DAIRY SOIL NUTRIENTS: MONITORING SOIL FERTILITY ON FLEURIEU DAIRY FARMS 2010/11

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CARING FOR OUR COUNTRY

CONTENTS

1. INTRODUCTION

Fertiliser continues to be a key input for grassland-based dairy farms, with its strong influence on pasture production and profitability (Gourley et al. 2007). However fertilizer decisions should be based on objective soil and/or plant testing information and decision support tools wherever possible, to avoid detrimental environmental impacts and best satisfy the dual goals of profitability and environmental sustainability.

Soil acidification is a chemical form of soil degradation and this process is accelerated under productive pasture and crop systems (Kealey, 1992). Soil acidity is recognised as a growing threat to pasture land and acidification rates can be increased by inappropriate fertilizer use (*ibid*).

Both of these issues highlight the need for better informed, more targeted fertilizer usage on dairy farms. This importance only grows when we consider the price of common fertilizers has increased by over 30% in the last five years, and that fertilizers now account for almost 10% of total operating expenses on Fleurieu dairy farms (D Beca, pers.comm.).

In spite of this, soil testing has not been undertaken comprehensively nor regularly on many Fleurieu dairy farms. This has limited farmers' ability to decide where, what and how much fertilizer to apply for best effect. Consequently, several groups of dairy farmers have participated in the **Dairy Soil Nutrients** project in the last two years and conducted a soil testing program on their farms. Soil testing work has been complimented by participants reviewing sustainability and environmental issues on their own farms using the 'DairySAT' tool. In the first year (2009/10), soil tests were taken on nine member dairy farms of the Mount Jagged Dairy Discussion Group plus the Mount Compass Area School Focus Farm. The results were reported and interpreted by Mitchell *et al* (2010).

This is the 2nd report in this series, and summarises soil testing work for participating dairy farms on the Fleurieu Peninsula in the 2010/11 year. This project work has been supported by **DairySA**, through funding from the Australian Government's **Caring For Our Country** program.

2. METHODOLOGY

Eleven dairy farms on the central and southern Fleurieu Peninsula participated in the Dairy Soil Nutrients program in 2010/11. Up to 20 soil tests were conducted for each farmer, with participants choosing what areas or paddocks on their home dairy farm would be tested. Several participants opted to use 3 to 5 of their tests to assess soil fertility on run-off blocks away from the home dairy farm.

Each soil test involved taking around 30 soil cores from a representative section of the paddock or area involved. A hand-held soil corer was used to take samples of the 0 to 10 cm soil horizon. Samples were then mixed, sub-sampled and sent to CSBP Laboratories in WA for analysis. Results were received for the following soil properties;

- Soil texture and colour
- pH $_{(water)}$
- pH $_{(CaCl2)}$
- Phosphorus $_{(COLWELL)}$
- Phosphorus $_{(OLSEN)}$
- Potassium $_{(COLWELL)}$
- Sulphur $_{(K\text{-}Cl\ 40)}$
- Electrical Conductivity (EC 1:5) – a measure of soil salinity

Results were interpreted with regard to soil test criteria published by Meat & Livestock Australia (Anon, 2008), Victorian Dept. Primary Industries (Gourley et al. 2007) and Primary Industries & Resources SA (Cayley et al. 2004). Soils were considered strongly acidic if $pH_{(water)}$ fell below 5.6 or if $pH_{(CaCl2)}$ fell below 4.9 (Hodge and Lewis, 1991). Soils were considered significantly saline if conductivity $_{(EC\ 1:5)}$ exceeded 0.20 ds/m, the level at which growth of clovers is significantly reduced (Anon, 1983). Soil phosphorus (P), potassium (K) and sulphur (S) levels were assessed with regard to the schedule of critical soil test levels in table 1, which take account of soil texture and phosphorus buffering index (PBI).

Table 1: Critical soil test levels used in this study.

Locality	Rainfall & Soil Type	Phosphorus (Colwell)	Phosphorus (Olsen)	Potassium (Colwell)	Sulphur (K-Cl 40)
Strathalbyn Plains	- 400-500 mm rainfall - Medium textured soil - Soil PBI: 50-100	40	16	200	10
Back Valley	- 550-700 mm rainfall - Deep acid sands - Soil PBI: <50	30	18	150	10
Inman Valley	- 550-650 mm rainfall - Medium textured soils - Soil PBI: 50-100	45	18	200	10
Middleton	- 450-550 mm rainfall - Medium textured soils - Soil PBI: 50-100	45	18	200	10
Mt.Compass Sands	- 700-800 mm rainfall - Deep acid sands - Soil PBI: <50	35	18	160	10
Meadows	- 700-850 mm rainfall - Medium textured soils - Soil PBI: 100-200	60	18	200	10
Parawa	- 700-850 mm rainfall - Medium textured soils - Soil PBI: 200-400	70	20	200	10

With regard to the levels of major nutrients (phosphorus, potassium and sulphur), paddocks were classified as follows;

- Low - If soil test level was less than 75% of the relevant critical test level
- Marginal - If the soil test level was between 75 and 90% of the relevant critical test level
- Adequate - If the soil test level was between 90 and 150% of the relevant critical test level
- High - If the soil test level was over 150% of the relevant critical test level

Paddocks were also assessed for the risk of nitrogen and phosphorus loss using the Farm Nutrient Loss Index (FNLI) Model described by Gourley et al. (2007). This model involves a computer program that uses a range of soil type, topographic, rainfall and management information to predict nutrient loss risks, either in surface runoff, subsurface lateral movements or in deep drainage. It calculates a risk loss ranking of nutrient loss, either low, medium, high or very high for each loss pathway. All study paddocks were analysed using the FNLI model, classified according to the most serious level of N and P loss risk as follows;

- Low - If the most serious nutrient loss pathway was ranked with a low risk of losses
- Medium - If the most serious nutrient loss pathway was ranked with a medium risk of losses
- High - If the most serious nutrient loss pathway was ranked with a high risk of losses
- Very High - If the most serious nutrient loss pathway was ranked with a very high risk of losses

Results and interpretations were delivered to participating farmers in written reports, together with key messages for soil and fertilizer management in 2011. Project information will also reviewed and discussed at an upcoming meeting of participating farmers and DairySA's Landcare Coordinator in May 2011.

