Optimierung der Nutzungsintensität von leguminosen- und grasbasierten Grünlandneuansaaten Teil 1: Trockenmasseertrag und Energiegehalte, Teil 2: Stickstoffeffizienz

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Abstract

The optimum management intensity of grassland swards is mainly judged by dry matter (DM)- and protein-yields. For the sustainable use of grassland systems the efficiency of the applied nitrogen and technical equipment has also to be considered.

In an experiment in Aulendorf, South Germany, 9 different variants of grassland swards (renewed grassland with late and early varieties of *Lolium perenne, Trifolium repens* and *Medicago sativa)* with different cutting frequencies (4 to 6 per year) and different date of first harvest of primary growth were compared and judged to their efficiency in view of yields of dry matter, crude protein and net energy. Moreover the N-efficiency has to be determined.

After 5 experimental years (2001 - 2005; not all investigation data yet available), the results show, that legume based grassland swards are much higher in N-efficiency than grass based swards (in average 46,7 kg DM kg^{-1} N for grass-based swards compared with 114,8 for white clover and 220,5 kg DM kg^{-1} N for lucerne). Dry matter yields were highest in lucerne variants with 4 cuts, also even the amount of net-energy was highest in both lucerne swards. In grass based swards net-energy could be increased by high utilisation frequency. The results suggested, that the optimum intensity of grassland use in South-Germany depends on the reference factor. Highest forage quality in grassland growths will be obtained with high cutting frequency; highest N-efficiency by 4 cuts. A main factor for sustainable farming systems is the use of legumes.

Introduction

The intensity of grassland production depends on local attributes of the grassland site and the specific use of the produced forage. Moreover „optimum intensity“ is depending on economic factors and agropolitical structures. Doubtless high yielding dairy cows need a high energy density in their forage. If such forage should be produced from permanent grassland, it is to investigate if highest cutting intensity gave the highest yields and a sufficient energy density. Further it is to ask, if the use of the applied mineral nitrogen, as a main factor in energy consumption on farm level is efficient. Results of former investigations show (WHITEHEAD, 1995; ELSAESSER, 1999; KELM ET AL., 2003), that N-delivery is rather low for grassland, but could be increased fundamentally by using legumes. Additionally the efficiency of nitrogen application is to increase by legumes. The objective of the 2001 installed experiment in Aulendorf was to investigate the effects of high intensive production on grassland with different yield parameters.

Materials and methods

In spring 2001, 9 seed-variants of grassland and forage mixtures were sown on a field of the experimental station in Aulendorf, which was used before as temporarily grassland (South Germany, altitude mASL 590, average yearly rainfall: 900mm). The variants are tested under different utilization conditions with 4 replications. Plot size was 1,5 x 6,0 m. All variants were sown with a basic seed mixture and received additional species (table 1). Details of seed mixtures and utilization regime are given in table 2.

Tab. 1: Basic seed mixture

Species	Cultivars	Var. 1-5	Var. 6,7	Var. 8,9
Lolium perenne	Toledo, Respect, Recolta: middle	6 kg ha^{-1}	8 kg ha^{-1}	3 kg ha^{-1}
Festuca pratensis	Cosmolit	5 kg ha^{-1}	7 kg ha^{-1}	8 kg ha^{-1}
Phleum pratense	Tiller, Lirocco	5 kg ha^{-1}	5 kg ha^{-1}	7 kg ha^{-1}
Poa pratensis	Lato, Oxford	4 kg ha$^{-1;}$	6 kg ha^{-1}	4 kg ha^{-1}
Festuca rubra	Gondolin	3 kg ha^{-1}	3 kg ha^{-1}	0 kg ha^{-1}
Trifolium repens	Lirepa	2 kg ha^{-1}	6kg ha^{-1}	6 kg ha^{-1}

