EFFECTS OF LIQUID MANURE APPLICATION ON YIELD, QUALITY AND BOTANICAL COMPOSITION OF GRASSLAND

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Introduction

Croatian farmers often consider liquid manure (LM) (a mixture of urine, small parts of faeces, bedding material, water and effluent from the dunghill) to be "waste" or, at best, unreliable source of nutrients, and find it difficult to assess the inorganic fertilizer-N requirement of LM-treated grassland. It is possible that LM, if used in combination with different nitrogen forms, affects their relative efficiency. Little information is available on the effects of LM application on forage quality and degradability of dry matter (DM) and crude protein (CP). We evaluated the effects of cattle LM application in combination with mineral fertilizer (MF) on forage yield, botanical composition and forage quality of the mountain grassland in comparison with MF.

Material and methods

The experiment was conducted during a period of three years (1999-2001), on an mountain pasture – on acid brown soil (pH 5.3, 650 m altitude, 1230 mm average annual precipitation, 6.6 $^{\circ}$C mean annual temperature). The experiment consisted of two fertilization treatments: MF with 450 kg ha^{-1} N:P:K 8:26:26 in March and 150 kg ha^{-1} calcium ammonium nitrate (CAN, 27% N) after the first harvest (T1), and the same rate of MF plus 5.0 L m^{-2} cattle LM in two equal applications (early in spring and after the 1st cut) in 1999 and 2000, and 2.5 L m^{-2} LM in 2001 (after the 1st cut) (T2). LM was applied using a standard trailed top-fill tanker with a power take-off driven centrifugal pump. Annually, 76.5 kg ha^{-1} N, 117 kg ha^{-1} P_2O_5 and 117 kg ha^{-1} K_2O were applied in T1 treatment. In T2 112 kg ha^{-1} N, 118.7 kg ha^{-1} P_2O_5 and 138 kg ha^{-1} K_2O were applied in 1999 and 2000, and 94 kg ha^{-1} N, 118 kg ha^{-1} P_2O_5 and 128.5 kg ha^{-1} K_2O in 2001. The plot size was 8 x 10 m, with 5 m borders between treatments. A randomized complete block design with 10 replications was used. From each plot, one 5 m long x 2.8 m wide strip was cut (in reproductive stage R2 of grasses-spikelets fully emerged) in the centre of the plot to a height of 5 cm using a tractor-mounted disc mower. The whole sample collected was weighed in the field. Two herbage subsamples (500 g) were taken at each harvest for determination of the DM content (at 60 $^{\circ}$C for 48 h) and for botanical separation into grasses, legumes and forbs. Dry herbage subsamples from the first and second harvests in 1999 were ground to pass through a 1-mm screen for determination of forage quality and *in-sacco* measurements: cell wall (neutral detergent fiber (NDF) and acid detergemt fiber (ADF)-Goering and Van Soest, 1970), protein fractions (CP and undegraded protein content (UDP) were determined as N x 6.25) and *in-sacco* dry matter degradability (ISDMD). For degradability studies, four rumen fistulated Charolais sheep (average weight 50 kg) were used and the *in-sacco* technique was applied (Ørskov et al., 1980). The incubation time was 48 hours. ISDMD was calculated as the weight loss of samples during rumen incubation. The UDP concentration in residues was expressed on

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the DM basis. All data were processed by the analysis of variance using the MIXED procedure of SAS (SAS Institute, 1999).

Results and discussions

Higher DM yield in 1999 and 2001 ($P<0.01$) compared to 2000 were due to higher rainfall and more even rainfall distribution over the year (Table 1). Seasonal precipitation (April-October) in 2000 (559.3 mm) was 28% below the 30-year average. A significant year x treatment interaction found for DM yield indicated differences in yield between fertilization treatments in different years. Larger amounts of N, but also other nutrients, in T2 caused a significantly higher DM yield in 1999 and 2000 (72 and 111%, respectively) compared to T1 (Table 1), primarily due to the positive action of N on grass yield in the first cuts. The trend reported by Long and Gracey (1990) of a slurry–fertilizer combination being more effective than inorganic fertilizer at the 1st harvest, followed by little difference in the response to N source at the 2nd harvest, was confirmed in this research as well (data not shown). According to the authors, the reasons for such trends might be higher ammonia losses in warmer and drier conditions at the time of summer applications of slurry, for the first regrowth, compared to equivalent spring-time applications. The poor effect of LM on herbage yield in its application in warm and dry conditions (May 25, 2001) is the reason why there were no significant differences in DM yields between treatments in 2001. A significant year x treatment interaction for grass DM yield was found (Table 1). In all experimental years a significantly higher grass DM yield ($P<0.01$) was recorded in T2 than in T1, but the smallest difference occurred in 2001. The treatments did not differ significantly during the said period in grass contribution to the total DM yield. Floristic change due to nutrient additions, including livestock manure, is thought to be caused by the faster and more intensive growth of some species (usually grasses) compared to other species (mostly dicotyledonous) when well-fertilized (van der Bergh, 1991). This was also confirmed in this research, since forage sward from both fertilizing treatments became increasingly dominated by grass species as the experiment progressed. As the grass content increased, the contribution of legumes and broadleaved weed species (forbs) declined, which is similar to the results of Griffin et al. (2002). Average legume (mainly white clover) contents (as % DM yield) recorded in 2000 and 1999 were significantly higher ($P<0.01$) than the legume content in 2001. There were no significant differences between fertilizing treatments in the legume DM yield and legume content. In 1999, 2000 and in the average over all years, a significantly higher forbs DM yield was recorded in T2 ($P<0.01$), while there were no differences between treatments in 2001. This is in agreement with Butorac (1999), who maintains that LM application to grasslands may cause spreading of herbaceous weeds, notably *Taraxacum officinale* and *Daucus carota L*. However, the mean content of forbs dropped from 35.5% in 1999 to 9.5% in 2001 just because of the more intensive and faster growth of grasses.

