Influence of total soil nitrogen levels on dry matter production responses to nitrogen fertilisation of dairy pastures in New Zealand

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Abstract
To test whether topsoil (0-7.5 cm) total soil N levels influence pasture dry matter yield (DM) responses at various rates of N fertiliser, field experiments were conducted in spring 2013 and autumn 2014 at five locations in the North Island (Whangarei, Te Awamutu, Central Hawke's Bay 1, Central Hawke's Bay 2, and Taihape) and two locations in the South Island (Culverden and Te Anau) of New Zealand. At each site, N fertiliser at rates of 0, 25, 50, 75, 100 and 200 kg N/ha were applied and pasture DM production data collected. At a little more than half the measurement events, the response in pasture DM production was greater at lower total soil N than at higher total soil N levels with the other sites showing a similar pasture DM production response at both low and high soil total N levels. Thus, total soil N was partially successful in predicting DM response to N fertilisation.

Key Words
Total soil nitrogen, pasture yield, nitrogen fertilisation

Introduction
In perennial ryegrass (*Lolium perenne*)-dominated dairy pastures of New Zealand, farmers tend to apply N fertiliser uniformly on their farms regardless of differences in inherent soil N fertility of their paddocks. This approach can be wasteful of N fertiliser input and can contribute to N pollution of the environment. In temperate pastures with relatively high total soil N levels such as those in New Zealand and Ireland, Parfitt et al. (2005) and McDonald et al. (2014) have shown that total soil N to be highly correlated with mineralisable N. Thus, total soil N can be used as an index of soil N availability and subsequently DM yield. The logic behind using total N as an index of soil N availability is that the available N pool in soils ultimately comes from organic matter through the mineralisation process. Currently, the 7-day anaerobically mineralisable N (AMN) test is employed as an index of available N and is used by nutrient advisers as a guide in N fertilisation but is considered more expensive and time consuming to analyse than total N. A simple total soil N test can potentially be useful in farms where there are substantial differences in total soil N between or among paddocks whereby paddocks with high total N will receive little or no N fertiliser while those with low total N will receive more N fertiliser thereby improving pasture N use efficiency. This paper tests the usefulness of this approach using pasture sites fertilised with varying rates of N fertiliser with low and high total soil N and covering seven locations across New Zealand.

Methods
Site selection
In winter 2013, on 28 farms, topsoil (0-7.5 cm) composite samples were taken from paddocks and analysed for total soil N. On farms where there was a total N difference between paddocks of at least 0.3 percentage points, four paddocks, two with low total soil N and two with high total soil N were selected to have the trial sites placed on them during spring 2013 and autumn 2014. In each of the four paddocks per farm, a suitable trial site of about 20 x 10 m was selected and a soil sample taken to check total soil N level. The site was then fenced to exclude livestock; the pasture trimmed to 3-4 cm and pegged out to contain 30 plots of 4 m x 1.5 m. The farm location, soil classification and soil total N levels are shown in Table 1. In autumn, two of the sites at Taihape were not suitable for further measurements and were abandoned. Several missing observations occurred in the Central Hawke's Bay 2 site in one of the low N paddocks in autumn and were not included in the analysis of the data.

Trial design, management and data analysis
In spring 2013 and autumn 2014, five rates of N (25, 50, 75, 100 and 200 kg/ha) were applied as urea to each plot in a randomised block design with six replicates. A control treatment was also included. Each plot received a basal application of 50 kg/ha each of P, S and K applied as superphosphate and muriate of potash. After N fertilisation, when an estimated pasture mass of 2000-2500 kg DM/ha was achieved, plots were mown, pasture samples weighed and subsamples taken for DM determination. The pasture was allowed to

regrow and a second cut taken 4-6 weeks later to measure any carryover effect of N fertiliser. Dry matter yields in the first and second cuts were combined. Analysis of variance was performed on the total dry matter data. N rate vs. pasture DM yield are presented graphically. The data for Central Hawke's Bay 1 and 2 were combined into one graph.

Table 1. Total soil N levels at the individual trial sites.

