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Moorby, Jon M.; Ellis, Naomi Mary; Fisher, William J.; Davies, D. W. Robert; Davies, David R.

Published in:
Proceedings of the Second Scientific conference of the International Society of Organic Agriculture Research

Publication date:
2008

Citation for published version (APA):
Moorby, J. M., Ellis, N. M., Fisher, W. J., Davies, D. W. R., & Davies, D. R. (2008). Effects of mixing red clover and maize silages on milk production and whole-body N partitioning in dairy cows. In *Proceedings of the Second Scientific conference of the International Society of Organic Agriculture Research* (pp. 16-20)
http://hdl.handle.net/2160/2475

Effects of mixing red clover and maize silages on milk production and whole-body N partitioning in dairy cows

Moorby, J. M.[1], Ellis, N. M., Fisher, W. J., Davies, D. W. R. & Davies, D. R.

Key words: dairy cows, maize, milk production, nitrogen partitioning, red clover.

Abstract

Twenty-four multiparous Holstein-Friesian dairy cows in mid lactation were used in a 3×3 Latin square changeover experiment with three 4-week periods to investigate the effect of altering the ratios of red clover (RC) silage and maize silage in the forage component of their diet. Ratios (in the dry matter (DM)) were: RC10, 0.1 RC:0.9 maize; RC50, 0.5 RC:0.5 maize; RC90, 0.9 RC:0.1 maize. All cows received ad libitum access to their allocated forage with 4 kg of a standard concentrate per day. Whole-body N partitioning and whole-tract diet digestibility measurements were carried out using a subset of cows (n=9). Results are presented in order of RC10, RC50 and RC90 respectively. Feed DM intakes (19.6, 20.5, 19.5 kg DM d^{-1}, s.e.d. 0.32, P<0.01) and milk yields (26.1, 27.3, 25.7 kg milk d^{-1}, s.e.d. 0.54, P<0.01) were highest on diet RC50. Milk protein concentrations decreased (P<0.001) as forage RC proportion increased, and protein yields were significantly (P<0.01) higher on diet RC50. Urine N excretion was lowest (as a ratio to N intake), and milk N secretion was highest, on diet RC10. It is concluded that milk and protein yields can be improved by feeding RC silage as 1:1 mix with maize silage, but that the efficiency of utilisation of forage N was reduced when diets contained more than 0.1 RC silage.

Introduction

Red clover (RC; *Trifolium pratense*), requires no nitrogen (N) fertiliser for growth and is therefore an excellent crop for use in organic dairy systems. Red clover can be successfully ensiled as bales, and RC silage has been shown to have a high intake potential, leading to higher yields of milk, than grass silage (Dewhurst *et al.*, 2003a; 2003b; Thomas *et al.*, 1985). However, due to its relatively low energy density, the efficiency of utilisation of RC silage can be low, and is best offered to cows as a mix with another energy-rich forage. Maize silage offers this potential, itself being relatively low in crude protein but high in starch. The objectives of this experiment were to investigate the effect of feeding three mixtures of RC and maize silage on milk yield and composition from dairy cows, and whole-body partitioning of dietary N.

Materials and methods

Twenty-four multiparous Holstein-Friesian dairy cows in mid lactation were used in a 3 × 3 Latin square changeover experiment. Cows were allocated to one of three replicate Latin squares on the basis of milk yield recorded shortly before the start of the experiment. Three experimental diets were offered to the cows differing in the ratios (on a dry matter (DM) basis) of maize silage to RC silage: 1) diet RC10: 0.9 maize:0.1 RC; 2) diet RC50: 0.5 maize:0.5 RC; 3) diet RC90: 0.1 maize:0.9 RC. The

[1] Institute of Grassland and Environmental Research, Plas Gogerddan, Aberystwyth, UK, E-Mail jon.moorby@aber.ac.uk, Internet www.iger.bbsrc.ac.uk

maize silage was a prepared and stored as a large clamp under cover. The red clover silage was a mixture of first and second cut bales and used in a ratio of two bales first cut to one bale second cut.

In each of three 4-week periods, the first 21 days were used for adaptation to diets, and the remaining 7 days were used for measurements. All cows received *ad libitum* access to their allocated forage diets (to allow at least 0.1 of offered feed as refusals), and also received a constant allocation of 4 kg standard dairy concentrate per day. Feed intakes and milk yields were recorded throughout the experiment.

Feed samples were collected during the measurement week and composited to give one sample per period. During the last 7 days of each experimental period separate collections of total outputs of faeces and urine were also taken from some of the cows (n=9). Apparent whole-tract digestibilities of DM, organic matter (OM), N, and neutral detergent fibre (NDF) were calculated (intake in feed minus output in faeces divided by intake in feed), together with whole-body N balance (by difference of intakes and total outputs of N in milk, faeces and urine). Milk fat and protein was measured by commercial near-infrared milk analysis in 4 consecutive samples taken during the measurement week in each period.

Results

The experimental forage mixtures differed significantly in their composition as the ratio of maize silage to RC silage varied (Tab. 1), with lowest crude protein (CP) concentrations on the RC10 diet. The dairy concentrate offered to all cows contained 929 g OM kg^{-1} DM, 152 g CP kg^{-1} DM, 87.6 g water-soluble carbohydrates kg^{-1} DM, 215 g NDF kg^{-1} DM, and 52.8 g acid hydrolysis ether extract kg^{-1} DM.

