SOIL TOTAL N CONTENT INFLUENCES PASTURE FERTILISER N RESPONSE

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Introduction

Soil nitrogen (N) supply, as one aspect of soil fertility, is important in determining the response of pasture to N fertiliser because fertiliser is used to meet the shortfall between demand by the pasture and soil N supply. Parfitt et al. (2005) demonstrated that net N mineralisation explained differences in pasture production in New Zealand soils (in the absence of fertilizer N); and also that net N mineralisation was strongly correlated with soil total N (TN), measured to 20 cm soil depth.

A series of sequential research projects have tested the hypothesis that ryegrass/white clover pasture N fertiliser response is related to soil total N (TN) content, used as a surrogate measure of soil N supply. Full details of the approaches and results are available in Ghani et al. (2015) and Shepherd et al. (2015). Here, we present a short summary of findings and discuss implications for N fertiliser management.

Approaches

The series of experiments comprised:

- A glasshouse experiment with ryegrass grown in soil (0-75 mm sampling depth) taken from 51 sites (Northland, Waikato, Bay of Plenty, Central Plateau, King Country, Taranaki and all major districts of the South Island). TN range: 0.24-1.40%
- A series of regional field trials in Waikato with 17 N fertiliser response experiments in spring (ryegrass/white clover pasture) within a radius of 7 km. TN range (0-75 mm): 0.40-0.98%
- A series of 41 national fertiliser N response trials in early summer. These spanned both North and South Islands. TN range (0-75 mm): 0.37-1.17%
- 20 individual fertiliser N response experiments at Tokanui research farm in spring. TN range (0-75 mm): 0.3-1.3%.

Results

In the series of glasshouse and national field trials, the variability in the soil TN alone was able to explain between 30 and 70% variability in pasture dry matter (DM) yield with no fertiliser N applied. Furthermore, in the regional field trials, TN explained 70% ($P<0.001$) of the variation in pasture response to 50 kg N/ha (increase in yield from fertiliser expressed as a percentage of the nil-N yield); response decreased with increasing TN, i.e. increasing soil N supply. When the concept was extended to the national series of experiments, there was also a significant ($P<0.05$) negative relationship between pasture response and soil TN with 35%

of the variation explained, but only when sites with low soil moisture content at the time of N fertiliser were removed from the dataset.

In the spring fertiliser N response trials at Tokanui research farm, significantly more variation in pasture DM yield (over two harvests, 49 days after N fertiliser application) was explained by including TN in a linear combination with a scalar of N fertiliser applied in a Mitscherlich model than was by using fertiliser N alone:

$$DM = 4297 - 4072 * \exp(-0.8449*(TN + 0.01143*Napplied)) \quad [1]$$

This relationship explained 72% of the variation ($P<0.001$) in DM yield when all fertiliser N rates (0, 25, 50, 100 and 200) were included.

Discussion

Combined, this research indicates that TN is a useful surrogate estimate of soil N supply, in agreement with Parfitt et al. (2005). The soils had a C:N ratio of c.10; the two exceptions that did not fit the same line were peat soils with a C:N ratio of 28:1 (Ghani et al. 2015). This suggests TN is only a good guide when the C:N ratio is narrow.

The results also demonstrate that soil TN affects pasture DM response to applied fertiliser N. The predictive capacity of TN was better in the regional trials than the national series. The regional trials were done in early spring when soil moisture tends not to limit pasture growth, whereas the national series started in early summer and gravimetric moisture content measurements at the start of the trials indicated a significant proportion were suffering moisture stress. All of the regional trials were done within a 7 km radius whereas the national trials spanned all of New Zealand. Thus, the reason for the better predictive capacity of TN in regional rather than the national series could be the influence of climate variation. Climate influences pasture growth and response (O'Connor 1982), and the variation would have been much greater at a national than a regional scale. When 20 N response experiments were done on the same property in early spring, TN was a good predictor of yield response; with all sites within 2 km, this minimised variation in climate, and soil moisture was not limiting.

