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Seasonality and grazing management effect on growth and nutritional composition of herbage on semi-natural grasslands grazed by dairy cows in Southwest Germany

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Abstract

Natural and semi-natural grasslands represent an attractive forage source for cows in organic dairy farming. Throughout the grazing season, however, diverse factors such as climatic conditions, botanical composition, as well as grazing and herd management, can influence growth and nutritive value of forage on grasslands.
We aimed at investigating the influence of seasonality and grazing management in forage growth and nutritional quality in seven commercial organic dairy cattle farms during the grazing season 2019 in South Germany. Therefore, forty exclusion cages (1 m^2) were installed on pastures, which were under three different grazing systems: rotational, short-grass, and continuous grazing. Pasture herbage within and outside the cages was harvested every 4-6 weeks. The botanical composition of the pasture vegetation was estimated by visual observation, its sward height measured by a rising plate meter, and the aboveground biomass accumulation determined gravimetrically. Besides, air temperature and relative humidity were monitored by climate logger. Pasture samples inside and outside the cages were measured for dry matter (DM) according to the Association of German Agricultural Analytic and Research Institutes (VDLUFA) methods. Crude protein (CP), neutral-detergent (NDF), and acid-detergent (ADF) fibre of the samples were determined by near-infrared spectroscopy (NIRS).
The forage biomass yield reached the growth peak in the second sampling (30.4 dt DM/ha) after 52 days. The CP concentrations outside the cages were greatest in late summer (166 g/ kg DM). While the ADF content outside the cages were greatest at the beginning of the grazing season (274 g/ kg DM). Besides, the CP content of the pastures was greatest under the short-grass system (193 g/kg DM) compared to the others systems.
In conclusion, the seasonality influences the nutritional characteristics of the herbage, as well as the grazing management. However, the grazing management is influenced by other factors that are difficult to statistically measure.

Introduction

In the last decades, interest in using and conserving natural or semi-natural grasslands managed as pastures or meadows has again increased in Europe due to the multiple benefits, such as forage production (Gianelle et al. 2018). The temporal dynamics in herbage growth and nutritional composition are influenced by several factors such as the prevailing climatic conditions which vary across seasons, the botanical composition of the vegetation, and different grazing and herd management decisions on for instance, stocking density, hours at pasture, and level of feed supplementation (Probo et al. 2014).

Therefore, it is essential to know and evaluate the dynamics in growth and nutritive value of herbage of these semi-natural pastures to ensure their role as a natural source of feed for domestic ruminants and to develop efficient and sustainable management practices (Pontes et al. 2007).

In this context, this case study aimed at analysing the dynamics in plant growth, botanical composition, and nutritional quality of the herbaceous vegetation on semi-natural temperate pastures for grazing dairy cattle in Southwest Germany during the grazing season 2019. A hypothesis was formulated: pronounced differences occur along the sampling time in forage biomass production, CP, NDF, and herbs percentage composition rather than grazing management.

Study Site and Methods

This case study was performed on seven commercial organic dairy cattle farms located in Southwest Germany from April to October 2019 (Table 1).

Table 1. Characteristics of seven commercial organic dairy farms in Southwest Germany during the grazing season 2019 (arithmetic means; standard deviation is given in parenthesis).

Variable	Farm A	Farm B	Farm C	Farm D	Farm E	Farm F	Farm G
Altitude (m above sea level)	788	537	387	678	807	549	302
Ambient air temperature (°C)	14 (3.7)	15 (4.4)	15 (4.4)	14 (4.1)	14 (4.0)	15 (3.9)	15 (4.0)
Rainfall (mm)	103 (50.3)	81 (29.8)	99 (42.4)	76 (31.8)	88 (44.3)	93 (27.4)	81 (24.9)
Relative humidity (%)	75 (11.4)	63 (8.2)	76 (7.2)	77 (8.3)	75 (9.0)	76 (10.0)	79 (8.3)
Breed	Simmental	Simmental, crossbreed	Holstein Friesian	Simmental, crossbreed	Simmental	Brown Swiss, Simmental	Brown Swiss
Dairy cows (n)	27	35	68	40	42	67	40
Area for grazing (ha/farm)	8.2	10.0	36.9	3.0	17.2	9.9	6.2
Grazing system	Rotational	Rotational	Short-grass	Continuous	Short-grass	Continuous	Rotational
Pasture cages (n)	6	5	10	2	7	1	8

