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Adaptation and Management of Forage Legumes – Strategies for Improved Reliability in Mixed Swards

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How and why does legume content of multispecies legume-grass vary in the field?

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ABSTRACT

Under conditions of low N availability N_2-fixation of legume-grass mixtures is mainly determined by the legume yield, reflecting the legume content. The objective of this study was to determine (i) the extent, (ii) the consistency, and (iii) the causes of variation in legume content in a field of legume-grass. The study was conducted under field conditions in a tertiary hilly landscape with high spatial soil variability in southern Germany. The yield and legume content of multispecies legume-grass mixtures were measured on one field in two years (1999 and 2002) in plots arranged in a regular grid. Uptake of soil N by the legume-grass mixture was calculated by multiplying yield, legume content, and the measured N-content of grasses and legumes, making the assumption that 90% of the legume-N would be derived from symbiotic N_2-fixation. Yield and legume content varied considerably, both temporally (harvest) and spatially (within the field), but independently from each other. Unlike the dry matter yield of the mixture, the legume content pattern across the field was highly consistent and correlated to the uptake of soil-N by the legume-grass mixture. It is concluded that, if only N is growth limiting, the legume content of legume-grass mixtures reflects the site-specific availability of soil-N.

Keywords: legume-grass, legume content, N_2-fixation

INTRODUCTION

N_2-fixation in legume-grass mixtures is the key process underpinning sustainability in organic farming systems. Under conditions of low N availability N_2-fixation of legume-grass mixtures is mainly determined by the legume yield, i.e. the legume content of the mixture (Boller 1988, Weißbach 1995). So far it has not been investigated whether site-specific differences in N-availability within a field are reflected as variations in the legume content of the sward.

Therefore, the objective of this study was to determine (i) the extent, (ii) the consiste
(iii) the causes of variation in legume content in a field of legume-grass.

MATERIALS AND METHODS

The study was conducted at the FAM-research station Scheyern, Germany, which has level of spatial soil variability (Sinowski & Auerswald, 1999). The mean annual temp is 7.5°C and annual rainfall is 800 mm. Multispecies legume-grass swards (*Medicago* L., *Trifolium repens* L., *Trifolium pratense* L., *Dactylis glomerata* L., *Phleum prate* *Lolium perenne* L., *Festuca arundinacea* Schreb., *Arrhenatherum elatius* L.) were gr the first and fifth years of a seven-year crop rotation. At each of 3 to 4 harvests per y yield and legume content were determined from plots within a field of 2.4 ha in siz plots (12m²) were arranged in a regular grid across the field. Fresh and dry matter yield determined. The legume content was measured by near infrared reflectance spectrosc described by Locher *et al.* (2005). Uptake of soil-N by legume-grass mixtures was calc by multiplying yield, legume content, and the N-content of grasses and legumes, mak assumption that 90% of the legume-N was derived from symbiotic N_2-fixatio correlation and regression analysis the georeferenced (DGPS or RTK-DGPS) data interpolated using inverse distance weighting (range 50 m, power 2) as offered in Arc GIS (Esri, Kranzberg, Germany).

RESULTS

The average dry matter yield ranged from 100 to 640 g/m² depending on the harvest 1). Concomitantly, the average legume content varied between 35% and 73%, and coeff of variation were high. No correlation between yield and legume content was found in the seven harvests. Unlike dry matter yield, the legume content pattern across the fiel highly consistent (Table 2). If the pattern of dry matter yield was similar between ha the correlation found had a small slope, illustrating the overall weak relationsh relationship between the N-uptake from soil and the legume content of legume-grass mi is assumed: if there is no uptake of soil-N only legumes will grow, i.e. the legume con 100%, while, with high availability of soil-N the competing grasses should dominate mixture. With our data the variation in uptake of soil-N by the legume-grass mixture explained 20 to 75% of the variation of legume content (Table 3). The highest values were repeatedly found for harvests in summer.

Table 1. Mean harvest dry matter yields and legume contents of legume-grass mixtures

Harvest date	n[$]	Dry matter yield mean [$g*m^{-2}$]	Dry matter yield cv [%]	Legume content mean [%]	Legume content cv [%]	Correlation[§]: dry matter yield x legume content
May 18, 1999	81	370	21	55	27	n.s.
July 17, 1999	84	450	23	65	18	n.s.
Aug. 26, 1999	87	350	20	73	15	n.s.
Oct. 07, 1999	86	100	37	72	22	**
May 31, 2002	108	640	19	51	20	n.s.
July 30, 2002	118	570	14	71	17	n.s.
Oct. 01, 2002	107	280	19	35	35	*

($) number of sampled plots (§) *,**, ***: significant at p=0.1, 0.05 and 0.01, n.s.: not significant

Table 2. Correlation between the first harvest of a year and the following harvests for dry matter yield and legume content of legume-grass mixtures

Reference data from	n	Parameter correlated[§]	Harvest no. 2 r^2	Harvest no. 2 m	Harvest no. 3 r^2	Harvest no. 3 m	Harvest no. 4 r^2	Harvest no. 4 m
May 1999	81	DM	0.01 n.s.	0.08	0.09***	0.19	0.01 n.s.	0.04
		LC	0.43***	0.38	0.56***	0.44	0.29***	0.43
May 2002	108	DM	0.22***	0.20	0.05**	0.07	-	
		LC	0.36***	0.51	0.28***	0.19	-	

Correlation statistics[$]

(§) DM: dry matter yield LC: legume content ($) r^2: coefficient of determination m: slope of the linear regression line

($) *,**, ***: significant at p=0.1, 0.05 and 0.01 n.s.: not significant

Table 3. Correlations between N-uptake from soil and the legume content of legume-grass mixtures. Coefficient of determination (r^2), slope (m), and intercept (b) of the linear regression line, and the number of values (n) are presented

Harvest date	r^2	m	b	n
May 18, 1999	0.19***	-8.0	84	81
July 17, 1999	0.63***	-7.1	91	84
Aug. 26, 1999	0.50***	-6.8	99	87
Oct. 07, 1999	0.20***	-12.5	88	86
May 31, 2002	0.41***	-3.3	75	109
July 30, 2002	0.75***	-8.3	107	118
Oct. 01, 2002	0.57***	-7.7	72	107

*,**, ***: significant at p=0.1, 0.05 and 0.01

DISCUSSION AND CONCLUSION

The legume content of the legume-grass swards varied strongly with time (between harv and within space (field) and was independent of dry matter yield, contrary to finding Loges (1998). This may be explained by the high spatial resolution of our data, sinc mean legume content of a field from one year correlated well with the corresponding that year. Even though large changes in the mean legume content were observed bet harvests, the legume content pattern was highly consistent. .Legume content was stro linearly correlated with the availability of soil-N. The intercept of the correlation was clo the theoretically expected value of 100 (Table 3); this indicates that legume-grass gr corresponded to the net N mineralisation in soil. Deviations may come from changes i availability of soil-N, or from reduced plant growth resulting in poorer correlations in sp and autumn. These findings are supported by results from pulses (Stevenson *et al.*, 1 Mahler et al. 1979). We conclude that since grasses are strong competitors for soil-N legume content of legume-grass mixtures reflects the site specific availability of soil N, the conditions for both plant growth and N mineralisation are favourable and (ii) N is growth limiting factor.

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