Sward quality and yields of grassland in a dairy farm with reduced fertilizer N rates

Verloop J., Oenema J. and Geerts R.H.E.M.
Wageningen UR, Plant Research International, the Netherlands

Abstract

The objective of this study was to explore under farming conditions the effect of reduced fertilizer N application rates on the dynamics of botanical composition and yields of grass-clover-swards. In both temporary and permanent grassland the percentage of highly productive grasses (good grasses) declined at a constant rate of 3.0 to 6.3% points y^{-1} during the aging of the sward. Good grasses were replaced by less-productive grasses and herbs. The percentage of clover did not show a significant trend. Reduced N fertilization did not significantly change these dynamics. The percentage of white clover and, in some cases, high-yielding grasses in the sward, enhanced the yields of nitrogen and herbage dry matter, while the percentage of herbs reduced yields.

Keywords: white clover, permanent grassland, temporary grassland, botanical composition

Introduction

In Dutch intensive dairy production, there is a high appreciation for grassland swards that consist mainly of productive grasses mixed with clover to fix nitrogen (N). This appreciation has been formalized in a classification system for grasses based on their potential yields and feed nutritional value (Sikkema, 1990). A distinction is made between good (GG), mediocre (MG) and inferior grasses (IG). Farming conditions may hamper maintenance of the optimal sward quality and lead to the replacement of GG by MG, IG and herbs (H). In particular, drought stress and the level of N fertilization could affect the sward quality (Oomes, 1992). Possibilities have been explored on the experimental farm 'De Marke', since 1989 to produce milk without violating environmental standards for N and P. Aiming for a higher system of N-use efficiency and lower N losses, in 2003 the N fertilization in grass (NF) was reduced from 214-247 to 146-177 kg ha^{-1}. In this study, we analysed the effects of reducing NF rates on the dynamics of sward quality and effects of sward quality on grass yields.

Materials and methods

The study is based studies on the experimental farm 'De Marke' in the Netherlands. The climate is favourable for grass production (annual precipitation of 792 mm and a temperature of 14 °C in summer). However, plant-available water on the deep-draining sandy soil is a major growth-limiting factor. The farm area consists of permanent grassland (PG) and a crop rotation in which three years of temporary grassland (TG) and three to five years of arable crops are alternated (Verloop, 2013). Part of the grassland is subjected to rotational grazing. PG is renovated when the sward condition is considered inadequate according to the recommendations, i.e. about once every six years. To establish a new grassland sward, 28 kg ha^{-1} perennial ryegrass, 7 kg ha^{-1} timothy and 9 kg ha^{-1} white clover are sown. Herbicides are used occasionally to control dandelion. The farm area (55 ha) was divided into 30 parcels. Botanical composition and the total 'sprout density of vegetation' (SDV) were monitored by visual observations on each parcel. The botanical composition was expressed in terms of sward quality distinguishing GG, MG and IG for grasses, H for herbs and L for legumes (Table 1). Dandelion was the dominant herb; thus, H can be considered a proxi of dandelion. Similarly, L is a proxi of white clover. For each parcel the crop management, grazing intensity and nutrient flows (inputs, yields) were recorded (Verloop, 2013). Each parcel was included as an observation unit in the analysis of the dynamics of sward quality. In most parcels the change of sward quality as the grassland sward aged was constant and could thus be described

Table 1. Species observed in grassland at 'De Marke' and their classification (acc. to Sikkema, 1990).[1]

Name *(scientific name)*	Class[2]	Name *(scientific name)*	Class
Perennial ryegrass *(Lolium perenne)*	GG	Annual meadow-grass *(Poa annua)*	IG
Timothy *(Phleum pratense)*	GG	Soft-brome *(Bromus hordeaceus)*	IG
Italian ryegrass *(Lolium multiflorum)*	GG	White clover *(Trifolium repens)*	L
Meadow fescue *(Festuca pratensis.)*	GG	Red clover *(Trifolium pratense)*	L
Cock's-foot *(Dactylis glomerata)*	MG	Dandelion *(Taraxacum officinale)*	H
Rough meadow-grass *(Poa trivialis)*	MG	Chickweed *(Stellaria media)*	H
Couch-grass *(Elytrigia repens)*	MG	Broad-leaved dock *(Rumex obtusifolius)*	H
Creeping bentgrass *(Agrostis stolonifera)*	MG	Shepherd's purse *(C. bursa-pastoris)*	H
Yorkshire fog *(Holcus lanatus)*	MG	Smooth hawk's beard *(Crepis capillaris)*	H
Smooth meadow-grass *(Poa pratensis)*	MG	Common yarrow *(Archillea millefolium)*	H

[1] Together representing >96% of the botanical composition of the sward.

