Effect of dairy effluent on millet yields and quality

Joe Jacobs and Graeme Ward
Department of Primary Industries, 78 Henna Street, Warrnambool, Vic 3280, Australia
joe.jacobs@dpi.vic.gov.au

Abstract

The effect of dairy effluent rates on dry matter (DM) yield, nutritive characteristics and mineral content of millet was determined. Effluent rates were 0, 15, 30, 45, 60 and 75 mm. 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). Rates of 30 mm and higher increased ($P<0.05$) DM yield at the first grazing compared with the control. By the second grazing, DM yield of the control was lower ($P<0.05$) than rates of 45 mm and higher. Apart from the lowest rate of effluent (15 mm), all other levels led to an increase ($P<0.05$) in total DM yield compared to the control. At the first grazing (29 January), rates of 60 and 75 mm resulted in higher ($P<0.05$) crude protein (CP) content compared with the control and the 15 mm rate. The metabolisable energy (ME) content of the control was higher ($P<0.05$) than for rates of 45 mm and higher. By the second grazing (20 March), the ME content of the 0, 15 and 30 mm was higher ($P<0.05$) than the 60 and 75 mm rates. The concentration of P, sulphur (S) and magnesium (Mg) at the first grazing was higher ($P<0.05$) with rates of 45 mm and higher compared to the control. This study indicates the potential for using dairy effluent to increase millet DM yield and improve its nutritive value in dryland areas of southern Victoria.

Additional Key Words: Crude protein, metabolisable energy, nitrogen, potassium, sodium

Introduction

Dairy effluent is recognised as a significant point source in the pollution of waterways. It contains organic matter, microbial contaminants, nutrients and suspended solids that can all impinge upon water health. In Victoria, the State Environment Protection Policy (SEPP) states that within 5 years (by 2005) all dairy waste will be retained within the boundary of the property. To achieve this, dairy farmers will require clear guidelines on appropriate and sustainable systems to effectively use dairy effluent.

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, most farmers apply effluent to less than 10 % of their available land, often to the same area each year. Despite being seen by many farmers as a undesirable waste, dairy effluent contains relatively large amounts of agronomically useful nutrients especially nitrogen (N) and potassium (K). Studies in New Zealand (Goold 1980, Roach *et al.,* 2000) indicate substantial dry matter (DM) yield increases are possible when effluent is applied to perennial pasture throughout the year. It should however be noted that the climatic conditions under which these trials were conducted are different to those in southern Victoria where effluent application in winter is likely to lead to nutrient run off or leaching. Given this limitation, there is potential to investigate the use of effluent on summer active forages. Previous work (Jacobs and Ward 2003) highlighted DM yield increase and improvements in crude protein (CP) content when effluent was applied to turnips.

This paper reports results from the first summer of a three year study that compares millet 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 (0-50cm) 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. On 16 October, pasture was cut for silage and bales removed from the paddock within three days. The area was then grazed to remove remaining residual pasture and mouldboard ploughed. Eight days later the area was power harrowed and on 11 November sown with millet (*Echinochloa utilis cv.* Shirohie) at a rate of 20 kg/ha with 200 kg/ha single superphosphate (17.6 kg phosphorus (P), 22 kg sulphur (S)).

From 27 December to 4 January, effluent was applied at up to 15 mm/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 covering 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 15mm/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.

Dry matter yield measurements were taken 11 weeks after sowing (29 January) and again on regrowth seven weeks later (20 March). At each harvest, 6 quadrats (1.0 m^2) were collected per plot, weighed individually and subsampled on a plot basis. Samples were collected approximately three hours after sunrise, stored in airtight bags and packed with ice in insulated containers. The samples were further divided with one portion being used to determine DM yield by drying at 100 °C for 24 h. The remaining sample was dried at 60 °C for 72 h, ground through a 1mm 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, 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

Prior to effluent application soil tests (0-10 cm) were: pH $_{(H2O)}$ 5.3, Olsen P 41.5 mg/kg, Skene K 230 mg/kg, organic matter content 5.7 % w/w and Effective Cation Exchange Capacity (ECEC) 18.8 meq/100g.

Effluent composition (Table 1) indicates a high K and sodium (Na) content.

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

Application rates of 30 mm and higher resulted in an increase (P<0.05) in DM yield at the first grazing compared with the control (Table 2). Rates of 45 mm and higher also increased (P<0.05) DM yield compared to the 15 mm rate. This trend continued through to the second grazing where the DM yield of the control was lower (P<0.05) than for rates of 45 mm and higher. Total DM yields over the two grazings showed that, apart from the 15 mm rate, all other levels led to an increase (P<0.05) in DM yield compared to the control. Furthermore, rates of 45 mm and higher resulted in higher (P<0.05) total DM yields than for the 15 and 30 mm rates.