Tab. 2: Mixture variants and cutting frequency

Var-iant	Basic seed mix-ture (see table 1) plus	Cultivars	Date of 1st cut 2001/02/03	Cutting frequency	Fertili-sation kg N ha^{-1}
1	*Lolium perenne* 10 kg ha^{-1}	Labrador, Sambin (early)	9.5./8.5./6.5.	6	340
2	*Lolium perenne* 10 kg ha^{-1}	Labrador, Sambin (early)	9.5./8.5./6.5.	5	250
3	*Lolium perenne* 10 kg ha^{-1}	Parcour, Linocta (late)	9.5./8.5./6.5.	5	250
4	*Lolium perenne* 10 kg ha^{-1}	Parcour, Linocta (late)	9.5./8.5./6.5.	4	180
5	*Lolium perenne* 10 kg ha^{-1}	Parcour, Linocta (late)	16.5./16.5./16.5.	5	250
6	*Trifolium repens* 6 kg ha^{-1}	Lirepa	9.5./8.5./6.6.	5	90
7	*Trifolium repens* 6 kg ha^{-1}	Lirepa	16.5./16.5./16.5.	4	90
8	*Medicago sativa* 3 kg ha^{-1}	Europe	16.5./16.5./16.5.	4	90
9	*Medicago sativa* 3 kg ha^{-1}	Europe	25.5./16.5./5.6.	3	60

Results and Discussion

Drymatter and energy yields

The seed variants differed widely in DM-yield per ha and year (table 3 and figure 1). Highest yields were obtained with 14,1 and 145,6 t DM ha^{-1} for both of the lucerne variants, but the first cut at optimum stage (early = beginning of May) had higher dry matter and energy yields. Grass variants were lower and some of them were significantly differ-

ent to lucerne. The rise of cutting frequency from 4 to 5 and moreover to 6 cuts per year gave DM yields of 10,0, 11,4 and 12,3 t ha^{-1} and increased the energy yields (table 4) from 62,3, 69,5 to 77,0 GJ NEL ha^{-1}. The comparison between early and late cultivars of *Lolium perenne* (var. 2 and 3), both used in optimum stage, showed same results, but gave no significant differences in energy yield, N-yield and N-efficiency. Also the effects of date of first cut were negligible, because parameters gave no significant difference between the same cultivars of *Lolium perenne* (variants 3 and 5). Even the energy yields were nearly the same, however the amounts of net energy differed markedly. The swards with *white clover* gave lowest drymatter and net energy yields.

Great variations are visible between the experimental years. The dry conditions in 2003 resulted nearly in all variants in lower drymatter yields. Similiar yields could only be observed in *lucern*e variants, which were both nearly the same and much higher than all of the other variants (Figure 1).

Tab. 3: DM-yields (2001-2005 in t ha^{-1})

Variant and cultivar	Cutting time	cuts	2001	2002	2003	2004	2005	Mean values
1 *Lolium per.*early	early	6	13,7	14,1	9,8	12,5	11,6	**12,3**
2 *Lolium per.* early	early	5	11,8	13,7	9,0	12,3	10,3	**11,4**
3 *Lolium per.* late	early	5	12,4	13,8	8,9	12,1	10,2	**11,5**
4 *Lolium per.* late	early	4	10,7	11,7	8,3	9,7	9,7	**10,0**
5 *Lolium per.* late	late	5	12,1	13,2	9,4	11,8	11,5	**11,6**
6 *Trifolium repens*	early	5	12,1	12,4	7,7	8,3	8,7	**9,8**
7 *Trifolium repens*	late	4	10,8	11,2	7,8	9,4	9,2	**9,7**
8 *Medicago sativa*	late	4	15,4	18,2	15,5	12,1	9,5	**14,1**
9 *Medicago sativa*	very late	4	14,0	15,8	16,9	15,0	11,1	**14,6**
Mean values			**12,5**	**13,8**	**10,4**	**11,5**	**10,2**	