Tab. 1: Mean composition of the silage mixtures offered to dairy cows during the experiment. Values in g kg^{-1} DM unless otherwise specified

	Diet			SED	Significance[1]	
	RC10	RC50	RC90		Linear	Quad
Dry matter, g kg^{-1}	333	416	514	8.7	***	n.s.
Organic matter	957	933	916	0.71	***	**
Crude protein	103	148	165	5.9	***	+
Water-soluble carbohydrates	18	53	76	8.1	**	n.s.
pH	3.73	4.14	4.57	0.044	***	n.s.
Acid detergent fibre	228	318	360	21.5	**	n.s.
Neutral detergent fibre	410	454	477	16.3	*	n.s.
Ether extract	32.7	22.8	17.0	1.35	***	n.s.

[1] n.s., not significant; +, P<0.1; *, P<0.05; **, P<0.01; ***, P<0.001

Total DM intake was highest (P<0.01) on the equal mix silage diet (RC50; Tab. 1), which led to a small increase in daily milk yields. Diet digestibility was significantly effected by treatment, with higher digestibilities of DM and OM with greater proportions of maize in the diet, but with higher NDF digestibilities with lower proportions of maize. Milk fat concentrations and yields were unaffected by treatment, while milk protein concentrations decreased (P<0.001) as the proportion of RC in the diet increased. Milk protein yield was highest (P<0.01) on the RC50 diet. Expressed

in terms of kg DM consumed, milk yield was not significantly affected by dietary treatment, with a grand mean of 1.33 kg milk yielded kg^{-1} DM consumed.

Nitrogen intake increased significantly as the proportion of RC in the forage mixture increased (Tab. 3). As N intake increased, the output of N in faeces and urine also increased significantly. However, overall whole-body N balance was not significantly different between treatments. Expressed as a proportion of dietary N intake, faeces N output tended to increase with increased proportion of RC in the silage mixture, and urine N output increased significantly. Milk N output, on the other hand, decreased significantly, so that efficiency of milk protein production was highest on the RC10 diet, which had the lowest CP concentration.

Tab. 2: Effect of altering the diet ratio of maize and red clover silage on feed DM intakes, diet apparent whole-tract digestibilities, and milk yield and composition by dairy cows

	Diet			SED	Significance[1]	
	RC10	RC50	RC90		Linear	Quad
Total DM intake, kg d^{-1}	19.6	20.5	19.5	0.32	n.s.	**
Digestible DM intake, kg d^{-1}	12.1	12.1	11.1	0.19	***	**
Diet digestibility, g g^{-1} intake						
Dry matter	0.62	0.59	0.57	0.008	***	n.s.
Organic matter	0.69	0.67	0.66	0.005	***	n.s.
Nitrogen	0.61	0.60	0.58	0.018	+	n.s.
Neutral detergent fibre	0.47	0.56	0.61	0.015	***	+
Milk yield, kg d^{-1}	26.1	27.3	25.7	0.54	n.s.	**
Fat conc., g kg^{-1}	36.7	37.5	38.9	1.40	n.s.	n.s.
Protein conc., g kg^{-1}	30.9	30.6	29.9	0.24	***	n.s.
Fat yield, g d^{-1}	941	1020	1000	38.4	n.s.	n.s.
Protein yield, g d^{-1}	798	834	775	18.7	n.s.	**

[1] n.s., not significant; +, P<0.1; *, P<0.05; **, P<0.01; ***, P<0.001

Discussion

Red clover silage has been shown to have a high intake potential in dairy cows and to improve milk yields compared to grass silage (Bertilsson and Murphy, 2003; Dewhurst *et al.*, 2003a; 2003b). Compared to lucerne silage, equal yields of milk at reduced levels of intake have been observed (Broderick *et al.*, 2001). The optimum rate of supplementation of RC silage with a high-energy forage such as maize silage is uncertain. In this study, the greatest intakes of DM were observed on the RC50 diet, and despite the fact that digestible DM intakes were not the highest, the yields of milk and milk components were (marginally) highest on this diet. Increasing the proportion of RC silage in the forage mixture led to increased N intakes, but also increased N outputs, so that the most efficient diet in terms of milk N output was the RC10 diet. Increased rates of excretion of N in urine (both in g d^{-1} and expressed relative to N intake) as the RC component of the forage mix increased indicates an increased rate of uptake of ammonia from the rumen as the relative availability of energy-yielding nutrients (i.e. starch from the maize silage) decreased. This agrees with previous reports of mixing white clover silage with maize silage (Auldist *et al.*, 1999).

Tab. 3: Effect of altering the diet ratio of maize and red clover silage on N intakes, N outputs, and apparent partitioning of dietary N in dairy cows

	Diet			SED	Significance[1]	
	RC10	RC50	RC90		Linear	Quad
N intake, g N d^{-1}	366	505	528	16.6	***	**
N output, g N d^{-1}						
Faeces	140	201	223	7.2	***	*
Urine	74	120	173	5.7	***	n.s.
Milk	128	145	137	4.8	n.s.	*
N balance	24	39	-5	18.2	n.s.	n.s.
N partition, g out g^{-1} in						
Faeces	0.38	0.40	0.42	0.018	+	n.s.
Urine	0.20	0.24	0.33	0.014	***	n.s.
Milk	0.35	0.29	0.27	0.012	***	n.s.

[1] n.s., not significant; +, P<0.1; *, P<0.05; **, P<0.01; ***, P<0.001

Conclusions

It is concluded that milk and milk protein yields can be significantly improved by feeding RC silage as 1:1 mix with maize silage, but that the efficiency of utilisation of forage N was reduced when diets contained more that 0.1 RC silage. However, reduced within-animal efficiency at higher rates of RC silage use would be less of a problem at the whole-farm level if manures are used appropriately as fertilisers, distributing legume-fixed N to other crops.

Acknowledgments

This study was funded by EU project QualityLowInputFood (QLIF; FP6-2002-Food-1-506358). Thanks to M. Leyland, M. Scott, J. Tweed and D. Jones for their assistance.

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