

Performance and quality of legume monocultures and grass-legume mixtures during two dry years

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Abstract

The paper presents the effect of weather variables on performance and herbage quality of legume monocultures and grass-legume mixtures. In a field experiment, the total dry matter yield and its distribution during the growing period, content of crude protein and fibre of monocultures of *Trifolium pratense* and *Medicago sativa* and grass-legume mixtures under the climatic conditions of hilly region in Central Slovakia during two dry years was investigated. *Medicago sativa* cv. Kamila and Tereza grown as monocultures or as mixtures with *Festulolium braunii* (cv. Achilles) outperformed *Trifolium pratense* cv. Fresko and Veles and provided a well-balanced total and seasonal dry matter yield during both years. Across all experimental years, crude protein content was significantly higher at *Medicago sativa* monocultures and mixtures when compared to *Trifolium pratense* monocultures ($P < 0.05$). Responses of nutritive parameters of both legume species to weather variables were different. The crude protein content in *Trifolium pratense* was independent of rainfall and temperature. In contrast, the fibre content correlated with temperature; correlations were stronger for *Medicago sativa* monocultures ($P < 0.05$) than *Trifolium pratense* monocultures.

Keywords: dry matter yield, *Trifolium pratense*, *Medicago sativa*, grass-legume mixture

Introduction

Forage legumes are considered to be the backbone of ley farming in southern regions of Slovakia (Jančovič *et al.*, 2005) and in upland and mountain areas with high proportions of natural habitats, where it is necessary to produce high-quality conserved forage for winter. Whereas *Medicago sativa* has the greatest productive potential in southern regions with a lower total rainfall, *Trifolium pratense* is cultivated mainly in upland and mountain areas with total annual rainfall of more than 700 mm. Increasing variability in the seasonal temperature and precipitation patterns influences not only productivity (Chaplin-Kramer and George 2013), but affects the nutritive value and digestibility of forage grasses and legumes. The objective of this study was to assess the impact of drought on the yield stability and quality of *Trifolium pratense*, *Medicago sativa* and their mixtures with *Festulolium braunii* during two consecutive extremely dry years.

Materials and methods

In 2010, the trial was established in Banská Bystrica (48°74'N, 19°85'E; altitude 369 m.a.s.l.). The site is located in a moderately warm region and on soil classified as Leptic Cambisol Skeletic. The climate variables (rainfall – R, maximum temperatures – Tmax) were recorded daily. The trial was arranged in a randomized complete block design with two replications. The trial comprised the following 6 treatments: Treatment 1 – *T. pratense* (TP) cv. Fresko; Treatment 2 – TP cv. Veles; Treatment 3 – mixture of TP cv. Fresko with *Festulolium braunii* cv. Achilles; Treatment 4 – *M. sativa* (MS) cv. Kamila, Treatment 5 – MS cv. Tereza; Treatment 6 – mixture of MS cv. Tereza with *Festulolium braunii* cv. Achilles. The seeding rates of the monoculture were 20 kg ha⁻¹ for TP and 15 kg ha⁻¹ for MS and the seeding rates of

the mixtures were 26 kg ha⁻¹, of which 16 kg ha⁻¹ was for *Festulolium braunii* and 10 kg ha⁻¹ for TP or MS, respectively. The fertiliser application included 30 kg N ha⁻¹, 30 kg P ha⁻¹ and 60 kg K ha⁻¹ applied before seeding in spring 2010; 30 kg P ha⁻¹ and 60 kg K ha⁻¹ were applied in spring 2011 and 2012. The stands were cut three times a year. The dry matter (DM) yield was determined by drying to a constant weight at 60 °C in an electric drier. The crude protein (CP) was determined by the Kjeldahl method (N × 6.25). Fibre was determined by the Hennenberg-Stohmann method. DM yield, CP and fibre were subjected to a multi-factor analysis of variance (ANOVA). Statistical analyses were performed using Statgraphics software version 5.0.

Results and discussion

The DM yield of TP was below the range typically reported for this crop (Tucak *et al.*, 2013) and varied from 3.87 Mg ha⁻¹ (cv. Veles) to 5.13 Mg ha⁻¹ (cv. Fresko) (Table 1). The mixture of TP with *Festulolium braunii* overyielded TP cv. Fresko and TP cv. Veles by 25 and 45%, respectively.

In 2012, the largest decrease (67%) in DM production was observed in TP cv. Veles (Treatment 2). In contrast to TP, treatments with MS showed a significant increase in DM yield in 2012 (Table 1) when compared to 2011. In 2011, in all treatments the highest DM yields were obtained in the 2nd cut. In 2012, TP demonstrated the same pattern with the highest DM yields in the 2nd cut. The low values for the correlation coefficients indicated that neither rainfall amount nor T_{max} during the regrowth period directly affected the DM yield of TP (Table 2). In contrast to the TP monocultures, the mixture of TP with *Festulolium braunii* was positively correlated with rainfall ($r=0.67$, $P<0.05$). The higher correlation with rainfall may be related to higher sensitivity of *Festulolium braunii* to water availability during growing season, compared with that of legumes. Similarly, Gutmane and Adamovich (2008) reported that the DM yield of *Festulolium* hybrids was strongly dependent on the weather conditions in the year of assessment, and particularly the period of regrowth. Similar to TP, no relation between DM yield and rainfall was found for MS (Table 1). On average, TP and MS exhibited significantly higher CP values ($P<0.05$) than their mixtures with *Festulolium braunii* (Table 2). MS and TP monocultures had the highest CP content in the 2nd cut.