In total, forty grazing exclusion cages (0.5 x 2 m) were placed in 16 pastures (1.5-3 ha each) before the grazing period started to measure the forage yield across the grazing season. Inside and outside the exclusion cages, the herbaceous vegetation was sampled every 4-6 weeks from mid of April to end of October 2019, resulting in four samplings per farm. For this, a wooden frame was positioned inside the cage or outside in close vicinity of the cage. First, the botanical composition of the aboveground plant biomass was recorded visually, estimating individual species' frequency and the proportion of total fresh plant biomass in the frame belonging to the following species group: grasses, clover, and herbs other than clover. A rising plate meter was used to measure the condensed sward height in five points per frame, and the average height was taken. Finally, the herbaceous plant biomass was cut manually with electric garden shears at 1cm above the ground, and the harvested plant biomass was weighed and dried in a forced-air oven at 45°C for 72 h. Thereafter, the dried herbage samples were first ground to pass a 1.0-mm-screen using a cutting mill and subsequently, to 1.0 mm in a cutting mill. Herbage samples from the cages and outside the cages were analysed for DM and organic matter (OM) according to the Association of German Agricultural Analytic and Research Institutes (VDLUFA) methods (methods 3.1, 8.1, respectively; VDLUFA, 1976). Additionally, CP, NDF, and ADF concentrations of the samples were determined by near-infrared reflectance spectroscopy.

Ambient air temperature and relative air humidity were recorded every 60 min from April to October 2019 by one data logger per farm positioned close to the grazing pastures. Rainfall information was taken from the data registered by the different weather stations, 10-15 km away from the farms (Table 1).

Forage allowance and growth rate were obtained according to the equations from Stuth et al. (1981). A two-way ANOVA with repeated measures was performed. The model included cut number and grazing system and their interactions to evaluate the temporal changes in biomass production, compressed sward height, CP, NDF, and ADF. As well as forage growth rate, herbage allowance, and the percentage botanical composition.

Results

Sampling time had an effect on forage biomass, with greatest forage growth rate in mid-summer and decreasing plant growth towards the end of the grazing season (Table 2). Growth rate was not influenced by grazing system (Table 2). Instead, compressed sward height between the grazing systems with low height for the short-grass system and a relatively constant value for the rotational grazing (Table 2).

The concentrations of CP, NDF, and ADF were influenced by sampling time and grazing system. With greater CP concentrations towards the end of the grazing season and with short-grass than continuous grazing system (Table 2). While ADF concentrations were higher at the beginning of the grazing season and within rotational system compared to short-grass system. There was an interaction between sampling time and grazing system for NDF concentrations the pastures' NDF-content started at the beginning of the season over 500 g/kg DM and decreased for the second and third sampling, while increased at the end of the season (Table 2). Together with this, it seems that the NDF content of the pastures is favoured under rotational grazing system compared to short-grass system during the grazing season 2019 (Table 2).

Botanical composition differed between sampling time, but not between grazing systems, with greater proportions of clover and herbs other than clover of total forage biomass during the second sampling time (Table 2). While the herbage composition was mainly based on grass at the beginning of the grazing season (Table 2).

Discussion [/Implications]

Maximum forage biomass production was reached in the second sampling time, which corresponds to mid-summer. Stem elongation of native species in European grasslands happens at the end of May or the beginning of June with maximum grass growth in July (Bruinenberg et al. 2002). The climatic conditions during the mid-summer i.e. air temperature and rainfall are ideal for forage biomass, although grazing system did not influence biomass production, suggesting that biomass production is more influenced by season.