Farm Location	NZ Soil Classification (Order Level)	Paddock Total Soil N (%)			
		Low	Low	High	High
Whangarei	Brown	0.40	0.55	0.75	0.85
Te Awamutu	Allophanic	0.54	0.58	0.96	1.32
Central Hawke's Bay 1	Pallic	0.43	0.44	0.68	0.82
Central Hawke's Bay 2	Brown/Recent	0.32	0.34	0.91	0.96
Taihape	Allophanic	0.52	0.52	0.90	1.04
Culverden	Pallic	0.25	0.37	0.44	0.57
Te Anau	Allophanic	0.39	0.40	0.75	0.82

Results and Discussion

Dry matter response to N fertilisation and its relationship to total soil N, Spring 2013

There was a significant response in pasture production ($P<0.05$) to N fertilisation at 26 out of the 28 sites. At 16 of the responsive sites, there was a significant response in pasture production up to the highest rate of 200 kg N/ha. For the remaining 10 sites, there were significant responses in pasture production up to 75 or 100 kg N/ha (Figure 1). In Whangarei, for all total soil N levels, there was a similar pattern of response that tended to level off above 100 kg N/ha. In Te Awamutu, for all total soil N levels, pasture DM production increased up to 100 kg N/ha and then levelled off. There was a steeper increase at the two lower total soil N levels compared with the two higher levels. In Central Hawke's Bay (combined data for 1 & 2), there was mostly a similar response in DM production at all total soil N levels. At Taihape, only three of the four sites were responsive to N. The results were the opposite of what would be expected with a greater response in DM production at the higher compared with the lower total soil N levels. It is not clear why this trend occurred given that pre-treatment DM yields did not differ among plots in the different N rate treatments. At Culverden, for all total soil N levels, the response was linear up to 75 kg N/ha and then levelled off. The slope of the response was highest at the lowest total soil N level. At Te Anau, there was a similar response in pasture DM production to N at all total soil N levels with the response levelling off at 75 or 100 kg N/ha.

Dry matter response to N fertilisation and its relationship to total soil N, Autumn 2014

At the remaining 25 sites, there was a significant DM response to N ($P<0.05$). At 11 of these sites, there was a significant response in pasture production up to 200 kg N/ha with the remainder responding significantly up to 50-100 kg N/ha (Figure 2). In Whangarei, there was a greater response up to 75 kg N/ha from the sites with lower total soil N levels compared with the sites with higher total soil N levels. At Te Awamutu, at up to 75-100 kg N/ha, there was a greater pasture production response to N as the total soil N level decreased. In Central Hawkes Bay (combined data for 1 & 2), there was a trend for the pasture production response to N to be lower at the sites with the two highest total soil N levels compared with the lower levels. In the two remaining sites in Taihape, there was a greater response in pasture production at the higher compared with the lower total soil N level which was consistent with what was observed earlier in spring. At Culverden, there was a response in pasture production up to 50-100 kg N/ha range and slopes of the response curves were steeper in the two low total soil N sites. However, the site with the highest total soil N (0.57%) had the greatest DM response to N fertiliser. At Te Anau, the greatest pasture production response to N occurred at the site with the lowest total soil N level and the lowest response at the second highest level (0.75%) with the other two (0.40 to 0.82% N) sites showing a similar response.

Conclusion

When the rate of N applied was related to the pasture DM response to N at varying levels of total soil N, there was a greater response at the lower total soil N levels at seven of the 12 measurement events (spring and autumn) but no difference at the other five measurement events. In spring, only two sites at Te Awamutu and Culverden had a differential response related to total soil N levels. This proportion increased to five out of six in autumn (Whangarei, Te Awamutu, Central Hawke' Bay 1 & 2, Te Anau, and partly in Culverden). Thus, total soil N was partially successful in predicting DM response to N fertilisation. Total soil N maybe a less sensitive predictor of N availability within the growing season because it is less dynamic compared to indices of available N (McDonald et al. 2014).While total soil N could be used to predict pasture DM production response, the present study shows that there is a need to understand and investigate further other factors that may affect N availability such as organic matter quality, pasture composition, individual plot total N levels (spatial variability), etc.