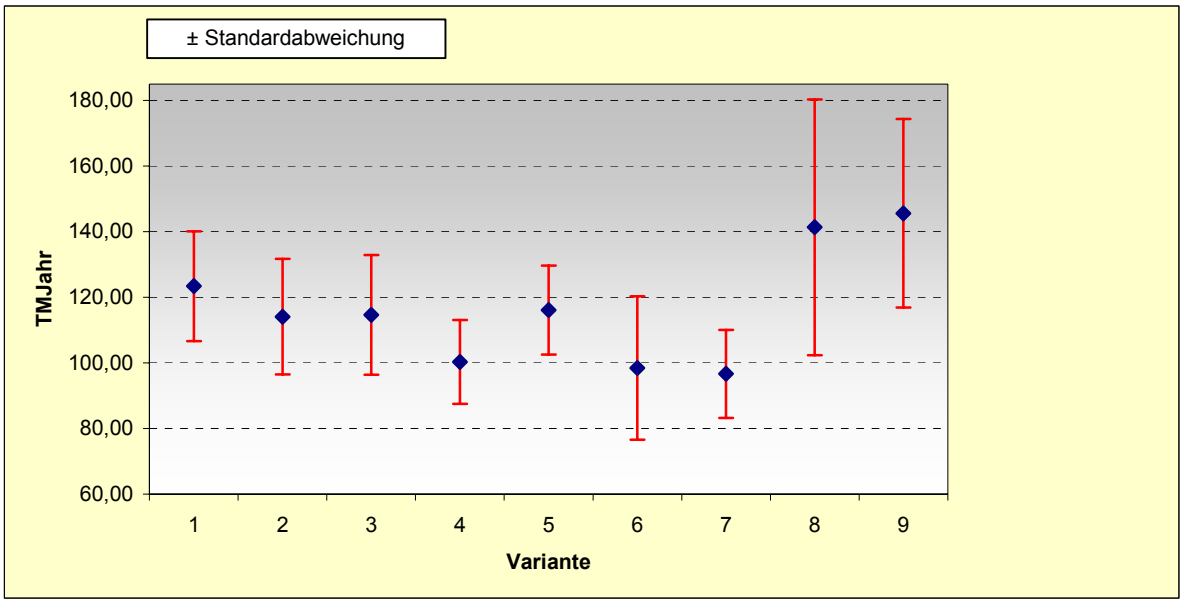

Fig. 1: Drymatter yields per year in dt ha $^{-1}$ (2001 - 2005)

Tab. 4: Energy yields, N delivery and N efficiency (2001 - 2003)

Variant and cultivar	Cutting time	cuts	DM-yield t ha^{-1}	Energy-yield MJ NEL ha^{-1}	N-yield kg N ha^{-1}	N efficiency kg DM kgN^{-1}
1 *Lolium per.*early	early	6	123,4	77 037 ab	342 ab	36,9
2 *Lolium per.* early	early	5	114,1	69 485 ab	300 ab	46,0
3 *Lolium per.* late	early	5	114,7	70 849 ab	306 ab	46,7
4 *Lolium per.* late	early	4	100,3	62 255 b	262 b	57,5
5 *Lolium per.* late	late	5	116,1	70 781 ab	296 ab	46,3
6 *Trifolium repens*	early	5	98,5	65 763 ab	310 ab	119,4
7 *Trifolium repens*	late	4	96,7	59 760 b	262 b	110,1
8 *Medicago sativa*	late	4	141,4	94 698 a	431 a	181,8
9 *Medicago sativa*	very late	4	145,6	88 676 a	434 a	259,3

Different letters indicate significant differences at the 0.05 level of significance

Nitrogen yields and efficiency of nitrogen use

Nitrogen yields, calculated with the crude protein contents, were highest for the Lucerne variants. Significant deeper were variant 4 and 7, *Lolium perenne* with late cultivars and late cut of primary growth and *Trifolium repens* with 4 cuts and also a late cutting date (Figure 2 and 3). The efficiency of nitrogen use was reverse for these variants: Highest efficiency was observed by 4 cuts with 57,5 kg DM per kg used N. Compared with this the highest cutting frequency (6 cuts a^{-1}) gave only an N efficiency of 36,9 kg DM kg N^{-1}. Legume based variants resulted in highest N-efficiency, whereas the *lucerne* variants with 181,8 and 259,3 kg DM kg N^{-1} were much higher than those with *Trifolium repens*.

