Effect of dairy effluent on perennial pasture in late spring and summer

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Abstract

Effluent was applied at six rates (0, 15, 30, 45, 60 and 75 mm) in November following silage harvesting, with pasture being monitored for dry matter (DM) yield and changes in nutritive characteristics and mineral content from November to April. The effluent contained high levels of potassium (K) (445 kg/ML) and sodium (Na) (508 kg/ML) and moderate levels of nitrogen (N) (155 kg/ML) and phosphorus (P) (23 kg/ML). With effluent, irrespective of rate, DM yields at the first grazing (27 November) were higher ($P<0.05$) than the control (0 mm). When effluent was applied at rates of 60 and 75 mm, DM yields were higher ($P<0.05$) than for all other effluent treatments. At the second grazing (17 December), effluent at 30mm and above resulted in higher ($P<0.05$) DM yields than the control. Pasture crude protein (CP) was higher than control ($P<0.05$) at the first grazing where effluent had been applied at 30 mm and higher, whilst by the second grazing this effect was only apparent at rates of 60 and 75 mm. The concentration of K at the first grazing was higher ($P<0.05$) when effluent was applied, whilst both P and Na concentration were higher ($P<0.05$) at rates of 30 mm or higher than control. There was no effect of effluent on either DM yield or nutritive characteristics for the third (27 February) and fourth (11 April) grazings. This study indicates the potential for using dairy effluent to increase pasture DM yield during late spring and summer in dryland areas of southern Victoria. Further research is required to determine the longer impacts of dairy effluent use on pasture composition and environmental factors such as soil health.

Additional key words: Crude protein, potassium, sodium

Introduction

It is estimated that only 50 % of dairy farms in the dryland regions of Victoria have suitable dairy effluent systems and of these only 25 % are managed effectively (IRIS Research 2000). Furthermore, the majority of farmers apply effluent to less than 10 % of their available land, often to the same area each year. Whilst there is considerable information available on dairy effluent collection systems, little data exists on sustainable ways to use dairy effluent on farm for forage production. Studies in New Zealand (Goold 1980, *Roach et al.*, 2000) indicate substantial DM yield increases are possible when effluent is applied to perennial pasture, however, the climatic and soil conditions under which these trials were conducted are different to those in southern Victoria.

This paper reports results from the first six months of a three year study that compares perennial pasture DM responses and changes in nutritive characteristics and mineral content to a range of dairy effluent application rates.

Methods

This study was conducted on a commercial dairy farm near Terang (38 °14'S, 142 °55'E) in western Victoria on a Mottled-Sodic, Eutrophic, Brown Chromosol soil (Isbell 1996). The soil has a plant available water (PAW) (0-50 cm) of 92 mm, a total stored water (0-50 cm) of 189 mm and a saturated hydraulic conductivity for the topsoil (A1 horizon) of 0.8 - 1.1 cm/hr. Long term average rainfall at the site is 769 mm with approximately 30 % occurring between November and March. A paddock was removed from the grazing rotation on 1 September 2002 and N was applied (50 kg N/ha) one week later. The pasture composition was predominantly perennial ryegrass (*Lolium perenne*), white clover (*Trifolium repens*), subterranean clover (*Trifolium subterraneum*) and tall fescue (*Festuca arundinacea*). On 16 October the pasture was harvested for silage with the cut material baled and removed from the paddock within three days of the harvest date. From 1 to 11 November, effluent was applied at up to 15 mm//ha/d providing six final application levels of, 0, 15, 30, 45, 60 and 75 mm over the period. Treatments were randomly allocated to plots (12 m x 12 m) within each block, and replicated six times in a randomised block design. Effluent was applied via a pressurised spray system (Irrifrance, Bosch Engineering) with sprinklers located on a 12 m x 12 m grid system (corner of each plot) with each sprinkler able to deliver within a 90° arc ensuring a uniform distribution. For each 12 m x 12 m plot a buffer zone of 2 m was established to minimise impacts from adjacent plots. Application rates did not exceed 15 mm/ha/d to try and avoid run off, lateral flow or deep percolation of effluent. Irrigation was only undertaken when wind conditions were such that drift did not occur.

All plots were grazed when the most advanced treatments attained a pre-grazing mass of 2200-2800 kg DM/ha, apart from the final summer grazing when plots were grazed to consume accumulated material prior to growth commencing from autumn rainfall. All plots were grazed with a milking herd to a post-grazing pasture residual of 1300–1700 kg DM/ha.

