DAIRY PASTURE YIELD AND QUALITY RESPONSES TO NITROGEN, PHOSPHORUS, POTASSIUM AND SULPHUR

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Abstract

Nitrogen (N) fertilisers were applied at 45 kg N/ha, with and without phosphorus (P), potassium (K) and sulphur (S) to autumn dairy pastures at two sites in western Victoria. N increased dry matter (DM) yield. Different N fertilisers (*eg*. urea versus ammonium nitrate) produced similar DM yield responses. Additions of P, K and S improved DM yield at Site 1 (lower soil fertility than Site 2), but had no effect on DM yield at Site 2. Primary yield N responses (without P, K and S) at Sites 1 and 2 were 10:1 (10 kg DM/kg N) and 13:1, respectively. With P, K and S, N responses were 12:1 and 15:1, respectively. Residual (second harvest) N responses were 5:1 and 3:1 (without P, K and S) and 6:1 and 4:1 (with P, K and S) at Sites 1 and 2, respectively. N with and without P, K and S increased crude protein and metabolisable energy at both sites. Neutral detergent fibre was decreased by all fertiliser treatments at Site 1, but was unaffected at Site 2. Water soluble carbohydrates were unaffected by treatment at either site. Different N fertilisers with and without P, K and S generally produced similar quality responses.

Key words: Crude protein, dry matter, metabolisable energy, neutral detergent fibre, water soluble carbohydrates.

Pasture dry matter (DM) yield responses to fertiliser nitrogen (N) may be limited by phosphorus (P), potassium (K) and sulphur (S) (6). Many dairy farmers in western Victoria, therefore, apply N with P, K and S.? Different N fertilisers (*eg*. urea and ammonium nitrate) applied with or without P, K and S may illicit differential DM yield responses.

N fertiliser is one of many factors influencing pasture quality. Pasture quality influences palatability which in turn affects animal intake (6). While the effect of applied N on pasture growth is fairly well known, the associated effects of N on pasture quality are not clearly defined.

This study determined the effect of different N fertilisers at the same N application rate, with and without P, K and S on autumn pasture DM yield and quality.

Materials and methods

Experiments were conducted at two sites in western Victoria from April to June 1996. Soil analyses and botanical composition for both sites are given (Table 1).? Site 1 (142°55'E, 38°14'S), near Terang, has a mean annual precipitation of 789 mm. The soil was a fine sandy clay loam derived from quaternary basalt. Site 2 (143°6'E, 38°30'S), near Simpson, has a mean annual precipitation of 994 mm. The soil was a Cooriemungle clay derived from Gellibrand Marl.

A randomised blocks design was used with four replicates. Plot areas of 2 m by 8 m were pre-grazed two days before fertiliser application and then 'topped' to 5 cm with a mower. Treatments comprised: no fertiliser, no N plus PKS, urea (U), U plus PKS (U1), Pasture-boosta (a fertiliser 'blend') (PB), PB plus PKS (PB1), ammonium nitrate (AN), AN plus PKS (AN1), di-ammonium phosphate (DAP), DAP plus PKS (DAP1), ammonium sulphate (AS), AS plus PKS (AS1), ammonium nitrate and sulphur (ASN) and ASN plus PKS (ASN1).

Fertilisers were applied on 19 April (Site 1) and 22 April (Site 2). Each N fertiliser was applied at 45 kg N/ha. P, K and S were applied at rates which balanced quantities of these elements within N fertilisers. For example, P was applied to a maximum of 50 kg/ha (DAP applied at 45 kg N/ha supplies 50 kg P/ha), K to a max- imum of 24 kg/ha (PB applied at 45 kg N/ha supplies 24 kg K/ha), and S to a maximum of 52 kg/ha (AS applied at 45 kg N/ha supplies 52 kg S/ha). Triple super phos-phate, potassium chloride and gypsum were used as sources for P, K and S.

Table 1. Experimental sites with soil analysis and botanical composition (assessed April 1996).

	Soil analysis				
Site	P (Olsen)	K (Skene)	S (CPC)	pH (water)	pH ($CaCl_2$)
	(mg/kg)	(mg/kg)	(mg/kg)		
1	16.9	215	11	5.4	4.8
2	39	313	100	5.2	4.9

	Botanical composition			
	Lolium perenne	*Trifolium repens* and *T. subterraneum*	Other grasses^A^	Broad leaved weeds^B^
	(%)	(%)	(%)	(%)
1	25	12	60	3
2	53	9	35	1

^A^ eg. *Agrostis capillaris, Anthoxanthum odoratum, Dactylis glomerata, Festuca arundinacea, Holcus lanatus* and *Poa annua*

^B^ eg. *Arctotheca calendula, Rumex dumosus* and *Taraxacum officinale*

Pasture DM yield was estimated using a sickle-bar mower by cutting a 1.1 m by 6 m strip to a height of 5 cm from within each plot. Treatments were harvested when ryegrass in the most advanced treatment reached the 3-leaf stage of development (60% tillers with 3 leaves). Herbage sub-samples were collected and oven dried (at 100^0C for 24 hours) for DM determination.? The residual effect of applied N was estimated by taking a second measure of DM yield using the same criteria as above. Sub-samples (dried at 60 ^{o}C for 48 hours) were analysed for crude protein (CP) (N x 6.25), neutral detergent fibre (NDF), metabolisable energy (ME) and water soluble carbohydrates (WSC).