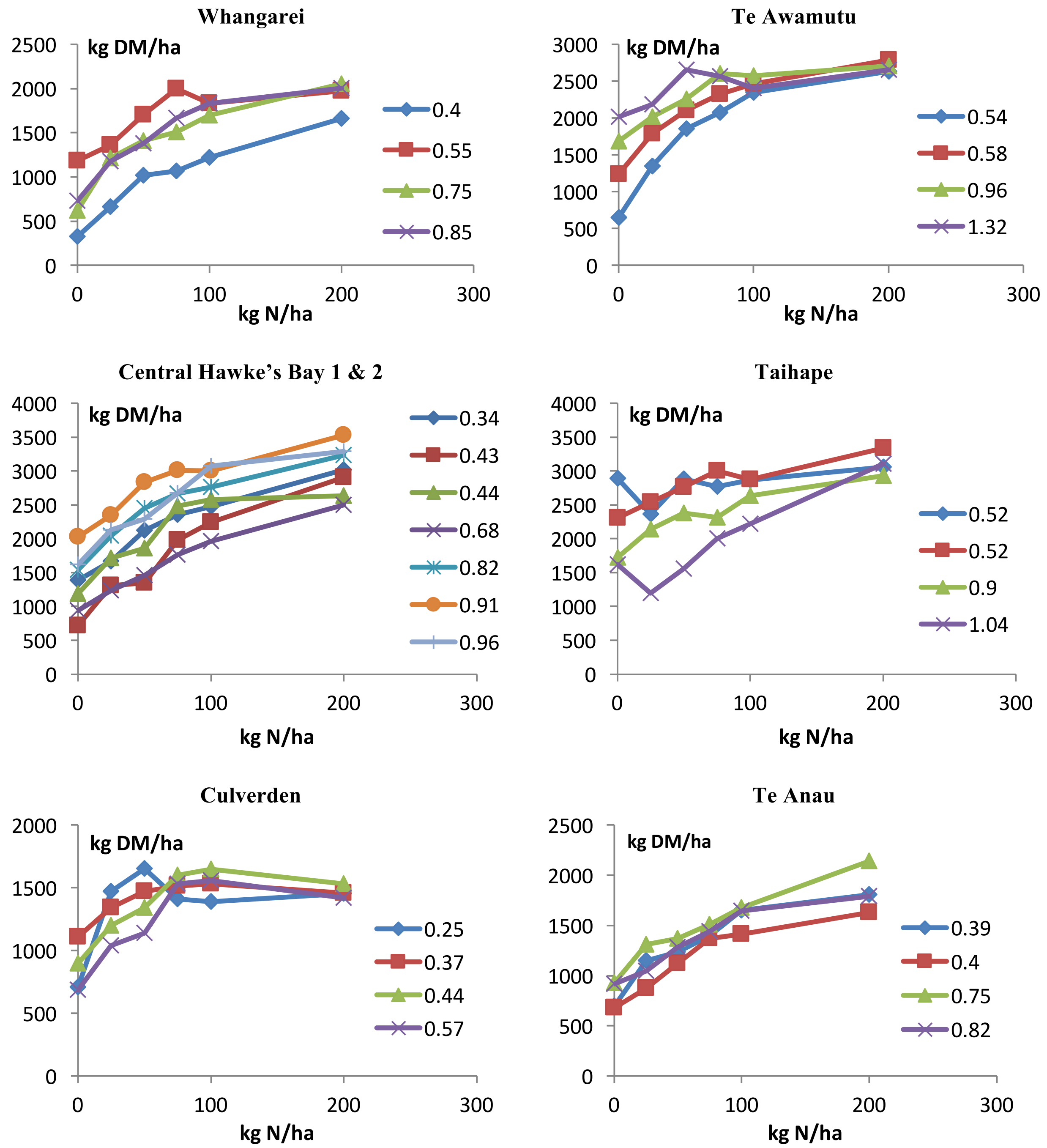

Figure 1. Dry matter yield responses of pasture to N fertilisation at different locations under low and high total soil N levels, Spring 2013.

