

The influence of legume species on the productivity and quality of multi-species swards in four production years

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Abstract

In Latvia's farms, the use of multicomponent grass–legume mixtures is a traditional practice, because swards can secure good persistence and stable productivity. Red clover *Trifolium pratense* (Tp) and lucerne *Medicago sativa* (Ms) are traditional forage crops, but fodder galega *Galega orientalis* (Go) is grown for a relatively short period. Field trials were carried out with the aim to investigate forage yield and quality during four production years of sown legume–grass swards. Mixtures were composed of 50% legumes and 50% grasses (G). Swards were cut three times during the vegetation season. Significant differences in dry matter (DM) yield were found between successive production years and mixture types (MT). Highest DM yield (15.92 Mg ha⁻¹ on average for four production years) was stated for the mixture containing lucerne (Ms+G). The decline in productivity between the first and fourth production years by 14.12 Mg ha⁻¹ (or 68%) was more expressed for red clover mixture (Tp+G), but a more stable productivity was demonstrated by swards containing galega (Go+G) – a yield decrease by 5.88 Mg ha⁻¹ (or 40%). Galega had slow establishment in the sowing year and in the first production year. Galega swards' productive longevity is one of its main advantages. The mixture containing galega (Go+G) demonstrated the highest crude protein content (CP) in the third and fourth production years. Red clover is a short-term perennial legume, and mixture (Tp+G) had the lowest CP content (99 g kg⁻¹ DM) on average for four production years.

Introduction

The increasing role of sustainable grassland-based ruminant systems in Europe highlights the use of sown multi-species swards and stresses the need of developing comprehensive studies on the influence of different grassland management strategies in different local conditions (Peyraud et al. 2014). The addition of legumes in mixtures contributes to the reduction of N fertilisation and to the improvement of forage quality (Tomić et al. 2012). Legumes allow improving the sustainability and stability of agroecosystems, and provide the cheapest source of nitrogen (Wilkins and Vidrih 2000). Red clover and alfalfa are traditional forage crops in Latvia. In Latvian agricultural practice, fodder galega (*Galega orientalis* Lam.) is grown for a relatively short period. Recently introduced in Latvia, it is raising an ever-growing interest due to its persistency, high yielding ability and good forage quality (Adamovics et al. 2015).

The objective of our study was to investigate the forage yield and quality during four production years of multi-species swards containing different legume species.

Methods and Study Site

Field trials were conducted at three experimental sites in Latvia. At each of the three sites, the same mixtures were sown in June 2014 – without a cover crop, in three replications, and with a 10-m² plot size. The following grass combinations were used in mixtures: *Festuca arundinacea*, ×*Festulolium loliaceum*, and *Lolium boucheanum* in equal parts (G). The mixtures were composed of *Trifolium pratense* 50% and grasses 50% (Tp+G); *Medicago sativa* 50% and grasses 50% (Ms+G); and *Galega orientalis* 50% and grasses 50% (Go+G). The following fertilization treatments were used for all mixture types: N60, P78, and K90 kg ha⁻¹. Swards were cut three times during the vegetation season. The crude protein (CP) content of dry matter (DM) yield was determined by modified Kjeldahl, NDF was determined by van Soest, and the mineral element Ca was analysed by atomic adsorption spectrometry. The data were statistically analysed using the two-way analysis of variance, and the difference among means was detected by LSD at the $P < 0.05$ probability level (Excel for Windows, 2003).

Results

The highest DM yield (15.92 Mg ha⁻¹ on average for four production years) was stated for the mixture containing lucerne (Ms+G). Lucerne showed fast development in the first three production years and good competitiveness with grasses. Fodder galega significantly surpassed other forage legumes in respect to productive longevity; however, it was characterised by slow establishment and development in the first

production years. Galega achieves its maximal DM yield only in the third year of sward use (Baležentiene and Spruogis 2011). A slow galega development in the first production years caused the lowest DM yield in Go+G mixture (11.98 Mg ha⁻¹ on average for four production years).

Significant differences in DM yield were found between successive production years. There was a significant ($P<0.05$) MT-by-year interaction. Red clover is the most common legume in the Baltic countries. It has fast development in the first production year, but its productive longevity is limited. The decrease in legume proportion in Tp+G swards contributed to a more expressed decline in productivity between production years. DM yield in the second production year decreased by 6.70 Mg ha⁻¹ or 32%. The decline of 5.20 Mg ha⁻¹ or 37% in productivity between the second and third production years was detected for Tp+G swards.

Galega- and lucerne-containing swards demonstrated a more stable productivity (Table 1). For Ms+G sward, no significant differences between the yields of the first and second production years were found, but a decline in productivity between the second and third production years was detected by 6.55 Mg ha⁻¹ or 32%. For Go+G sward, a decline in productivity between the first and second production years was detected by 1.03 Mg ha⁻¹ or 7%, and between the second and third production years – by 3.5 Mg ha⁻¹ or 22%.

