Use of non fertiliser "growth promotants" as alternatives to urea on high production pastures

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Abstract

The effect of a range of fertiliser amendments and alternative products on pasture growth, feed quality and the cost of additional pasture production were compared at three sites in coastal NSW. Treatments included a range of alternative products, either alone, or in conjunction with urea, compared to urea alone and urea coated with several amendments. Alternatives included examples of organic liquids, gibberellic acid and free living nitrogen fixing bacteria.

Dry matter yields from pasture treated with alternative products alone were not significantly different to the nil fertiliser control. Yields from urea treatments were always significantly greater than the nil fertiliser control but were not improved by alternatives or amendments. Response to gibberellic acid was not significant (<250 kg DM/ha) and variable across sites. There were differences in feed quality due to treatment, however they were of no value commercially. Urea alone was the most cost effective treatment, producing additional pasture at costs in the range $80-150/t DM. The non-urea treatments produced no additional dry matter yet cost as high as $200/ha/yr. This series of experiments were unable to measure an advantage from using these non-fertiliser products as 'growth promotants' compared to nil fertiliser.

Key Words

Alternative fertiliser, pasture growth, pasture quality, biological stimulants

Introduction

Concern over cost and the environmental impact of fertilisers such as urea, have created an exponential increase in 'alternative' products and fertilisers that are promoted as being more friendly to soil biology and the environment in general. Equally, pressure to minimise greenhouse gas emissions has brought renewed interest in the profitability of urease and nitrification inhibitors in high input dairy pastures.

Pastures consisting of Italian ryegrass (*Lolium multiflorum)* over-sown into kikuyu *(Pennisetum clandestinum*) form the basis for most dairy farming systems on the NSW coast. With an annual rainfall of 900-1400 mm and the use of supplementary irrigation, 15-18 t DM/ha pasture consumed is feasible. Being grass dominant, these pastures can require 350-500 kg nitrogen (N)/ha/yr to replace nutrients removed in milk and losses (Staines et al. 2011).

Many alternative products are marketed as 'growth promotants' or 'biological stimulants' rather than fertilisers. When applied at recommended rates (5-20 L/ha) they do not supply enough N to replace that removed in product and measured losses. Organic liquids, characterised as water based solutions derived from organic materials such as kelp, animal waste and vermiculture liquid, are typical of this scenario containing (1-15% N w/v) and supply 1-3 kg N/ha/grazing when applied at recommended rates. Many products of this nature are marketed actively in the region despite a body of evidence that refutes claims increased plant growth due to either added nutrients or plant growth substances (Edmeades 2002).

Gibberellic acid has a well established mode of action for growth promotion and application technology supported by relevant research in other colder environments (Mathew et al. 2009). It requires validation in untested environments such as the subtropical NSW coast. Others such as Twin N™, a diazotrophic microbe, are in a development phase and so have little comparable research in pastures.

Amendments *via* fertiliser coating used to reduce N losses include the urease inhibitor, N-(n-butyl) thiophosphoric triamide (nBTPT) marketed as Green Urea™, a nitrification inhibitor, 3,4-dimethylpyrazole phosphate (DMPP), marketed as Entec Urea™, and a slow release polymer coating marketed as TNN Urea Supreme™. Although the efficacy of these products is well established in the literature for crops where a single large application is made, authors differ in their assessment of their profitability in pastures where low rates (30-50 kg N/ha/grazing) are applied each grazing so that N supply closely approximates plant demand (e.g. Watson et al. 2009; Stafford et al. 2008).

This paper provides an objective assessment of the effect on dry matter yield, feed quality and profitability for milk production when these products are applied in winter and spring, to highly fertile ryegrass *(Lolium* spp.) pastures in the NSW coastal environment.