Where effluent was applied at 60 and 75 mm there was a higher (P<0.05) crude protein (CP) content compared to both the control and the lowest rate of effluent application (15 mm) (Table 3). A rate of 75 mm also gave rise to a higher (P<0.05) CP content than either the 30 or 45 mm rates. The ME content of the control was higher (P<0.05) than for rates of 45 mm and higher. By the second grazing, there was no difference in CP content, whilst the neutral detergent fibre (NDF) content of the control was lower than for 45 mm and higher. The ME content of the 0, 15 and 30 mm rates was higher (P<0.05) than for the 60 and 75 mm rates at the second grazing.

Table 2. The effect of different effluent application rates (mm) on millet dry matter yield (t DM/ha) over subsequent grazing periods and growth rates from sowing to Grazing 1 (S-G1) and grazing 1 to Grazing 2 (G1-G2) (kg DM/ha/d)

	Grazing 1	Growth rate (S-G1)	Grazing 2	Growth rate (G1-G2)	Total yield
A - 0	4.54	57.5	1.48	29.5	6.02
B - 15	4.95	62.6	1.88	37.7	6.83
C - 30	5.75	72.7	1.84	36.8	7.59
D - 45	7.05	89.2	2.29	45.8	9.34
E - 60	6.26	79.2	3.01	60.2	9.27
F - 75	7.02	88.9	2.60	52.0	9.62
l.s.d (P=0.05)	0.874	11.06	0.711	14.22	1.358

At the first grazing, rates of 45, 60 and 75 mm had higher (P<0.05) P, S and Mg content than the control (Table 4). Potassium content of the control was lower (P<0.05) than rates 30, 45 and 60 mm, whilst the control also had a lower (P<0.05) Na content than all other treatments. By the second grazing there was no effect of effluent application on mineral content apart from the S content of the control being (P<0.05) greater than rates of 30 mm and higher.

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

	0	15	30	45	60	75	l.s.d (P=0.05)
Grazing 1							
ME	11.1	10.8	10.8	10.3	10.3	10.5	0.37
CP	12.9	13.1	14.1	14.0	15.2	16.1	1.56
NDF	53.6	56.2	55.8	58.4	56.5	55.5	2.38
WSC	13.8	11.6	9.9	7.4	7.0	7.1	2.30
Grazing 2							
ME	10.8	10.5	10.4	10.1	9.8	9.9	0.40
CP	15.1	14.7	15.9	14.7	14.9	16.5	2.05
NDF	53.9	54.9	54.9	56.2	58.2	57.4	2.06
WSC	13.1	12.8	11.5	10.8	9.4	8.2	2.17

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

	0	15	30	45	60	75	l.s.d. (P=0.05)
Grazing 1							
P	0.19	0.22	0.23	0.25	0.25	0.25	0.033
K	3.45	3.68	4.25	4.17	4.08	3.82	0.409
S	0.41	0.45	0.44	0.61	0.61	0.58	0.113
Ca	0.42	0.45	0.40	0.44	0.44	0.46	0.059
Mg	0.50	0.60	0.62	0.78	0.82	0.82	0.104
Na	0.45	0.62	0.67	0.82	0.88	0.95	0.156
Grazing 2							
P	0.20	0.20	0.21	0.21	0.19	0.21	0.022
K	2.35	2.32	2.3	2.25	2.32	2.48	0.395
S	0.45	0.43	0.40	0.39	0.37	0.37	0.039
Ca	0.50	0.50	0.49	0.47	0.47	0.48	0.050
Mg	0.67	0.68	0.69	0.68	0.72	0.68	0.100
Na	0.41	0.37	0.40	0.34	0.37	0.37	0.081

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 158 effluent ponds 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 millet to applied effluent ranged from a 13 to 38 % compared to the control. The responses at the lower rates (15-30 mm) were similar to those observed for turnips (Jacobs and Ward 2003) in an earlier study. Comparative studies with this work (Jacobs *et al.,* 2004) where effluent was applied to perennial pasture showed responses ranging from 19 to 44 % over a similar timeframe. Whilst there are no comparative data for millet or other C4 species, these results would indicate that similar responses are likely irrespective of species under comparative conditions. Initial data from year 2 of this study (unpublished) indicates similar millet DM yield responses to effluent. One of the challenges with multi-nutrient solutions such as dairy effluent is determining the key factors responsible for such DM responses. Given the adequate soil levels of P, in plant material by inductively coupled plasma-Optical emission spectroscopy'. Department of Natural resources and Environment, Werribee, K and S at the site, it is postulated that the DM responses were largely a result of N and water.

To the authors knowledge there are no other studies that have been conducted to measure the effect of effluent application on the nutritive characteristics of millet. The data collected in this study show a positive CP response to applied effluent, however there was also a negative effect on the ME content. This drop in ME is likely to be a reflection of increased DM yield and an additional rise in the NDF content.

In conclusion, dairy effluent has the potential for increasing DM yields of millet during summer, a period when feed is often limited 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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