Table 1. Effects of mineral fertilizer (T1) and combination of mineral fertilizer and liquid manure (T2) on herbage DM yield, DM yield of grasses, legumes and forbs and their contribution to total DM yield.

Year	Treatment	DM	Grasses		Legumes		Forbs	
		t ha^{-1}	t ha^{-1}	%	t ha^{-1}	%	t ha^{-1}	%
1999	T1	6.13	3.69	60.22	0.21	3.62	2.23	36.16
	T2	10.57	6.43	60.63	0.49	4.48	3.65	34.89
	Mean	8.35	5.06	60.42	0.35	4.05	2.94	35.52
2000	T1	3.38	2.36	71.40	0.31	8.06	0.71	20.54
	T2	7.15	4.91	66.69	0.28	4.22	1.96	29.09
	Mean	5.26	3.64	69.04	0.29	6.14	1.33	24.81
2001	T1	7.25	6.34	87.54	0.10	1.35	0.81	11.10
	T2	8.32	7.50	90.04	0.16	2.00	0.65	7.96
	Mean	7.79	6.92	88.79	0.13	1.68	0.73	9.53
1999-2001	T1	5.59	4.13	73.05	0.21	4.34	1.25	22.60
	T2	8.68	6.28	72.45	0.31	3.57	2.09	23.98
	Significance / LSD (0.05)							
Year (Y)		**/0.9	**/0.96	**/6.28	ns	**/2.7	**/0.19	**/4.26
Treatment (T)		**/0.72	**/0.65	ns	ns	ns	**/0.32	ns
Y x T †		**/1.24	**/1.13	ns	ns	ns	**/0.55	ns

†LSD values for comparing means within growing seasons. ** Significant at the 0.01 level. ns not significant

In general, there were no significant differences in NDF, ADF and CP contents between fertilization treatments (Table 2). Min et al. (2002) found that application of dairy slurry increased the CP content in grasses but not in alfalfa-grass mixtures, while the NDF and ADF contents were not affected by dairy slurry. The first cut forage had higher NDF and ADF contents and a lower CP content compared to the second cut. This is in agreement with the results of Spanghero et al. (2003) where the first-cut hay obtained after the spring growth had generally lower CP and higher NDF contents compared to the other cuts. Higher NDF and ADF contents in the 1st cut were highly related to the significantly lower ISDMD of this cut in comparison with the 2nd cut. A significant cut x treatment interaction was found for ISDMD (Table 2), which indicated differences in ISDMD of cuts in different fertilization treatments. There were no significant differences in ISDMD between cuts in T2, while ISDMD of the 1st cut in T1 was significantly lower than ISDMD of the 2nd cut. Knowledge of the rumen degradable and undegradable protein contents of forages is essential for a more precise prediction of animal performance and animal response to protein supplements. The average CP degradability in the rumen of 84.4% is in agreement with the results of Lardy et al. (2004), who found that the degradable intake protein levels, when expressed as CP percentage, were higher than 80%. The 2nd cut had 27% higher UDP than the 1st cut ($P<0.01$) because of the higher CP content (169.13 g kg^{-1}) and lower percentage of CP degradability in the rumen (83.5%) compared to the 1st cut (151.64 g kg^{-1}CP and 85.4% rumen protein degradability). T1 had 11% higher UDP than T2 ($P<0.01$) due to lower CP degradability in the rumen (83%) compared to T2 (85.8%), while the differences in CP contents between fertilizing treatments were not significant.

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Table 2. NDF, ADF, CP, ISDMD and UDP (g kg^{-1} DM) of forage harvested in 1999.

	Cut	T1	T2	Mean	Significance / LSD (0.05)		
					Cut (C)	Treatment (T)	C x T
NDF	1st	564.8	568.6	566.7	*/48.15	ns	ns
	2nd	511.2	508.4	509.8			
	Mean	538.0	538.5				
ADF	1st	325.2	330.8	328.0	**/18.88	ns	ns
	2nd	283.2	297.0	290.1			
	Mean	304.2	313.9				
CP	1st	142.77	160.51	151.64	*/16.35	ns	ns
	2nd	168.03	170.23	169.13			
	Mean	155.4	165.37				
ISDMD	1st	782.25	790.18	786.21	**/5.04	ns	*/7.13
	2nd	795.36	792.92	794.14			
	Mean	788.81	791.55				
UDP	1st	23.53	20.39	21.96	**/0.54	**/0.54	ns
	2nd	29.24	26.55	27.89			
	Mean	26.39	23.47				

* Significant at the 0.05. ** Significant at the 0.01. ns not significant

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