Methods

A series of field experiments were established at Paterson, Taree and Nowra in 2009 and continued in 2010. Each was a randomised block design with four replications. The sites were in fertile, commercial pastures dominated by kikuyu in warmer months and ryegrass in cooler months. Sites were known to have adequate phosphorus, potassium and sulphur, and N was expected to be the nutrient limiting plant growth. Each experiment had between 12 and 23 fertiliser treatments including untreated controls. Treatments common across all experiments were urea, Green Urea™, Entec Urea™, Twin N ™ and ProGibb™ (gibberelic acid) and poultry litter. The organic liquids TNN Organic NK™, TNN 15:5:5™, and liquid Blood and Bone™ were applied at Paterson. Liquid Blood and Bone™ and Nutrisoil™ (vermiculture liquid) were applied at Nowra. In addition, TNN Urea Supreme was applied at Patterson and Taree. The treatments were applied after each harvest and rates are shown in Table 1 and Figure 1.

Experiments were harvested using quadrat cuts or a lawn mower every 3-8 weeks depending on species, season, and grazing rotation on the farm. The fertiliser treatments were reapplied 24-96 h after each harvest. Gibberellic acid was only applied to ryegrass in cooler months. Urea based treatments were applied at 2-3 rates and alternative products were applied at the timing and rate recommended on product labels.

The first and third harvests (August and October 2009) at Paterson and Berry were analysed for feed quality using a commercial NATA accredited laboratory. Selected treatments from the Paterson site were tested at end of experiment after 2 years of treatment application for soil biological activity using fluorescein diacetate (FDA) and microbial biomass carbon tests. Analysis of variance was conducted for dry matter yield at each harvest and total annual yield, and for feed quality.

Results and discussion

Forage dry matter yield

There was a significant ryegrass yield response of 6-30 kg DM/kg N for the Urea 50 kg/ha/grazing treatment (i.e. 23 kg N/ha/grazing) in all harvests and across the three locations ($P<0.05$). There were no significant yield responses to the urea amendments (Green Urea, Entec Urea and Urea Supreme) at any site or rate. Yields from liquid fertiliser or Twin N applied alone were not significantly different to the nil fertiliser control at any harvest or location. Twin N provided no additional yield when combined with Urea. Kikuyu yield responses mirrored the ryegrass results. Gibberellic acid applied to ryegrass in winter and spring provided variable responses (3-38 kg DM/g a.i. gibberellic acid resulting in <250 kg DM/ha/cut) which were not significant when applied alone and with urea ($P>0.05$) (data not shown).

Forage quality

There were differences in forage quality of the ryegrass pasture topdressed with the different products ($P<0.05$), however they showed no commercial benefits. For example, at Patterson, metabolisable energy of ryegrass sampled in August, 2009 ranged from 11.5 MJ/kg DM (TNN Organic NK (30 L/ha) and Progibb [20 g/ha]) to 12.1 MJ/kg DM (Green and Entec Urea at 100 kg/ha) (Figure 1). Crude protein ranged from 25.1% (TNN Organic NK at 30 L/ha) to 29.9% (Poultry litter applied at 15m^3 and Green Urea at 200 kg/ha) and increased with N rates$\geq$23 kg/ha/application. Water soluble carbohydrate ranged from 3.8% (Poultry litter (15m^3) and Green Urea [200 kg/ha]) to 5.5% (liquid Blood and Bone applied at 20 L/ha) and declined when N rate exceeded 92 kg N/ha. Nitrate levels ranged 15.1 (Nil fertiliser control) to 373.8 mg NO_3^-/kg (Green Urea applied at 200 kg/ha). Levels were below the threshold for nitrate poisoning and were not significantly different between treatments at recommended nitrogen rates of 25-50 kg N/ha/grazing. However, nitrate was significantly higher when >75 kg N/ha was applied either as Urea, Green Urea, Entec Urea, TNN Urea Supreme or poultry litter at Paterson (Figure 1). At these rates Green Urea had significantly higher nitrate than urea alone or Entec Urea indicating greater N retention; however this effect was not translated into an increased yield (Figure 1).