The nutritional value (CP and NDF) from native European grasslands followed a seasonal pattern, in accordance to Pontes et al. (2007) the CP content at the beginning of the grazing season was lower due to the phenological stage at spring and increased during the year. The shift in the botanical composition especially/specifically the clover and herbs that were not clover may be explained by the phenological development in the semi-natural grasslands.

On the other hand, it seems that grazing system had more influence in the nutritional composition of the herbage where CP is positively influenced under short-grass system, whereas NDF and ADF content were in the rotational system favoured. However, evaluating the grazing management system is difficult to measure, because the factors cannot always be measured statistically.

Conclusions

In conclusion, plant growth, botanical composition, and nutritional quality of forages on pastures of organic dairy cows in Southwest Germany vary with season and grazing management. Further research is needed to predict the dynamics in quantity and quality of forage in natural or semi-natural grasslands to optimize its utilization while preserving their other ecosystem functions.

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Table 2. Forage biomass production, nutritional compositions, and percentage of the botanical composition of the semi-natural pastures along grazing season and grazing system in seven commercial organic dairy cattle farms in Southwest Germany in summer 2019

S[1]	1			2			3			4			SEM	P-value		
GS[2]	R[3]	SC[4]	C[5]	R[3]	SC[4]	C[5]	R[3]	SC[4]	C[5]	R[3]	SC[4]	C[5]		S[1]	GS[2]	S* GS
Biomass yield (kg DM/ha)	1360.3	1826.5	1583.3	3208.9	3008.2	2160.0	1907.1	1706.4	1746.8	732	512.7	956.7	0.03	0.001	0.890	0.05
CSH [6] (cm)		4.0	7.5	6.7	3.8	4.1	6.7	3.8	7.7	4.8	4.2	4.4	0.22	0.17	0.001	0.1
CP[7] (g/kg DM)		142.4	158.4	155.7	177.2	162.4	174.1	210.8	169.4	181.9	207.3	162.9	2.82	0.001	0.001	0.2
NDF[8] (g/kg DM)		530.6	516.5	531.8	489.0	474.8	513.6	452.7	514.6	509.9	506.0	532.8	2.80	0.001	0.001	0.001
ADF[9] (g/kg DM)		276.3	262.7	278.4	241.9	255.9	251.6	219.6	251.6	256.6	211.4	246.6	2.88	0.001	0.001	0.39
GR[10] (kg DM/ha/ sampl.)				64.6	46.6	52.8	28.3	32.8	40.7	13.3	8.7	12.9	0.04	0.001	0.24	0.32
FA[11] (kg DM/ha)	13.0	48.2	69.3	37.9	29.5	24.7	34.5	38.4	34.3	18.2	38.5	15.9	0.04	0.21	0.66	0.39
SR[12] (ha/cow)	33.9	14.8	22.8	34.6	14.5	23.2	34.3	15.2	25.6	36.5	15.4	26.1	0.03	0.98	0.001	1.0
Grass (%)	58.3	56.5	40	49.7	41.4	36.7	49.2	41.7	23.3	50.8	48.5	45.0	1.94	0.20	0.10	0.96
Clover (%)	13.3	11.9	40	16.1	17.8	26.7	24.4	32.6	51.7	23.3	34.5	28.3	1.75	0.01	0.5	0.58
Herbs (%)	28.3	31.5	20	34.3	43.3	36.7	26.5	24.5	25.0	25.8	17.2	26.7	1.82	0.01	0.1	0.71

[1]S: sampling; [2]GS: grazing system; [3]R: rotational; [4]SC: short-grass; [5]C: continuous; [6]CSH: compressed sward height; [7]CP: crude protein; [8]NDF: neutral detergent fibre; [9]ADF: acid detergent fibre; [10]GR: growth rate; [11]FA: forage allowance; [12]SR: stocking rate