Response of the DCAD of plantain to potassium fertilisation

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Abstract

A low dietary cation to anion difference (DCAD) in the ration fed to dairy cows prior to calving reduces incidences of milk fever post calving. Most perennial forage species have a high DCAD and should be limited in the pre calving diet. This challenge is exacerbated when these forages are grown on high K soils (e.g. areas that receive effluent applications). Plantain (*Plantago lanceolata*) is a perennial forage species with an inherently low DCAD value. This experiment was undertaken to determine the effect of fertilisation with muriate of potash on plantain mineral concentration and DCAD. Seven rates of muriate of potash (from 0 to 300 kg K/ha) were applied in July 2014 to an established plantain pasture located in north-western Tasmania. Soil and plant mineral concentrations were monitored during the following two grazing cycles. Both soil and plant K and Cl concentrations increased with increasing K fertiliser application rates. Plantain DCAD was unaffected by fertiliser application and averaged 7.6 and 15.3 meq/100g over the first and second grazings. This value was lower than those typically expected for perennial ryegrass (*Lolium perenne*). Plantain DCAD was correlated with tissue Cl concentration (correlation coefficient of -0.78) but not with tissue K, Na and S concentration, (correlation coefficient of 0.18, -0.25 and -0.22 respectively). It is concluded that plantain will maintain a low DCAD when grown on soils with a high K concentration. This suggests that plantain grown in areas with high soil K concentrations (e.g. fields that receive effluent) will be suitable for inclusion in a pre-calving diet.

Key words

Lead feeding, alternative forage species, potassium fertiliser, hypocalcaemia

Introduction

After mastitis, hypocalcaemia (milk fever) is the second biggest animal heath challenge facing dairy farmers (Roche et al. 2008). Clinical milk fever can result in death, while sub-clinical milk fever results in decreased milk production and reduced reproductive performance (Block 1984, Chapinal *et al*. 2012). Milk fever is estimated to cost \$300 per clinical case and \$125 per subclinical case in terms of treatment costs and lost production (Oetzel and Eastridge 2013) and consequently is a significant cost to the dairy industry.

On Tasmanian dairy farms specially formulated diets are fed prior to calving to help alleviate the incidence of milk fever. These diets (termed lead feeding diets) are often comprised of a restricted pasture allocation, grass hay and specially formulated pellets. These pellets are formulated to have a negative dietary cation to anion difference (DCAD). The DCAD of a feed/diet is based on the concentration of potassium (K), sodium (Na), chloride (Cl) and sulphur (S). It is expressed as milliequivalents (mEq) per 100gDM and is calculated as DCAD $= (\%Na \times 43.5 + \%K \times 25.6) - (\%Cl \times 28.2 + \%S \times 62.5)$ (Lean et al. 2006). The objective of lead feeding is to provide a diet that has a DCAD close to 0 (Roche et al. 2003). This establishes the physiological processes in the cow that release of calcium from storage in her bones so it is available for the production of milk. Lead feeding pellets are relatively expensive (\$700/tDM) and the feeding of the diet is often logistically difficult.

Plantain (*Plantago lanceolata*) is a perennial forb that is becoming a more popular forage species on Tasmanian dairy farms. This increase in popularity is due to its tolerance to drought and heat (Stewart 1996) and its lower fibre content nutritional value during periods when the pasture base of perennial ryegrass (*Lolium perenne*) is high in fibre (Woodard *et al*. 2008). Plantain is also unique amongst the perennial forages in that it has a relatively low and seasonally stable DCAD (Jacobs and Ward 2011, Raeside *et al*. 2012, K.G. Pembleton unpublished data). Recent research where cows grazed plantain in place of a lead feed diet identified that it was just as effective in establishing calcium cycling within the cow as a traditional lead feed diet (Hill 2014).
As perennial forages take up K in luxury amounts when it is readily available in the soil (Kresge and Younts 1962) the DCAD of pastures is particularly high when grown on fields with a high soil K availability. On dairy farms the highest soil K levels are typically found in fields close to the dairy shed as these are the areas that

receive regular applications of effluent (Gourley *et al*. 2007). Unfortunately these fields are also favoured for lead feeding as their proximity to the dairy shed makes managing the logistics of lead feeding easier.

The aim of this experiment was to determine if plantain would be a suitable alternative lead feeding option when grown in areas with a high soil K level (e.g. fields that receive dairy effluent). It achieved this by assessing how the DCAD, mineral composition and growth of plantain are influenced by increasing levels of K fertiliser applications.

Methods

The experiment was undertaken in an established field of plantain at the Tasmanian dairy research facility (TDRF) at Elliott (41.08°S, 145.77°E) in northwest Tasmania. This location has a red ferrosol soil type, a cool temperate climate and a winter dominant rainfall pattern (average annual rainfall of 1200 mm). Long term average maximum and minimum air temperatures are 19.4 and 10.3°C respectively in January and 10.4 and 4.3°C respectively in July. The field was established in December 2013 by direct drilling plantain after spray-grazing with glyphosate. The field was grazed on a rotation basis with dairy heifers or dry cows with herbicides and insecticides applied when necessary.