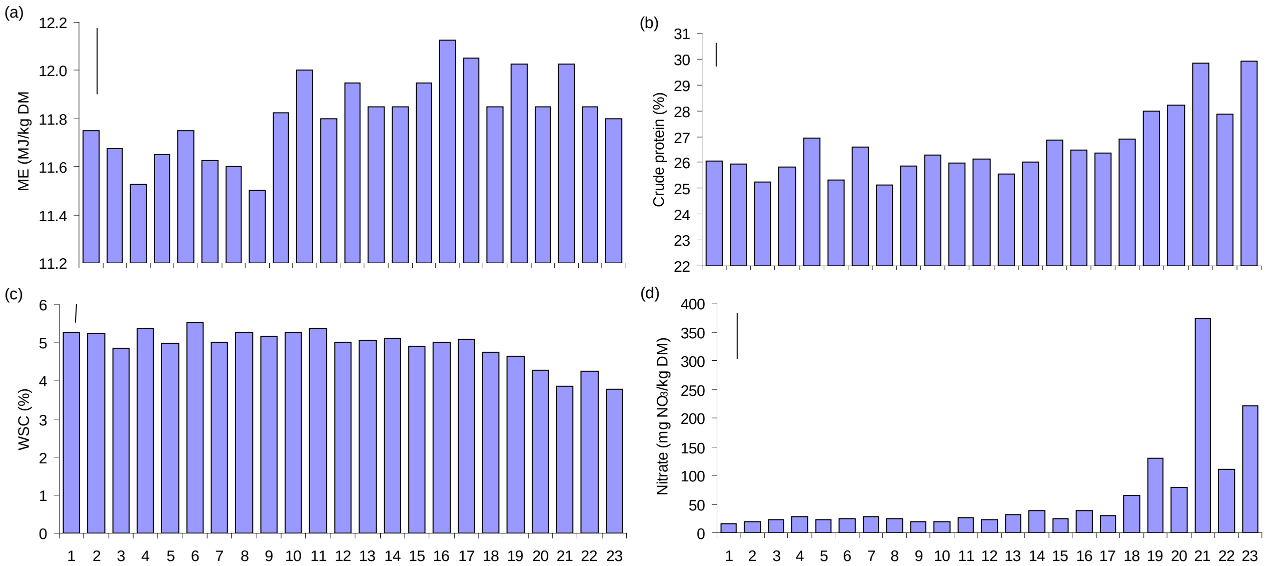

Figure 1. (a) Metabolisable energy (ME, MJ/kg DM), (b) crude protein (%), (c) water soluble carbohydrate (WSC, %), and (d) nitrate (mg NO_3/kg DM) of ryegrass pasture topdressed with a range of products at Paterson in the first harvest 2009. LSDs (P=0.01) are shown on each figure. Product and rate treatments were 1, Nil ; 2, Twin N; 3, Progibb 20 g/ha; 4, Liquid Blood and Bone 10 L/ha; 5, TNN 15:5:5 10 L/ha; 6, Liquid Blood and Bone 20 L/ha; 7, TNN Organic NK 20 L/ha; 8, TNN Organic NK 30 L/ha; 9, Urea 50 kg/ha; 10, Green Urea 50 kg/ha; 11, Entec Urea 50 kg/ha; 12, Twin N + Urea 50 kg/ha; 13, Progibb 20 g/ha + Urea 50 kg/ha; 14, TNN Urea Supreme 75 kg/ha; 15, Urea 100 kg/ha; 16, Green Urea 100 kg/ha; 17, Entec Urea 100 kg/ha; 18, TNN Urea Supreme 150 kg/ha; 19, Poultry litter 7.5 m^3/ha; 20, Urea 200 kg/ha; 21, Green Urea 200 kg/ha; 22, Entec Urea 200 kg/ha; 23, Poultry litter 15 m^3/ha.