Pasture DM yield (kg DM/ha) at each grazing was estimated by measuring pre- and post-grazing pasture mass with a calibrated rising plate meter (Earle and McGowan 1979). Prior to each grazing, 30 randomly cut pasture samples (5 x 15 cm quadrat cut to ground level) per plot were collected. Samples were thoroughly mixed with a sub sample washed, dried (60 °C for 72 h), ground through a 1 mm screen (Tecator Cyclotec 1093 sample mill) and used to determine nutritive characteristics and mineral content. Analysis of samples for nutritive characteristics was undertaken at FEEDTEST, Agriculture Victoria, Pastoral and Veterinary Institute, Hamilton using near infrared spectroscopy. Metabolisable energy (ME) (MJ/kg DM) values were calculated from predicted DM digestibility values (SCA 1990). Mineral analysis of leaf and root was by a microwave digestion (Lautenenschlaeger, 1989; Nackashima, *et al.*, 1988) followed by Inductively Coupled Plasma - Optical Emission Spectroscopy (SCL 1987). Statistical analysis was undertaken using analysis of variance (ANOVA) (GenStat Committee 2000) with significance declared if $P<0.05$.

Results

Initial soil tests (0-10 cm) prior to effluent application were: pH (H_2O) 5.25, Olsen phosphorus (P) 33.5 mg/kg and Skene potassium (K) 160 mg/kg, organic matter content 5.7 % w/w and Effective Cation Exchange Capacity (ECEC) 18.8 meq/100g. The composition of effluent is presented in Table 1 and indicates that the effluent had a high content of both K and sodium (Na).

Table 1. pH (H_2O), electrical conductivity (EC) (dS/m), sodium adsorption ratio (SAR), phosphorus (P), potassium (K), sulphur (S), nitrogen (N), calcium (Ca), magnesium (Mg), sodium (Na) (kg/L) of effluent

	pH	EC	SAR	P	K	S	N	Ca	Mg	Na
Mean	7.95	4.3	6.1	23.3	445	22	155	170	220	508
s.d	0.058	0.14	0.15	1.50	12.9	4.1	10.0	8.2	11.6	17.1

Dry matter yields at the first grazing (27 November) showed an increase (P<0.05), irrespective of effluent application rate, compared to the dryland control (Table 2). Furthermore, rates above 30 mm also increased (P<0.05) DM yield compared to the 15 mm rate. Where effluent was applied at 60 and 75 mm, DM yields were higher (P<0.05) than for all other treatments. This effect carried through to the next grazing (17 December), where the DM yield from the control was lower (P<0.05) than for treatments receiving 30mm or more effluent. The DM yield of the 15 mm rate was also lower (P<0.05) than the 30, 45 and 60 mm rates, whilst the 75 mm rate gave rise to a higher (P<0.05) DM yield than the 30 mm rate. There were no differences in DM yield at the two subsequent grazings (27 February and 11 April). Between the third and fourth grazings, the prevailing climatic dry conditions were such that there was cessation of pasture growth in most treatments with considerable leaf decay and loss, thus measured DM yield appeared to be negative despite harvesting to ground level.

Total DM yield over the late spring and summer period for all effluent applications rates were higher (P<0.05) than the dryland control. Applications of 30 mm and above also led to higher (P<0.05) DM yields than the 15 mm rate.

Effluent at 60 and 75 mm led to an increase (P<0.05) in herbage crude protein (CP) compared to all other treatments at grazing 1 (Table 3). In addition, effluent at 30 and 45 mm led to an increase (P<0.05) compared with the control. At the first grazing, there was an increase (P<0.05) in neutral detergent fibre (NDF) with applications of 45 and 75 mm compared with the control. At the second grazing, the CP content of the control was lower (P<0.05) than where effluent was applied at 60 mm and higher (Table 3). The ME of pasture was higher (P<0.05) than the control at the second grazing when effluent was applied at rates of 30 mm or higher. At the third and fourth grazings there were no differences in the nutritive characteristics of the pasture (data not presented).

Table 2. The effect of different effluent application rates (mm) on pasture dry matter yield (t DM/ha) over subsequent grazing periods in late spring and summer

Effluent rate	Grazing 1	Grazing 2	Grazing 3	Grazing 4	Total yield
0	1.08	0.41	0.93	-0.16	2.26
15	1.57	0.45	0.80	-0.03	2.79
30	2.06	0.59	0.90	-0.02	3.53
45	2.10	0.64	0.94	-0.09	3.59
60	2.41	0.67	0.80	-0.06	3.83
75	2.32	0.75	0.90	0.07	4.03
l.s.d (P=0.05)	0.244	0.153	0.21	0.224	0.335

Table 3. **The effect of different effluent application rates (mm) on pasture metabolisable energy (ME) (MJ/kg DM), crude protein (CP), neutral detergent fibre (NDF) and water soluble carbohydrate (WSC) (%DM) contents**

