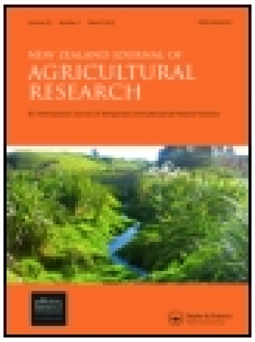

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SHORT COMMUNICATION

Soil nutrient concentrations and farm gate nutrient balances for dairy farm management in Tasmania

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ABSTRACT
Soil testing was undertaken on 1698 pasture paddocks on 109 dairy farms across Tasmania as part of the Fert$mart planning process. Forty-five per cent of paddocks had soil Olsen P concentrations above the concentration where any response could be expected from the application of additional P fertiliser. There was uneven distribution of nutrient concentrations across farms possibly relating to different soil types, previous fertiliser applications and grazing management practices. The range in Olsen P across paddocks was 5–134 mg/kg. Many paddocks (43%) had mean soil extractable K and KCl-S (39%) concentrations above that required for optimum plant growth. Only 3.7% of paddocks tested had nutrient levels in the optimum range for all of the four nutrient measures. Whole farm nutrient budgets found deficits to large surpluses for P, K and S. The Fert$mart process combines a farm nutrient budget with soil testing as tools for improved fertiliser management.

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KEYWORDS
Soil; soil testing; pasture; nutrients; nutrient budget

Introduction

A strategic soil testing program that covers the entire farm on a regular basis has been undertaken by very few dairy farmers in Australia and in some regions, information on soil nutrient levels is extremely limited (Nicon Rural Services 2010). The Fert$mart program has been developed by Dairy Australia to ensure dairy farmers are provided with appropriate knowledge and support to make good decisions about fertiliser application, thereby reducing nutrient runoff from their farms while still ensuring maximum pasture growth. High soil nutrient levels are seen as an asset and are used as a method of risk management, like money in the bank. However, several studies have demonstrated that surface P losses from pasture-based industries pose a substantial risk to water quality (Scharer et al. 2007; Broad & Corkrey 2011) with dairy pastures contributing 11.1 kg P/ha to Tasmanian rivers.

The aims of this work were to report on the soil nutrient status of intensive pasture soils on dairy farms in Tasmania that have participated in the Fert$mart program over two years (2014–2016) and to compare farm gate nutrient balances on individual farms.

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Methods

Fert$mart plans are developed one-on-one with farmers and the key messages are that using fertiliser is about right product, right rate, right time and right place for maximum profitability. The Fert$mart plan involves collection of farm data so that farm production goals and feed requirements are known, accessing information for calculating the nutrient budget, a farm map, collection of soil samples, soil analysis, understanding the effluent disposal system and disposal areas, and assessment of pasture and soil condition including soil structure and drainage.

A total of 1698 paddocks were sampled on 109 farms during 2014–2016 which was approximately a quarter of the dairy farms in Tasmania. Some farms had all suitable paddocks sampled including paddocks where dairy shed effluent had been spread but others had as few as three paddocks sampled due to previous soil testing history, cost or uncertainty about the benefits by farmers. Suitable paddocks were generally larger than 1 ha and generally did not have fertiliser applied within the 5–6 weeks prior to sampling. Paddocks were sampled with a corer to 7.5 cm or 10 cm depth. Samples were analysed by commercial laboratories that were all Australian Soil and Plant Analysis Council (ASPAC) certified. Samples were analysed for pH in water, Olsen extractable P, Colwell K or K as part of determination of exchangeable bases, and KCl extractable S. The exchangeable bases K was converted to 'extractable K' by multiplying by 390.

Soil sampling transects were marked onto a farm map together with property and paddock boundaries. Separate nutrient distribution maps for P, K, S and pH were generated for inclusion in the Fert$mart report for each farm. Individual paddock soil nutrient concentrations were sectioned into ranges and assigned colours on the maps to represent soil nutrient concentrations that were less than, within the optimum range, above, or well above the accepted optimum concentration for dairy pasture production (Gourley et al. 2007; Cotching & Burkitt 2011). The nutrient budget calculator used was NutriMatch® (Department of Primary Industries 2010) to determine whole farm nutrient budgets.