Table 1. Total dry matter (DM) yield of ryegrass in 2009 (3 winter harvests) and 2010 (3 winter harvests), the additional DM yield (kg DM/ha, difference between the average of 2009 and 2010 yields for each product and the nil treatment), and the calculated cost of additional yield, potential milk return, and the cost of extra DM produced ($/tonne) of a range of products

Product name and application rate (/ha/harvest)	N applied (kg N/ha/ harvest)	Yield (kg DM/ha)		Extra yield (kg DM/ha)	Total cost ($/ha)	Milk return ($/ha)*	Cost of extra DM ($/t)
		2009	2010				
Twin N (10 g)	0	3120	4720	-420	180	-370	
Nil	0	3013	5247	0	0	0	
TNN 15:5:5 (10 L)	1.5	3407	4893	40	420	-400	10500
TNN Organic NK (20 L)	3.5	3233	5173	146	440	-370	3000
Liquid B&B (10 L)	1	2887	5647	274	330	-210	1220
Progibb (20 g)	0	3147	5840	727	80	250	110
Progibb + Urea (20 g+50 kg)	23	5233	6310	3283	300	1180	90
Urea (50 kg)	23	4587	5420	1747	220	560	130
Urea (100 kg)	46	5587	7120	4447	440	1560	100
Twin N + Urea (10 g+50 kg)	23	4707	5987	2434	400	690	170
Entec Urea (50 kg)	23	4587	6227	2554	290	870	110
Entec Urea (100 kg)	46	5493	6793	4026	570	1240	140
Green Urea (50 kg)	23	4720	6727	3187	260	1180	80
Green Urea (100 kg)	46	5540	6120	3400	510	1020	150
LSD (P=0.05)		620.0	698.0				

* Assumes each extra kilogram of dry matter produces one litre of milk (45c/L), less the cost of product and urea at $750/tonne.

Cost of extra forage produced from topdressing treatments

At all sites the urea based treatments were the only competitive source of energy, being cheaper than grain at $250/tonne (Table 1). Milk return per hectare was ~$1600-1900/ha higher when treatments using 50-100 kg urea/ha/grazing were compared to the organic liquid products and Twin N over two winters (Table 1). At Taree in 2010, milk return per hectare was ~$1700/ha higher when 150 kg Urea/ha/grazing was compared to Twin N and gibberellic acid without N over 6 harvests (data not shown). In the same year at Berry, the milk return per hectare (from 3 harvests of ryegrass) was ~$1600/ha higher when Urea applied at 100 kg urea/ha/grazing was compared to organic liquids, Nutrisoil and Liquid Blood and Bone and to Twin N and gibberellic acid applied without N (data not shown). This represents an opportunity cost that far outweighs the perceived benefit of lower cost alternative products.

Soil biological activity
Results did not support claims that ‘alternative’ products improved soil biological activity compared to the nil control or urea treatments (data not shown).

Conclusions
Results from these experiments support current recommendations for application of nitrogen as 50-100 kg Urea/ha/grazing or 1-1.5 kg N/day when topdressing productive ryegrass and kikuyu pastures (Staines et al. 2011). These experiments were unable to confirm claims of improved production, feed quality or soil health from the liquid organic products. This adds to the evidence presented by Emeades (2002) indicating that a similar range of ‘organic liquids’ did not increase pasture dry matter yields at suggested rates. The diazotrophic microbes provided no advantage with or without urea.

The absence of a significant dry matter yield response to any of the urea amendments does not support the repeated use of urease or nitrification inhibitors for increased milk production on the NSW coast. However the inherent difficulty in predicting optimum N rate for ryegrass frequently leads to over fertilisation and can mask any potential savings these products may offer. Furthermore the incidence of N loss is episodic and short term experiments such as these can not assess probability of benefit in the longer term. Profitability may change if the return from reduced nitrous oxide emission were considered.

Although the responses to gibberellic acid were of a similar magnitude to other studies (Mathews 2009), they were highly variable and could be matched by using higher N rates. Further work would be required before these products could be recommended on the NSW coast.

Dairy farmers can pay a substantial penalty when they substitute untested products for proven fertiliser products such as urea. These experiments show the value of adhering to sound agronomic principles such as replacing nutrients removed in product and losses and addressing the most limiting nutrient. They confirm the need for independent, replicated experiments conducted in the local environment and context before adopting new products.

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