	0	15	30	45	60	75	l.s.d (P=0.05)
Grazing 1							
ME	10.5	10.7	10.7	10.9	10.7	10.7	0.33
CP	13.3	14.8	16.1	17.1	19.5	19.0	1.83
NDF	60.4	61.0	62.3	64.5	62.5	63.3	2.49
WSC	14.0	12.2	9.7	7.4	4.7	4.5	2.35
Grazing 2							
ME	10.0	10.1	10.4	10.3	10.7	10.4	0.22
CP	12.9	13.7	14.7	14.0	17.0	15.0	1.71
NDF	63.3	63.0	61.7	63.6	61.1	64.4	2.01
WSC	11.1	10.1	10.4	10.0	8.7	8.1	2.10

Effluent at rates of 30 mm or higher led to an increase (P<0.05) in P and Na content of the pasture compared with the control and lowest application rate of effluent at the first grazing (Table 4). Where effluent was applied the K content of pasture was higher than the control, whilst applications of 45 mm and higher resulted in an increase (P<0.05) in sulphur (S) and magnesium (Mg) content compared to the control.

By the second grazing only effluent at the highest rate had a higher (P<0.05) P content than the control. Potassium content was lower (P<0.05) in the control and 15 mm rate compared to all other treatments, and Na content was higher (P<0.05) for the 60 and 75 mm rates compared to the control treatment. There were no differences in mineral content of pasture at the third or fourth grazing (data not presented).

Table 4. **The effect of different effluent application rates (mm) on pasture phosphorus (P), potassium (K), sulphur (S), calcium (Ca), magnesium (Mg) and sodium (Na) (%DM) contents**

	0	15	30	45	60	75	l.s.d. (P=0.05)
Grazing 1							
P	0.28	0.30	0.33	0.38	0.38	0.38	0.030
K	2.17	2.57	2.92	3.47	3.55	3.52	0.279
S	0.25	0.25	0.27	0.31	0.31	0.31	0.025
Ca	0.48	0.50	0.51	0.45	0.55	0.51	0.091
Mg	0.24	0.25	0.27	0.29	0.32	0.29	0.027
Na	0.39	0.45	0.49	0.56	0.64	0.64	0.099
Grazing 2							
P	0.29	0.31	0.31	0.31	0.32	0.33	0.020
K	1.92	2.22	2.57	2.52	2.88	2.85	0.214
S	0.27	0.27	0.26	0.26	0.28	0.27	0.021
Ca	0.52	0.51	0.51	0.46	0.53	0.49	0.088
Mg	0.29	0.28	0.29	0.28	0.30	0.30	0.023
Na	0.41	0.42	0.48	0.48	0.53	0.53	0.078

Discussion and Conclusions

The concentration of nutrients within the effluent used for this study fell within the ranges quoted by Kane (*pers comm.*) from a study of farms in south west Victoria. Furthermore, effluent composition was similar to that of Jacobs and Ward (2003) who found P, K and N levels of 35, 427 and 122 kg/ML respectively.

The DM yield responses of perennial pasture to applied effluent for the total measurement period ranged from 24 to 79 % increase compared to the control treatment. Goold (1980) comments that application rates equivalent to 24 and 48 mm/ha applied in four applications over a three month period increased annual pasture production by 27 and 43 % respectively. Whilst it is difficult to compare the two studies directly as the periods of measurement and the concentration of nutrients in the effluent differ, some comparisons can be drawn. Typically, the annual DM yields for perennial pastures at the study site are approximately 10 t DM/ha (McKenzie, *et al.,* 2003). Therefore if there were no further increase in DM yield from effluent after this measurement period, the range in response across the whole year would be 5-18 %, values lower than those of Goold (1980).

The primary change in nutritive characteristics was an increase in pasture CP at the higher effluent application rates over the first two grazings. These two grazings were within six weeks of effluent application and given that pastures were still growing (ie. moisture was not limiting) such a response would be expected (McKenzie *et al.,* 2003). The amount of N applied was 23, 47, 70, 93, 116 kg N/ha, and whilst N responses would be expected even at the lower rate, a proportion of this N is likely to be unavailable for immediate utilisation by the pasture. Crocos and Wrigley (1993) comment that only 50 % of the N within effluent is readily available for plant uptake, however it is unclear if this figure refers to effluent from 1st or 2nd ponds. The effluent used in this trail came from a 2nd pond and is likely to have gone through considerable breakdown during the storage period. Given that some of the N may be in an organic form, measurements of CP in pasture following the autumn break will provide valuable information on potential mineralisation of this N when moisture becomes available (Frame and Newbould, 1986).

In conclusion, dairy effluent has the potential to increase DM yields of perennial pasture during late spring and summer, a period when feed is often limiting on dryland farms in southern Victoria. This study will continue for a further two years and assist in determining long term sustainable practices for the use of effluent in terms of achieving a balance between production and environmental implications.

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