Data were subjected to ANOVA and l.s.d's (P=0.05) applied to treatment means.

Results

Nitrogen increased (P<0.05) pasture DM yield at both sites for both harvests (Table 2). Pasture growth, how-ever, was delayed by a dry autumn resulting in first harvests after 37 to 47 days. DM yields ranged from 495 (no fertiliser) to 1167 kg DM/ha (ASN1) at Site 1, and from 573 (no fertiliser) to 1272 kg DM/ha (AN1) at Site 2. Residual N resulted in regrowth DM yields ranging from 205 (no fertiliser) to 520 kg DM/ha (AS1) at Site 1, and 305 (no fertiliser) to 517 kg DM/ha (DAP1) at Site 2.

Average N responses (excluding P, K and S) were 9.7:1 (9.7 kg DM/kg N) and 13.0:1 for Sites 1 and 2 (Table 2). With P, K and S, average N responses were 12.2:1 (26% increase) and 14.5:1 (11% increase), respectively. The residual average N responses for regrowth (excluding P, K and S) were 4.5:1 and 3.4:1 for Sites 1 and 2, respectively. With P, K and S, residual average N responses for regrowth increased by 33 and 23%, respectively.

Generally, N fertiliser type produced similar DM yields.? The exception was at Site 1 where DAP resulted in a higher (P.05) DM yield than urea (Table 2).? The effect of P, K and S generally had no effect on DM yield.? An exception was again found at Site 1 were additional P, K and S improved (P<0.05) DM yield (Table 2).

The application of N, with and without P, K and S increased (P<0.05) CP from 13.5 (no fertiliser) to 19.7% (AN) at Site 1 (Table 3). At Site 2, DAP, AS, U1, AN1, AS1 and ASN1 increased (P<0.05) CP over a range of 22.6 (no fertiliser) to 24.9% (AS).

N with and without P, K and S increased (P<0.05) ME from 9.5 (no fertiliser) to 10.7 MJ/kg DM (AN and PB1) at Site 1, and from 10.5 (no fertiliser) to 11.1 MJ/kg DM (PB and AN1) at Site 2 (Table 3). U, AN, U1, PB1 and DAP1, however, had no effect on ME at Site 2.

With the exception of AN1, WSC were unaffected by fertiliser application and ranged from 5.5 (AN1) to 7.4% (no fertiliser) at Site 1 (Table 3). At Site 2, WSC ranged from 2.6 (PB1) to 4.6% (PB); the application of fertiliser having no effect.

Except for U, the application of N with and without P, K and S decreased ($P<0.05$) NDF from 58.2 (no fertiliser) to 54.4% (U1) at Site 1 (Table 3). At Site 2, NDF ranged from 49.0 (DAP) to 51.7% (PB1); the application of fertiliser again having no effect.

Discussion

Pasture growth was delayed by prevailing dry conditions after fertiliser application at both sites.? Climatic conditions in western Victoria are, however, unpredictable in autumn. Application of N under dry conditions increases the risk of volatilisation (3).? Nitrogen fertilisers like urea in particular, are highly susceptible to volatilisation (5) and this is the most likely reason for the relatively poorer growth responses from urea than from other N sources over this period.? Therefore, N fertilisers like ammonium nitrate, or ammonium sulphate may be preferred choices for use in relatively drier autumns.

Table 2. The primary (harvest 1) and residual (harvest 2) dry matter yields (kg DM/ha) and nitrogen efficiencies (kg DM/kg N) of different fertilisers applied in autumn and spring at Sites 1 and 2.

	Site 1				Site 2			
	Harvest 1, 47 days after fertilising		Harvest 2, 30 days after harvest 1		Harvest 1, 37 days after fertilising		Harvest 2, 29 days after harvest 1	
Fertilisers	Yield	Efficiency	Yield	Efficiency	Yield	Efficiency	Yield	Efficiency
No fertiliser	495	-	205	-	573	-	305	-
PKS	512	-	255	-	636	-	399	-
U	865	8	382	4	1012	10	405	2
PB	883	9	362	3	1079	11	407	2
AN	837	8	396	4	1248	15	488	4
DAP	1061	13	448	5	1174	13	490	4
AS	927	10	429	5	1208	14	511	5
ASN	935	10	482	6	1226	15	455	3
U1	910	9	450	5	1128	12	475	4
PB1	1051	12	473	6	1232	15	503	4
AN1	933	10	518	7	1272	16	500	4
DAP1	1114	14	422	5	1228	15	517	5
AS1	1098	13	520	7	1258	15	500	4
ASN1	1167	15	495	6	1219	14	469	4
l.s.d. (P=0.05)	197	-	97	-	152	-	93	-

Table 3. Pasture quality (crude protein, metabolisable energy, soluble carbohydrates and neutral detergent fibre) after the application of different fertilisers at Sites 1 (47 days post fertiliser application) and 2 (37 days post fertiliser application).