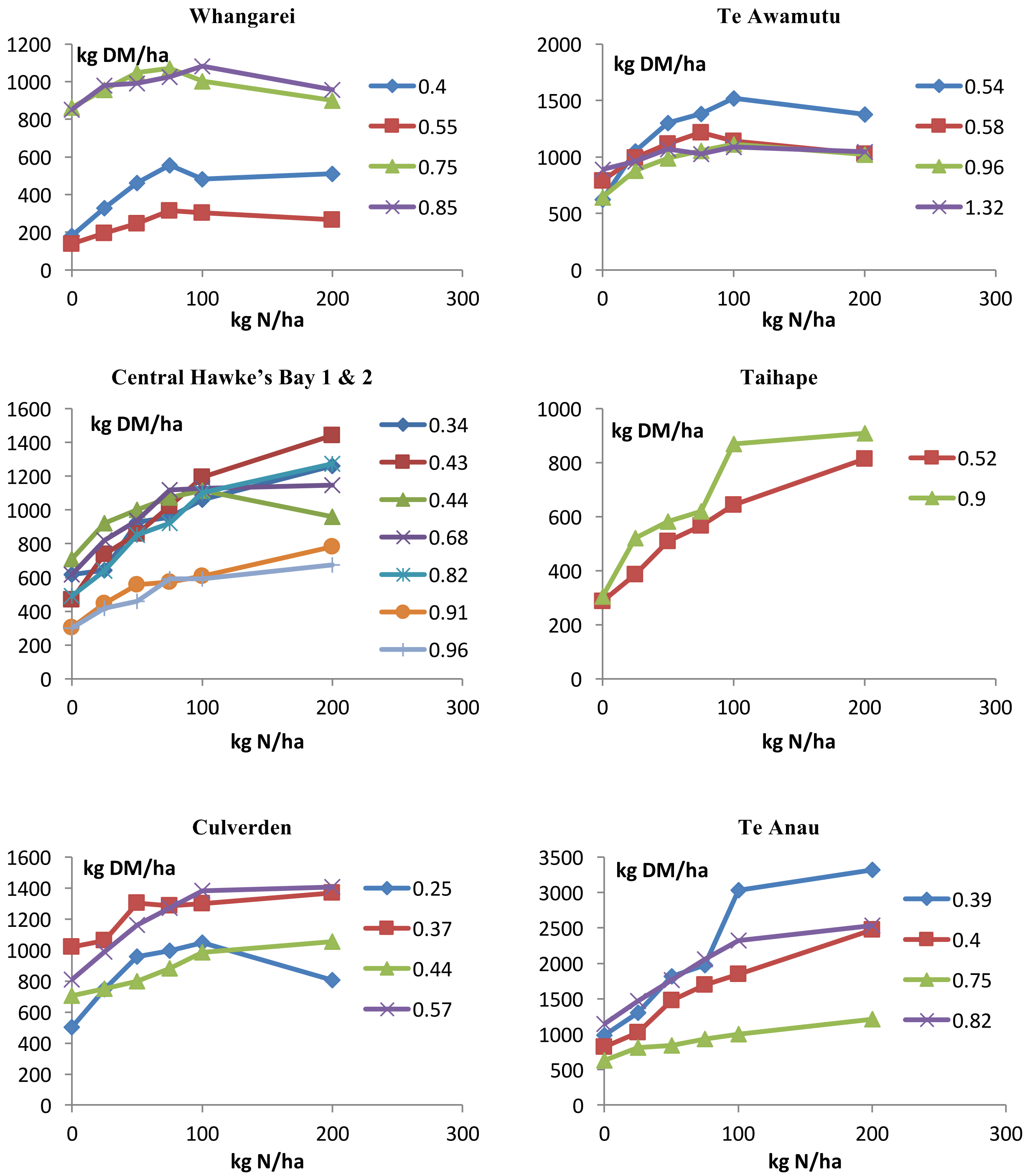

Figure 2. Dry matter yield responses of pasture to N fertilisation at different locations under low and high total soil N levels, Autumn 2014.

References

McDonald, NT, Watson, CJ, Lalor, ST, Laughlin, RJ and Wall, DP 2014. Evaluation of soil tests for predicting nitrogen mineralization in temperate grassland soils. Soil Science Society of America Journal 78, 1051-1064.

Parfitt, RL, Yeates GW, Ross DJ, Mackay AD, Budding PJ (2005) Relationships between soil biota, nitrogen and phosphorus availability, and pasture growth under organic and conventional management. Applied Soil Ecology 28: 1-13.