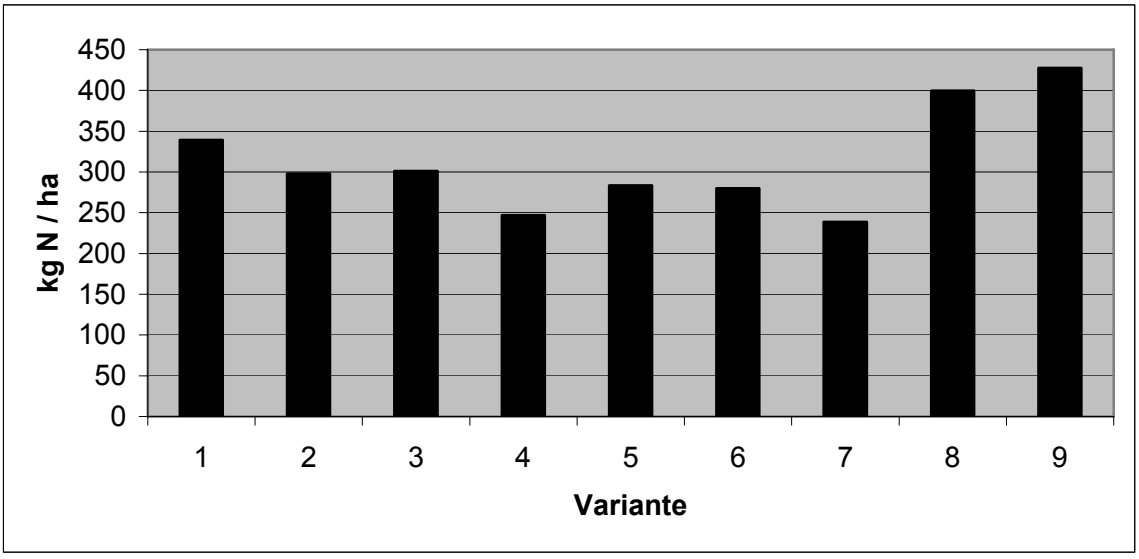

Fig. 2: Nitrogen yield in kg ha^{-1} (2001-2004)

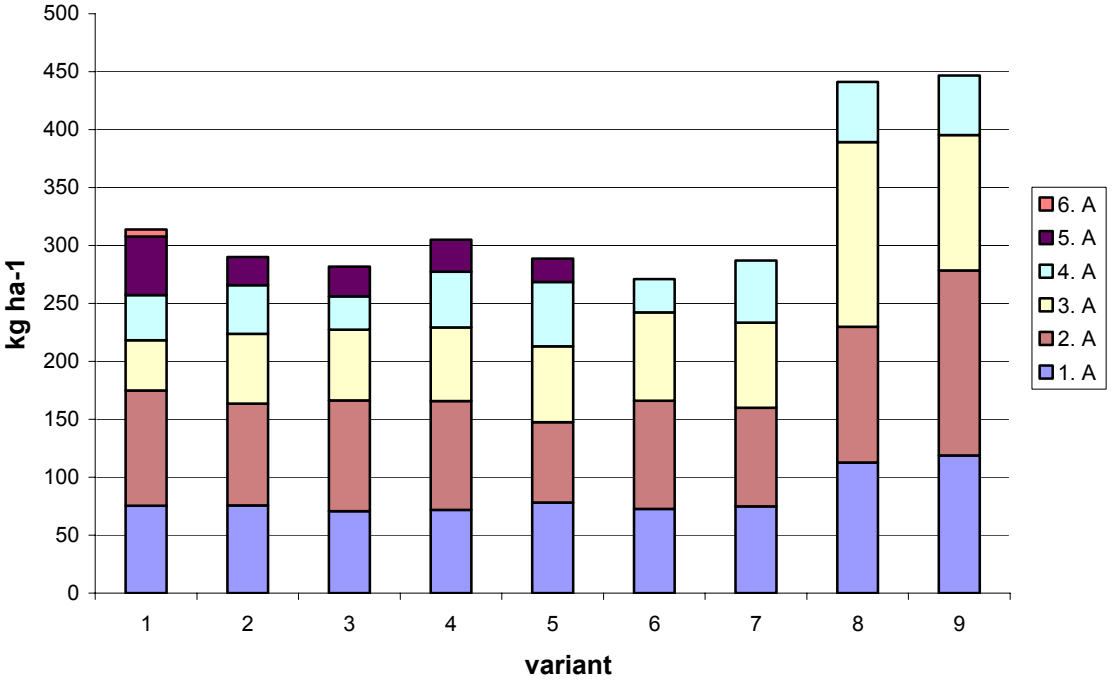

Fig. 3: Average nitrogen yield in kg N ha^{-1} (2001 - 2003) (A = Aufwuchs)