[2] GG = good grasses; MG = mediocre grasses; IG = inferior grasses.

by linear functions. Therefore, we expressed the change of sward quality by regression coefficients (RC), e.g. $\Delta GG\ \Delta t^{-1}$. We compared RC values for 1989-2003 (HighN) with those for 2004-2012 (LowN) to explore effects of the management changes (Table 2). Moreover, we analysed which sward components significantly affect yields of nitrogen (NY) and dry matter (DMY) – ranging from 118 to 378 and 5,347 to 14,412 kg ha^{-1}, respectively – using all data, except the first-year TG and PG to avoid bias caused by establishment of the new sward. In this analysis, we compared the performance of basic regression models for NY and DMY – comprising only the effects of year, NF and grazing intensity – with extended models in which GG, MG, IG, H and L were also adopted.

Results and discussion

Table 3 presents information on sward quality and its change over time for PG and TG in the HighN and LowN management systems. GG declined significantly over time in PG and TG (Table 3), the two types following similar patterns. The decline of GG is associated with an increase of H, MG and, occasionally, with IG. The measures SDV and L show no significant trend over time. For sward quality and the dynamics of sward quality there were no significant differences between the HighN and LowN management systems, or between PG and TG. Moreover, regression analysis in > first-year grassland showed no significant relationship between NF and sward quality.

L and H had significant effects on the N yield (P<0.01). Adoption of L and H to the basic model resulted in a better description of the N yield (increase of R^2_{adj} from 17 to 69%). L enhanced the N yield by 4.4 kg ha^{-1} per % and H reduced the N yield by 3.6 kg ha^{-1} per %. Effects of GG, GM and GI on the yield of N and dry matter were not significant. The effects of L and H on the N yield were twice as strong in

Table 2. The N fertilization level (NF) and grazing intensity (GI) in a HighN (1989-2003) and LowN (2004-2012) system (kg ha^{-1}); means of all observations (with range given in brackets).

	Permanent grassland		Temporary grassland	
	NF[1]	GI[2]	NF	GI
HighN	214 (120-300)	94 (35-185)	247 (120-310)	65 (0-216)
LowN	146 (124-219)	42 (0-138)	177 (99-240)	28 (0-155)

[1] Calculated as 0.5 × N-manure rate + 0.15 × N-grazing rate + N-mineral fertilizer rate (kg ha^{-1}).

[2] The excretion of N during grazing (kg ha^{-1}) was used as a proxi of the grazing intensity.

Table 3. The sward quality in first-year grassland (FY, %) and the change of sward quality over time (regression coefficient, RC, % point y^{-1}); number of observations (n).[1,2]

System	Land use (n)	Parameter	SDV	GG	L	MG	IG	H
HighN	PG (12)	FY[3]	92	79	11.3	1.7	3.8	4.3
		RC[4]	-0.6	-3.9*	-0.6	2.9*	0.4	1.3*
	TG (15)	FY	87	82	12.4	0.4	2.9	2.2
		RC	0.3	-3.0	-0.5	1.4*	0.5	1.5*
LowN	PG (6)	FY	89	84	3.2	4.0	4.7*	5.0
		RC	0.6	-6.3*	1.8	4.1*	1.2	-0.8*
	TG (10)	FY	88	87	10.5	0.7	0.4	1.6
		RC	-0.8	-4.4*	0.0	0.5	0.8	3.2*

[1] Abbreviations used: SDV = sprout density; GG = good grasses; L = legumes; MG = mediocre grasses; IG = inferior grasses; H = herbs; PG = permanent grassland; TG = temporary grassland.

[2] Values with an * are different from 0 at $P<0.05$, according to Student t-test.

[3] Standard deviations for SDV, GG and L are 8, 9 and 9%, respectively, and 2 to 3% for MG, IG and H.

[4] Standard deviations for the RCs of SDV, GG and L are 6, 4 and 4% point y^{-1}, respectively, and 2 to 3% point y^{-1} for MG, IG and H.

the LowN as in the HighN system. L and GG had significant effects on the dry matter yield ($P<0.05$). Adoption of L and GG to the basic model resulted in an increase of R^2_{adj} from 17 to 31%. L enhanced the dry matter yield by 70 kg ha^{-1} per % and GG increased the dry matter yield by 51 kg ha^{-1} per %. The positive effect of L on yields can be explained as a result of the capacity of L to bind nitrogen. Our results indicate that effects of sward quality on yields are significant under practical farming conditions and not neutralized by other sources of variability on the farm. The stronger stimulating effects of L on grass yields in the LowN than in the HighN system indicates that the N-binding effect of L is more effective under a regime of tight N fertilization. The maintenance of GG seems more effective at lower N rates, not because the share of GG is lower, but because it has a stronger effect on yield.

Conclusions

This study has shown for the experimental farm 'De Marke' that:

- The dynamics of sward quality was not significantly affected by reduction of N fertilization.
- The share of good grasses declines during aging of both permanent and temporary grassland swards at a constant rate of 3.0 to 6.3% points per year.
- The botanical composition of the grass sward has significant and substantial effects on the nitrogen and dry matter yields of the grassland.

References

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