The experiment commenced on the June 27, 2014. After grazing 21 three by six metre plots were established over three blocks (seven plots per block). Each plot in each block received one of seven K applications which were 0, 50, 100, 150, 200, 250 or 300 kg K/ha applied as muriate of potash. A pre experiment soil test (to 100 mm soil depth) indicated that soil had 50 mg mineral nitrogen (N)/kg, an Olson phosphorus (P) level of 29.6 mg P/kg, a Colwell K level of 488 mg K/kg, a CPC S level of 15.3 mg S/kg and a pH in water of 5.7. Each plot received 40 kg N/ha and 45 kg P/ha as di-ammonium phosphate at the same time as the K treatments were being applied. The plots were allowed to grow for 70 days and then were grazed (harvest 1). Plots were then regrown for a further 29 days and then grazed again (harvest 2). The plots were stocked with enough cows to graze them to a residual biomass of 700 kgDM/ha in a 24 hours.

Immediately prior to harvest 1 and harvest 2 each plot was soil sampled by collecting 30 soil cores per plot to a soil depth of 100 mm. These samples were then dried a 40°C for 120 hours and then were milled to pass through a 2 mm screen. The milled samples were analysed for their K (Colwell extraction) and Cl (aqueous soil extraction) concentrations. After soil sampling a 1 by 6 m strip was mown from the centre of each plot with a sickle bar mower. The cut material from each plot was gathered, weighed and then sub-sampled. Each sub-sample was weighed, dried in a fan forced oven at 60°C for 48 hours and then weighed again. Dry matter (DM) content and DM yield was calculated. The dried pasture samples were milled to pass through a 1 mm screen before being analysed for their K, Na, Cl, S concentrations by inductively coupled plasma-atomic emission spectrometry after digestion with nitric acid and hydrogen peroxide. The DCAD for the forage from each plot was then calculated.

Results

There was a linear response in soil K concentration to the increasing K fertilizer applications at harvest 1 and 2 (Figure 1). There was also a linear response in soil Cl concentration at harvest 1 in response to the increasing K fertilizer application rates. No linear or quadratic response in soil Cl concentration was evident for harvest 2. Tissue K concentrations increased at a decreasing rate in response to increasing K application rates and reached a maximum of 34.8mg/kg between 250 and 300 kg K/ha. There was no linear or quadratic trends in tissue K concentration at harvest 2. For both harvest 1 and 2, tissue Cl responded non-linearly to increasing K fertilizer application rates.

The potassium fertilizer treatments affected the DM yield of plantain for harvest 1 (Table 1). The greatest yield was achieved when 150 kg K/ha were applied and the lowest yield occurred when no potassium was applied. There was no impact from the rate of potassium fertilizer on tissue Na and S concentration or on the DCAD of the forage. The DCAD of plantain was negatively correlated (r:-0.78) with plant Cl concentration (Figure 2). The correlations between DCAD and tissue K, Na and S concentrations were weak with correlation coefficients of 0.18, -0.25 and -0.22 respectively.