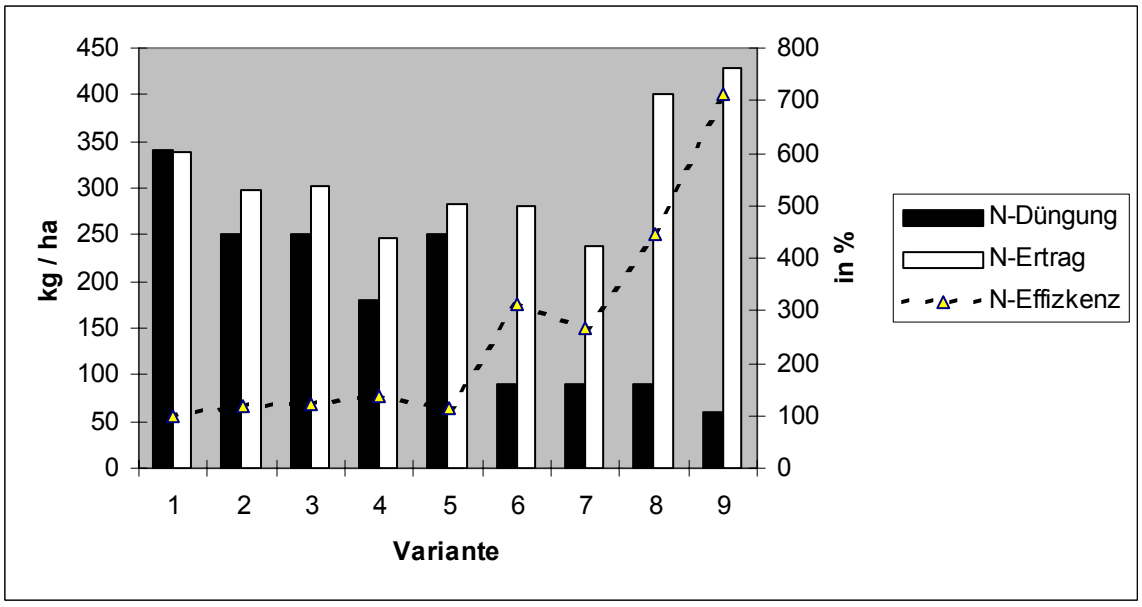

Fig. 4: Fertilization of nitrogen (kg ha^{-1}), N- yield (kg ha^{-1}) and N-efficiency in % (2001 - 2004)

The use of legumes gave great increase of productivity because of the much higher N efficiency, but there exist significant differences between *white clover* and *lucerne*. It seems to be absolutely crucial to use *white clover* based grassland swards with higher cutting frequency. Only 4 cuts and a late date of the first cut gave lowest DM and energy yields. Whereas *lucerne* used with 4 cuts per year and an early harvest of primarily growth had best results in this experiment. Even a late first cut had the same DM- and net energy yields like the most intensive grass variant.

Conclusion

Highest cutting frequency gave highest dry matter and energy yields of grass-based swards. Optimum date of first cut in intensive grassland has maybe effects on energy density, but the energy yields showed no differences. Similiar observations could be made for the comparison of early and late cultivars of *Lolium perenne* under the conditions of this experiment. Four cuts were too less for producing highest dry matter and energy yields. Legume based grassland swards had much better results for nitrogen efficiency than grasses. The use of legumes has to be forced even for reaching highest amounts of net energy.

Observations in 2003, a year with an exceptional drought, show, that the advantage for legume based grassland swards compared with grass based swards was still higher than in the first two experimental years. Best success gave the lucerne variants.

References

ELSAESSER, M. (1999): Auswirkungen reduzierter Stickstoffdüngung auf Erträge, Futterwert und Botanische Zusammensetzung von Dauergrünland sowie Nährstoffverhältnisse im Boden. Habilitationsschrift, Universität Hohenheim, Wissenschaftsverlag Dr. Fleck, Gießen.

ELSAESSER, M. (2005): Optimum management intensity of legume- and grass-based new sown grassland swards. In: Grassland reswoing and grass arable crop rotatitions, Report No. 3, Wageningen (in press).

KELM, M., WACHENDORF, M., TROTT, H., VOLKERS, K. und TAUBE, F. (2003): Energieeffizienz im Futterbau - Ergebnisse aus dem N-Projekt Karkendamm. Mitteilungen Pflanzenbauwissenschaften, 15, 202-204.

WHITEHEAD, D.C. (1995): Grassland nitrogen. CAB International, Wallingford.