At Tokanui, the effect of TN appeared to be on increasing nil-N yield and thereafter 'flattening' the response to fertiliser N. This is shown when we run the regression model (Equation 1) for a range of soil TN values (Figure 1). The consequences of this relationship can be highlighted by the following example. To adequately feed lactating cows and also maintain pasture quality, farmers in New Zealand aim to provide c. 1600 kg DM eaten pasture/ha each grazing (DairyNZ 2015). Over two grazings this equates to 3200 kg DM/ha. Figure 1 estimates the amount of N fertiliser (albeit in a single dressing) required to achieve this pasture over two harvests. N fertilizer requirement decreased at higher soil TN levels; for example, at 0.4% TN c. 105 kg N/ha was required, compared with c. 55 kg N/ha at 0.9% TN. Efficiency of production was also higher at the lower TN: 18 vs 14 kg DM/kg N at 0.4 and 0.9% TN, respectively. This suggests that farmers should consider targeting differential application rates to different parts of the farm to improve N use efficiency.

The value of TN in differentiating between high and low response areas on a farm will depend on the variation in TN found on that farm. Also, because we eliminated the effect of variable climate by siting 20 experiments within 2 km, no climate factors were included in our regression model (Equation 1). Consequently, the absolute growth curve equation will not be transferable to different sites or different seasons even within the same site, as the pasture growth rate will also depend on environmental conditions at the time.

Without accounting for climate variation, measurement of soil TN concentration probably best serves as a method to rank responsiveness of paddocks across a farm rather than to predict absolute yield. Further research is required to continue to develop and evaluate the approach.

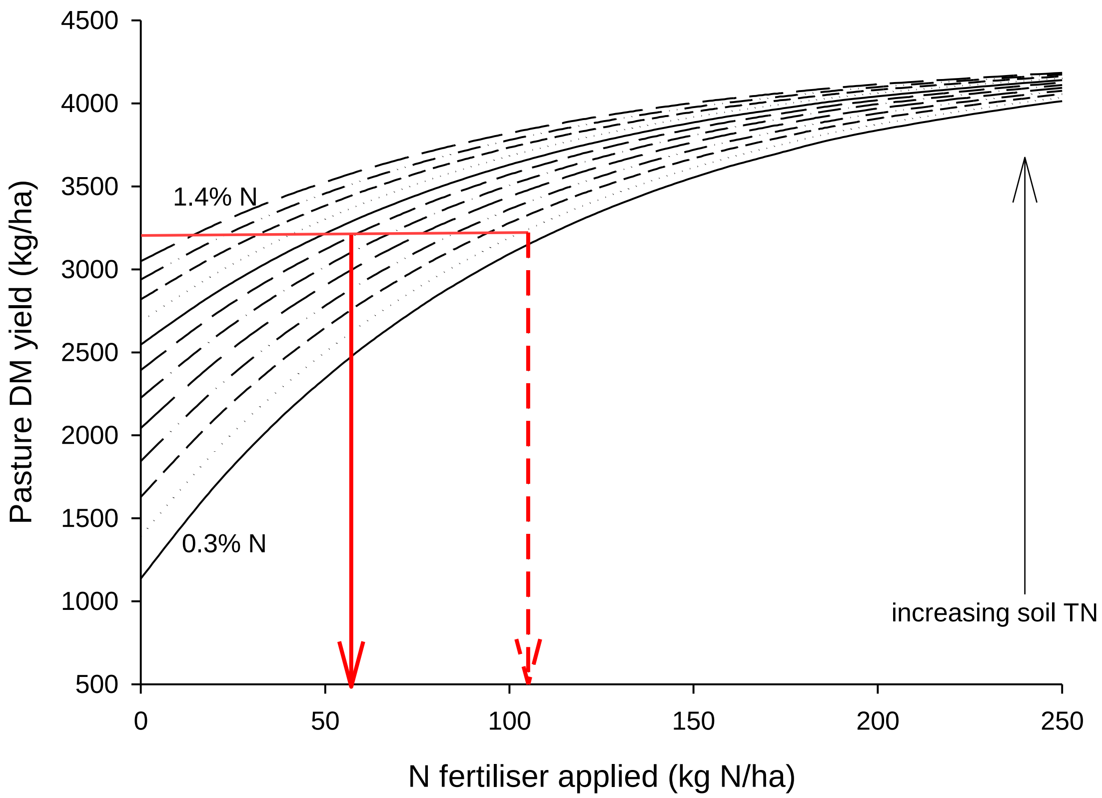

Figure 1. *Effect of soil total N (TN) on yield and fertiliser N response based on the regression function derived from the Tokanui experiment series. Lines show the estimated fertiliser N input required to harvest 3200 kg DM/ha over two simulated grazing events when the soil has 0.4 (solid line) or 0.9 (broken line) %TN.*

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