Results and discussion

Soil fertility

Mean soil Olsen P values in all the four regions sampled were above the optimum range of 20–30 mg/kg (Table 1) with 45% of the paddocks having soil Olsen P concentrations greater than the recommended optimum, that is, above the concentration where any response could be expected from the application of additional P fertiliser (Gourley et al. 2007; Cotching & Burkitt 2011), and 26% of the paddocks having soil Olsen P concentrations less than the recommended optimum. These results compare with those of Gourley et al. (2011) who reported that 80% of paddocks in an Australia wide study of dairy farms had soil P concentrations above the agronomic optimum. The range in soil P concentrations between all paddocks was 5–134 mg/kg indicating that there was uneven distribution of soil P concentrations within farms as reported by Aarons et al. (2015). Within paddock, spatial variability can mean that large parts of paddocks could be responsive to fertiliser (Trotter et al. 2014). Some of the high soil P concentration paddocks were near the dairy and could have been due to repeated effluent application or the proportion of time that the herd spent grazing these paddocks compared to those further

Table 1. Soil test results for farms in the Tasmanian Fert$mart program 2014–2016.

Region	Northwest	North	South	King Island	All districts
No. of farms	50	38	10	11	109
No. of paddocks	733	567	290	109	1698
pH (water) mean	5.9	5.9	6.4	6.4	6
pH (water) median	5.9	5.9	6.4	6.4	6
Paddocks below optimum pH					16%
Paddocks above optimum pH					2%
Phosphorus Olsen mean	30.6	30.0	32.9	39.5	31.5
Phosphorus Olsen median	26.5	26.7	30	36.8	27.8
Paddocks below optimum P					26%
Paddocks above optimum P					45%
Extractable potassium mean	268	290	270	184	269
Extractable potassium median	230	234	240	183	227
Paddocks below optimum K					25%
Paddocks above optimum K					43%
Sulphur mean	17.9	19.4	14.5	24.9	18.3
Sulphur median	13.8	14.7	13.0	18.8	14
Paddocks below optimum S					14%
Paddocks above optimum S					39%
No. of paddocks meeting all optimum nutrient levels (63)					3.7%

away from the dairy (Gourley et al. 2011). The high and excessive Olsen P concentrations measured consistently across some of the properties could be due to high application rates of P fertilisers together with nutrients imported in supplementary feed, such as grain, or by different soil types.

Many paddocks (43%) had mean soil extractable K concentrations above that required for optimum plant growth (Table 1) and 9.5% of paddocks had more than double the optimum level. Such high soil K levels can cause severe metabolic disorders in ruminants (Rogers et al. 1977). There was a large variation in soil K concentrations measured across all paddocks, 20–1380 mg/kg (Figure 1). Paddocks that contained low soil K concentrations may have been due to direct export of K through harvesting of hay and/or silage from those paddocks without returning a sufficient amount of K fertiliser to replace the export, as fodder contains 17 kg of K per tonne of dry matter (Department of Primary Industries 2010).

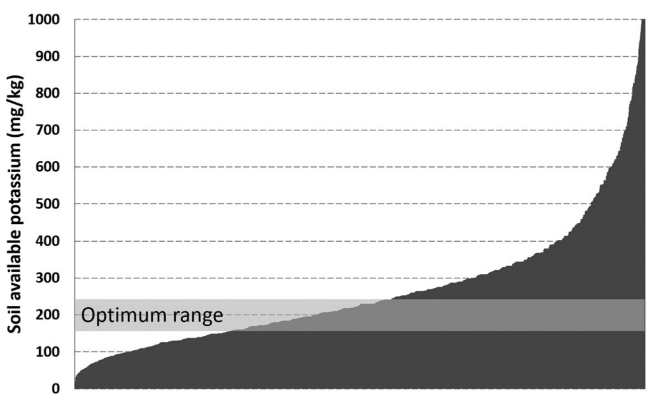

Figure 1. Distribution of paddock soil extractable K concentrations on farms in the Tasmanian Fert $mart program 2014–2016.