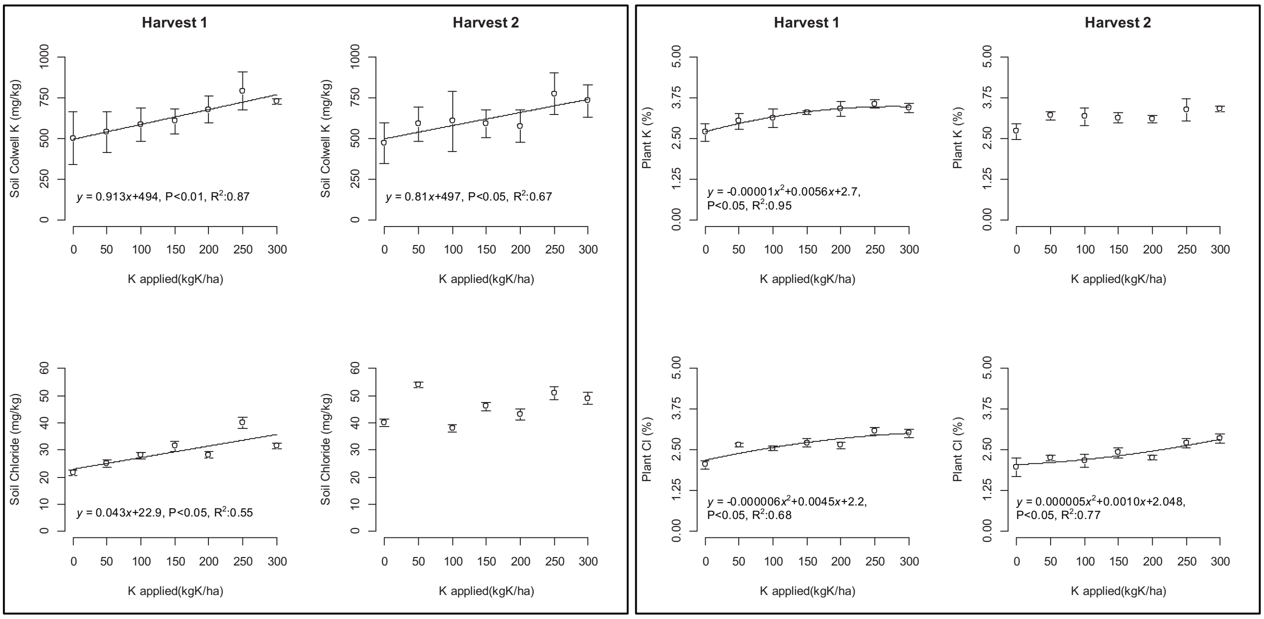

Figure 1. The response of the potassium (K) and chloride (Cl) concentration of the soil (left panels) and the plant tissue (right panels) at harvest 1 and harvest 2 to the K fertiliser application rates applied. Error bars represent the standard errors of the means.

Table 1. The impact of increase potassium fertiliser application on the yield sodium (Na), and sulphur (S) concentration and the dietary cation to anion diference (DCAD) of plantain at harvest 1 and harvest 2.

K applied (kgK/ha)	Yield (kgDM/ha)	Plant Na (%)	Plant S (%)	DCAD (meq/100g)
		Harvest 1		
0	1345 c	0.61	0.34	16.6
50	1572 abc	0.61	0.36	6.9
100	1518 bc	0.52	0.36	7.3
150	1830 a	0.47	0.34	6.1
200	1425 bc	0.44	0.35	10.2
250	1681 ab	0.45	0.34	2.3
300	1672 ab	0.52	0.35	3.9
P value	<0.05	Ns	ns	ns
SED	133	0.07	0.01	5.6
		Harvest 2		
0	1105	0.52	0.28	19.0
50	1587	0.50	0.31	20.8
100	1671	0.47	0.32	20.7
150	1513	0.44	0.30	12.1
200	1322	0.41	0.30	14.6
250	1551	0.47	0.31	11.2
300	1481	0.49	0.31	8.7
P value	ns	Ns	ns	ns
SED	267	0.05	0.01	7.2

Discussion

The DCAD of plantain in this experiment was well below the values reported for other forage species (Mckenzie and Jacobs 2002). Furthermore, it was unaffected by increasing the availability of potassium through the application of mutate of potash. This was despite an increase in tissue K concentration. The increase in tissue Cl concentration that also occurred was enough to balance out the impact that increasing the tissue K concentration had on DCAD. This was confirmed by the correlation analysis in which DCAD was most strongly correlated with tissue Cl concentration. Even at the second harvest where there was no effect from the fertilizer applications on soil Cl availability there was still no response in DCAD to the increase in soil K availability. The soil K concentrations achieved in this experiment were very high even for dairy pastures and were reflective of those often recorded for fields that regularly receive dairy effluent (Gourley *et al*. 2007). Consequently plantain sown on such areas of a farm should still be suitable for inclusion in the pre-calving diet. A response in the DCAD of plantain to potassium fertilizer may still be observed at lower soil K levels. This experiment and the work reported in Hill (2014) highlight the opportunities that plantain presents with respect to increasing the amount of home grown forage that can be included in a pre-calving diet.

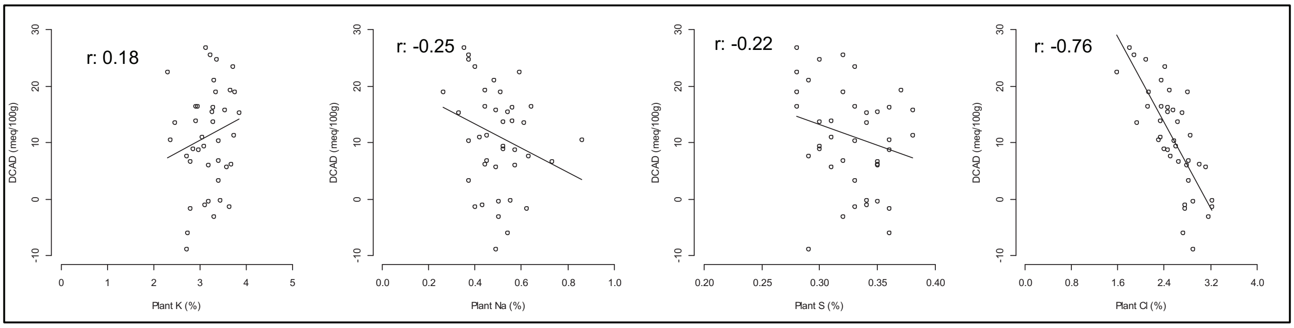

Figure 2. Correlations between tissue K, Na, S and Cl concentrations and the DCAD of the harvested forage.

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