The yield decline between the third and fourth production years for all mixtures was caused not only by sward aging, but also by meteorological conditions – dry summer in the fourth production year. The proportion of legumes in sward in the fourth production year contributed to legume longevity. The highest proportion of legumes was detected in Go+G sward (24.2%), but the lowest proportion – in Tp+G swards (5.6%). The proportion of legumes in Ms+G sward in the fourth production year was 16.3%.

Table 1. Dry matter yield, Mg ha⁻¹, and crude protein content in DM yield, g kg⁻¹, during four production years

Mixture type (MT)	DM yield, Mg ha ⁻¹				CP content in DM, g kg ⁻¹			
	Year of sward use (Y)				Year of sward use (Y)			
	First	Second	Third	Fourth	First	Second	Third	Fourth
Tp+G	20.72	14.02	8.82	6.60	107.5	102.7	91.8	93.9
Ms+G	19.83	20.56	14.02	9.28	107.2	140.6	128.1	98.0
Go+G	14.73	13.70	10.65	8.85	91.1	131.1	135.8	115.6
Mean	18.43	16.09	11.16	8.24	101.9	124.8	118.6	102.5
LSD _{0.05}	MT= 1.69; Y=1.95; MT/Y= 3.38				MT= 12.58; Y= 14.53; MT/Y= 25.17			

LSD – least significant difference

Significant differences in CP content were found between production years and mixture types. Galega is reported as a high-value legume, providing fodder rich in protein and bio-active substances (Baležentiene 2008). In our trials, CP content (118.4 g kg⁻¹ on average for four production years) for galega-containing mixtures was not very high due to the large grass proportion in swards (especially in the first year of sward use). The mixture containing galega (Go+G) had the highest CP content in the third and fourth production years.

Red clover mixture (Tp+G) had the lowest average CP content (99 g kg⁻¹ DM). A successive CP content decrease with sward aging was not observed. The significant CP differences between the years of sward use can be explained not only by different legume contents, but also by different meteorological conditions – dry summer in the first and fourth production years.

Legumes accumulated Ca more than grasses, and Ca content in mixture DM is closely connected with legume proportion in sward (Adamovics and Gutmane 2018). The highest Ca content in DM yield (9.56 g kg⁻¹ on average for four production years) was stated for the mixture containing lucerne. The Ca content in Go+G mixtures in the third and fourth production years was significantly higher in comparison with Tp+G mixtures (Table 2).

There were no significant differences in the average NDF content between the mixtures. A significant increase in NDF content during the first three production years was found for Tp+G mixtures. It correspond with red clover content decrease in sward during production years. The mixture containing lucerne (Ms+G) demonstrated a stable NDF content during the four production years.

Table 2. NDF and Ca content in DM yield, g kg⁻¹, during four production years

Mixture type (MT)	NDF content in DM, g kg ⁻¹				Ca content in DM, g kg ⁻¹			
	Year of sward use (Y)				Year of sward use (Y)			
	First	Second	Third	Fourth	First	Second	Third	Fourth
Tp+G	473.9	522.2	568.6	565.2	8.50	8.33	5.62	4.55
Ms+G	527.3	522.6	547.1	525.9	8.05	12.75	10.65	6.80
Go+G	541.2	547.3	563.1	510.8	4.88	8.72	6.88	6.45
Mean	514.1	530.7	559.6	534.0	7.14	9.93	7.71	5.93
LSD _{0.05}	MT= n.s.; Y=20.92; MT/Y= 36.24				MT= 1.20; Y= 1.38; MT/Y= 2.39			

LSD – least significant difference; n.s. – not significant

Discussion

Significant differences in DM yield and in the CP and Ca content in DM yields were found between production years and mixture types. The highest yields for all legume-containing mixtures were obtained in the first harvest year. Three production years was the maximal duration of sward use for the mixture containing red clover. Even in third production year, a decrease in red clover proportion in sward contributed to a significant decrease in DM yield and in the content of CP and Ca.

Mixtures containing lucerne are appropriate for four years of sward use, providing high average DM yields with good forage quality. A longer (five or more years) use of Ms+G sward in a three-cutting management is not recommended due to a significant decline in productivity and forage quality (the CP and Ca content).

Mixtures containing fodder galega could be recommended for a long-term (more than for years) sward use. The slow establishment and development of galega caused the lowest DM yields in the first and second production years. In the fourth production year, the DM yield of Go+G sward was essentially higher in comparison with Tp+G mixtures, but differences in Ms+G mixtures were not significant. Galega-containing mixture demonstrated a more stable productivity and forage DM quality during sward aging.

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