Three of the four regions had mean soil S concentrations greater than the optimum (Table 1). Many paddocks (39%) had soil S concentrations above optimum. There was uneven distribution of S concentrations across the farms. The range across all paddocks was 1.2–447 mg/kg. Above optimum levels of S may be due to a history of single superphosphate fertiliser use that contains 9% P and 12% S resulting in accumulated S inputs as an incidental process of P application. This is supported by the strongest correlation in nutrient budget correlations between P and S ($R^2 = 0.57$, see below).

Soil pH's across the regions were mostly within the optimum range with mean values of 5.9–6.4. Soils in Tasmania are naturally strongly acidic (National Land and Water Resources Audit 2001) and so the optimum mean pH values reflect regular application by farmers of locally sourced dolomite ($MgCO_3/CaCO_3$) or lime ($CaCO_3$). It is noteworthy that only 63 paddocks tested (3.7%) had nutrient levels in the optimum range for all of the four nutrient measures (Table 1).

Nutrient budgets

Nutrient budgets on 41 of the 106 farms sampled for the 12 months immediately prior to soil sampling found that 51% of farmers had applied or brought in a net surplus of P, with budgets ranging from a deficit of 36.5 to a surplus of 51 kg P/ha/year. Many of the farm gate nutrient budgets were in deficit but the range in P budgets across the farms in this study was less than those found in many other Australian studies (Gourley et al. 2011). Seventy per cent of the farmers applied a net surplus of K, with K budgets ranging from a deficit of 32 to a surplus of 76 kg K/ha/year. Eighty-three per cent of farmers had applied a net surplus of S with S budgets ranging from a deficit of 14 to a surplus of 80 kg S/ha/year. The surpluses could amount to a saving of up to $A174/ha in P and $A91/ha in K but the deficits could amount to extra costs of up to $A124/ha in P and $A38/ha in K (single super@$A300/T, MOP @ $A600/T).

However, the actual amount saved or spent will depend on a farm's stocking rate, production, soil type and the mix of current soil test levels for individual nutrients. One farmer was able to save $A180,000 in fertiliser the year following the Fert$mart plan.

There were positive but weak correlations between the different nutrient budget values (P:K, $R^2 = 0.49$; P:S, $R^2 = 0.57$; K:S, $R^2 = 0.36$). The mixed results are perhaps an indication that soil nutrient concentrations are the result of a complex set of factors, including nutrient application rate, export in products, stocking density of land and the resultant nutrient deposition from urine and dung (Gourley et al. 2011), soil type differences in sorption and losses to the environment.

Conclusions

The soil nutrient testing undertaken as part of the Fert$mart planning process on Tasmanian dairy farms has provided a good picture of the soil nutrient status of pasture soils across Tasmania. There was uneven distribution of nutrient concentrations across the farms with some farms containing paddocks with nutrient concentrations below the agronomic optimum concentration, while also containing paddocks with excessive nutrient concentrations. This variability may be attributed to different soil types, previous fertiliser applications and grazing management practices. Whole farm nutrient budgets found a wide range of deficits to surpluses of P, K and S. The results reinforce the value of combining a nutrient budget with whole farm nutrient distribution maps as tools for improved nutrient management.

Fertiliser recommendations in the Fert$mart plans have resulted in reduced fertiliser rates for some farmers while others will redistribute applied fertilisers to raise nutrient levels in deficient areas and reduce levels in 'hot spots' to reduce the risk of nutrient loss to the environment via waterways. Significant cost savings were made by some farmers but the actual amount saved or spent will depend on a farm's stocking rate, production, soil type and the mix of current soil test levels for individual nutrients. The nutrient budgeting and farm nutrient distribution maps provided the ideal framework to discuss and promote sustainable fertiliser application rates and techniques.

Disclosure statement

No potential conflict of interest was reported by the authors.

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