Fertiliser	CP (%)		ME (MJ/kgDM)		WSC (%)		NDF (%)	
	Site 1	Site 2	Site 1	Site 2	Site 1	Site 2	Site 1	Site 2
No fertiliser	13.5	22.6	9.5	10.5	7.4	3.6	58.2	50.4
PKS	14.4	22.9	9.6	10.7	6.7	3.1	57.9	50.8
U	17.5	23.0	10.2	10.9	6.3	4.2	56.2	51.1
PB	18.9	23.5	10.5	11.1	6.8	4.6	54.8	49.9
AN	19.7	24.1	10.7	10.9	6.2	3.4	54.8	50.9
DAP	17.3	24.4	10.4	11.0	7.2	4.1	55.7	49.0
AS	18.2	24.9	10.3	11.0	6.7	3.3	55.4	49.4
ASN	19.0	24.1	10.5	11.0	6.6	4.5	55.3	49.8
U1	19.4	24.7	10.7	10.9	6.4	3.0	54.4	49.5
PB1	18.8	24.0	10.4	10.8	6.1	2.6	55.1	51.7
AN1	19.6	24.7	10.5	11.1	5.5	3.4	54.5	50.2
DAP1	17.9	24.0	10.3	10.9	6.0	3.8	55.9	49.7
AS1	19.4	24.3	10.6	11.0	6.0	3.4	55.3	50.0
ASN1	18.4	24.3	10.5	11.0	6.3	4.4	55.8	49.6
l.s.d. (P=0.05)	1.92	1.59	0.48	0.45	1.59	2.96	1.80	3.08

Apart from the relatively poorer responses from urea, different N fertilisers produced similar growth respon-ses within a site. Only where soil fertility levels were relatively low (Site 1) did a fertiliser such as DAP produce higher DM yields than straight N fertilisers like urea and ammonium nitrate, suggesting no real advantage in one N fertiliser over another. Whitehead (6) contends that differences in yield response to various forms of N, are due mainly to differences in the loss of N from the soil rather than to differences in the form of plant uptake.

Application of N with P, K and S did lead to a slight DM yield advantage over straight N fertilisers. This was, however, only significant on soils where essential nutrients like P, K and S were relatively low, supporting the findings of a review on the influence of other elements on N responses in pastures (6).

Residual responses to N (relative to the initial response) vary, depending on the initial rate of applied N, soil fertility, species composition, climatic conditions and the initial response to applied N (2). A positive residual response was obtained at both sites. McGowan (2), however, suggests that positive residual effects may be short-lived and that a negative residual effect may be observed over the longer term if clover content in the pasture declines. It would appear that N fertiliser not used for growth soon after application, does contribute to residual growth and is not necessarily lost from the pasture system. Under grazing, it may be reasonable to expect a higher positive residual response because of the added effect of nutrient recycling. Farmers considering multiple applications of N could potentially exploit this situation by applying N after every second grazing.

N increased pasture CP. This result is consistent with the findings of a review conducted by Whitehead (6).?? Also N, with and without P, K and S increased ME at both sites. Such findings may have important implications for the use of N to manipulate pasture CP and ME for high producing dairy cows.

N generally has little effect on pasture fibre (4). In the current study, NDF was decreased by N, with and without P, K and S at Site 1, but was unaffected at Site 2. There appeared to be no pattern in the treatments that did influence NDF. These results serve to highlight the inconsistency in the effects that N has on NDF.

The content of WSC in pasture is often substantially reduced by applied N (1). In the current study, applied N, with and without P, K and S had no effect on WSC at both sites. Such a study needs to be repeated to test the effect of N on WSC in other seasons, particularly in spring where reduced WSC may impact on the quality of silage (7).

Conclusions

Different N fertilisers produced similar pasture growth responses, however, N fertilisers such as ammonium nitrate are likely to be less susceptible to volatilisation than urea under dry conditions. While the application of N together with P, K and S did lead to a slight DM production advantage over straight N fertilisers, this was only significant for pastures on soils where P, K and S are relatively low.

Applied N increases CP and may increase ME and decrease WSC, with effects on NDF being inconsistent.? Different sources of N, with and without P, K and S, however, do not affect pasture quality differently.

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