Table 1. Dry matter yield (Mg ha⁻¹) of the monocultures of *Trifolium pratense* (TP), *Medicago sativa* (MS) and of their mixtures with *Festulolium braunii* (FB) in the 1st, 2nd and 3rd cut, and Pearson correlation coefficients between the dry matter yield and sum of rainfall per cut (mm; r_R) and mean of maximum temperature (°C; r_{Tmax}).

Year	Cut number	T _{max}	R	Treatment ¹					
				1	2	3	4	5	6
2011	1 st	19.1	59.0	1.22	0.73	2.38	1.09	1.41	1.00
	2 nd	23.4	51.4	3.65	3.71	4.12	3.58	3.13	3.18
	3 rd	25.1	48.2	1.61	1.18	2.53	3.02	3.31	1.45
Total DM yield				6.48	5.62	9.03	7.63	7.85	5.83
2012	1 st	18.4	69.4	1.34	0.82	2.32	4.51	4.89	4.43
	2 nd	25.5	33.6	1.74	1.00	1.68	4.14	3.29	3.37
	3 rd	26.4	0.0	0.70	0.30	0.59	3.38	3.09	3.51
Total DM yield				3.78	2.12	4.58	12.02	11.27	11.31
r _{Tmax}				0.05	0.05	-0.32	0.23	0.04	0.03
r _R ²				0.33	0.29	0.67*	-0.09	0.14	-0.15

¹ Treatment 1: TP cv. Fresko; Treatment 2: TP cv. Veles; Treatment 3: TP cv. Fresko with *Festulolium braunii* cv. Achilles; Treatment 4: MS cv. Kamila, Treatment 5: MS cv. Tereza; Treatment 6: MS cv. Tereza with *Festulolium braunii* cv. Achilles.

² * Positive correlation with rainfall ($P<0.05$).

Table 2. Mean content of crude protein (g kg⁻¹), fibre (g kg⁻¹) and Pearson correlation coefficients between the content of crude protein (g kg⁻¹), fibre (g kg⁻¹), sum of rainfall per cut (mm; r_R) and mean of maximum temperature (°C; r_{Tmax})

Cut	Crude protein						Fibre					
	Treatment ¹						Treatment ¹					
	1	2	3	4	5	6	1	2	3	4	5	6
1 st	123	121	94	192	118	107	198.4	222.2	251.3	186.3	248.0	249.2
2 nd	170	150	132	170	164	118	256.2	254.5	267.9	295.4	284.9	305.9
3 rd	144	139	148	144	142	147	268.7	255.2	325.4	328.5	365.9	290.8
Mean ²	143 ^b	137 ^b	124 ^s	169 ^c	141 ^b	124 ^a	241.1 ^a	243.1 ^a	281.6 ^b	270.0 ^a	299.6 ^c	281.9 ^b
r _{Tmax} ³	0.07	0.08	-0.59*	0.55	-0.31	-0.49	-0.41	-0.35	-0.43	-0.53	-0.56	-0.38
r _R ³	0.29	0.31	0.81	0.72*	0.52	0.51	0.56	0.33	0.61*	0.70*	0.67*	0.57

¹ Treatment 1: TP cv. Fresko; Treatment 2: TP cv. Veles; Treatment 3: TP cv. Fresko with *Festulolium braunii* cv. Achilles; Treatment 4: MS cv. Kamila, Treatment 5: MS cv. Tereza; Treatment 6: MS cv. Tereza with *Festulolium braunii* cv. Achilles.

² The values in the same row with different superscript letters are significantly different at $P < 0.05$.

³ * Significantly different at the 95% level.

For grass-legume mixtures, there was a positive relationship between CP content and T_{max}, and a negative correlation between CP content and total rainfall. The TP monocultures had a lower concentration of fibre than both MS monocultures and legume mixtures (Table 2). In our study, there was a non-significant negative correlation between fibre concentration and T_{max}. The fibre content was positively correlated with sum of rainfall available for the cut.

Conclusions

The results showed significant impact of water stress on DM production of *Trifolium pratense* and seasonal pattern of DM yield. In contrast, *Medicago sativa* displayed high yield potential and stability during two consecutive dry years. As would be expected, legume monocultures exhibited significantly higher CP content than mixtures with *Festulolium braunii*. Ambient temperature was the weather variable that predominantly affected the concentration of CP and fibre, especially of *Medicago sativa* monocultures.

Acknowledgements

The study was supported by the Slovak Research and Development Agency grant No. APVV-0098-12.

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