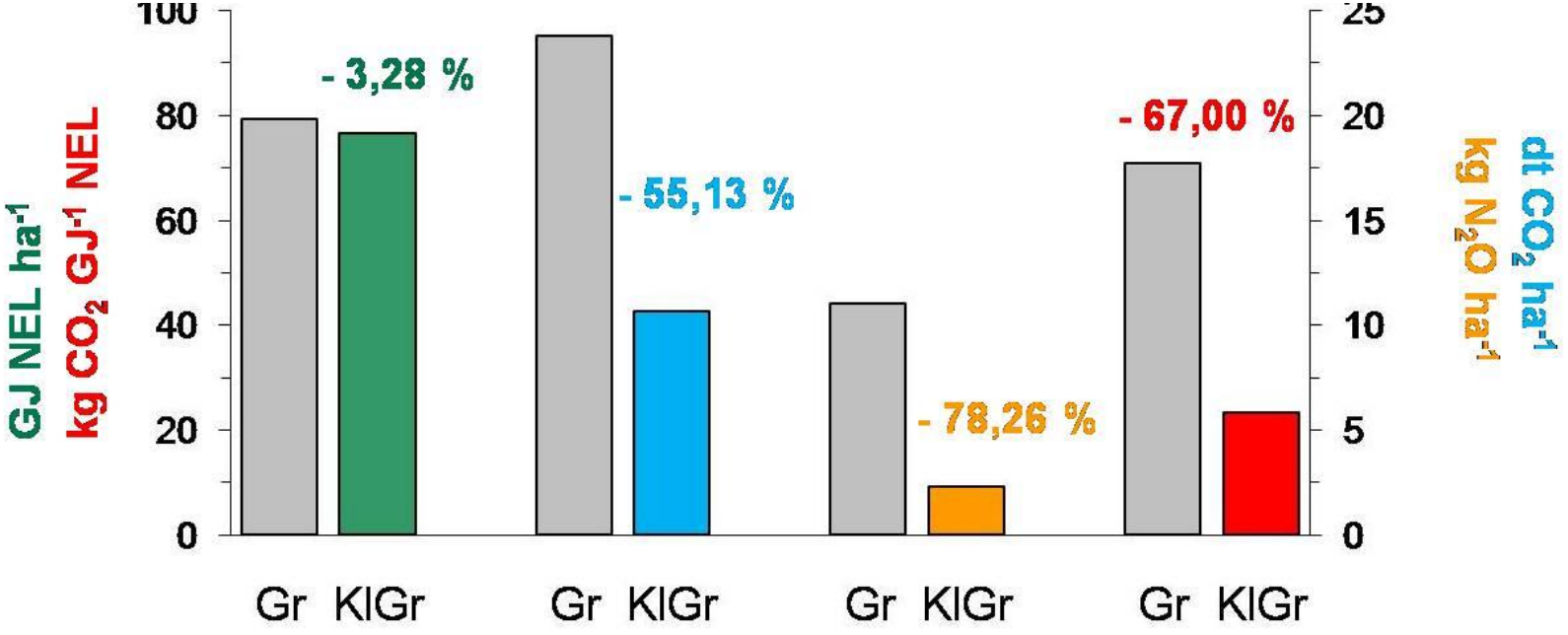


5-Cut System



CO_2-Balance – Fertilised Grass (Gr) versus Alfalfa-Grassclover (KLGr)

Net-Energy-Yield	CO_2-Emissions	N_2O Emissions	Emissions of CO_2- equivalents per unit Net-energy



Location	**Versuchsbetrieb Hohenschulen)**
Defoliation	**3-Cutsystem**
Gr	**Grass sward fertilsed with 360 kg mineral N ha^{-1} (CAN)**
KlGr	**Alfalfa-Grass clover without aditinal N-fertilisation**

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Conclusion Grass Clover-leys

Leys based on forage legumes are an alternative production method for the production of RP-rich and mineral-rich forage.

Seed mixtures containing red clover and Lucerne/alflalfa can achieve very high protein yields without additional N fertilization, which can otherwise only be achieved with very heavily fertilized field grass swards

As a rule, legume grass mixtures achieve a maximum of 80% of the energy yield of intensively fertilized grass stocks, which means that 25% more forage area must be used to achieve the same net amounts of energy.

A great deal of attention must be paid to the fodder conservation of stocks rich in legumes (processing, waste heat drying).

High root performance = high humus performance = high CO2 binding in the soil in combination with low CO2 or nitrous oxide losses Legumes as a mitigation strategy in the climate gas debate

Thank you for your attention

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