3. OVERVIEW OF SOIL TEST RESULTS

With around 220 soil samples taken from paddocks (and sections of paddocks), this study is one of the most comprehensive studies of soil fertility across Fleurieu Peninsula dairy farms for some time, and has equipped 11 farm managers to better understand trends in soil fertility across their farms and to more efficiently select and use fertilizers on their farms. Table 2 provides an overview of test results.

Table 2: Proportion of study paddocks in each soil fertility ranking in this study (2010/11)

Soil Acidity	**Strongly Acidic** (pH < 4.9)	**Moderately Acid** (pH 4.9-5.5)	**Slightly Acid** (pH 5.6 – 6.5)	**Neutral-Alkaline** (pH >6.5)
pH $_{(Cacl2)}$	45%	30%	21%	4%
Salinity		**Not Saline** (EC < 0.20 ds/m)	**Saline** (EC ≥ 0.20 ds/m)	
EC 1:5		83%	17%	
Major Nutrients	**Low**	**Marginal**	**Adequate**	**High**
Phosphorus (P)	14%	4%	27%	55%
Potassium (K)	48%	13%	27%	12%
Sulphur (S)	31%	15%	36%	18%
Nutrient Loss Index	**Low**	**Medium**	**High**	**Very High**
Nitrogen (N)	42%	39%	19%	
Phosphorus (P)	67%	33%	-	-

Soil Acidity: This remains a significant problem on Fleurieu dairy farms, with 45% of paddocks testing as strongly acidic in this study. In the previous year's study on Mt.Jagged Group farms, 77% of tested paddocks were strongly acidic (Mitchell *et al*, 2010). Strong acidity reduces the availability of certain soil nutrients, increases levels of soluble aluminium (a plant toxin) and reduces the activity of beneficial soil micro-organisms (Kealey, 1992). Farmers have recognised these problems and understand that application of lime can reduce and counter soil acidification. However, surface-spread lime normally works slowly to boost productivity, and farmers have often preferred to re-direct fertilizer expenditure to quicker-acting major nutrient fertilizers. These study results have given farmers an increased understanding of the incidence of soil acidity, and that lime applications need to a regular feature of their fertiliser programs.

Salinity: Although a much less widespread problem, 17% of study paddocks tested at least moderately saline. This is virtually identical to the level of saline paddocks in the Mt.Jagged Group study (Mitchell *et al*, 2010). As in that study, most of paddocks identified as saline here were either irrigation pastures or low-lying flats. The measured levels of salinity here would be sufficient to reduce the growth of (at least) sensitive clover species and, for some paddocks, reduce ryegrass growth and persistence as well.

Participating farmers have taken note of where saline areas exist on their farms and are considering strategies to respond to this, by either;

- Altering grazing and fertilizer management to boost the growth (and water use efficiency) of perennial grasses,
- Considering a switch from full summer irrigation to partial irrigation, so as to reduce the total amount of groundwater salts applied to paddocks in irrigation water,
- Sowing phalaris, which has slightly improved tolerance to salinity and waterlogging than ryegrass (Watson, 1993),
- Introducing late-maturing balansa clovers to their pastures, which can tolerate moderately soil salinity (Craig and Rowe, 1998), and/or
- Revamping surface drains in affected areas.

Phosphorus: In general, participating farmers had been regularly applying P fertilizers (inputs usually between 15 and 30 kg P/ha p.a.) and have been rewarded with increased soil P test levels, and which have contributed to significant increases in measured pasture productivity on Fleurieu dairy farms (Mitchell, 2000).

This study reveals 82% of sampled paddocks now have adequate-to-high soil P levels (66% in the previous year's study), and farmers can now reduce P inputs to maintenance levels on those areas. Indeed the 55% of paddocks tested this year had sufficiently high P to allow for zero P fertilizer inputs for a year or two without any loss in productivity.

Potassium: Over half of sampled paddocks tested marginal-or-low for soil K, similar to the results on other Fleurieu farms in the previous year (Mitchell *et al*, 2010). Deficiencies were most commonly either on sandy paddocks or those used regularly for hay and silage production. Many of the paddocks used for fodder conservation have actually been receiving 80 to 100 kg K/ha p.a., and this reflects the heavy drain on soil K levels when cutting hay or silage. Affected farmers are consequently trying to (1) rotate paddocks that are used for fodder conservation if possible, and in some circumstances (2) redirect fertiliser expenditure away from P to increased K inputs targeted onto low K-testing paddocks.

For two participating farmers, low soil K may also have been due to the application of moderately salty irrigation water (>1500 ppm TDS), where dissolved cations in the water may be displacing K ions from the soil. Partly in response to this issue, one farmer has switched from full irrigation to partial (starter and finisher) watering only. The reduced total depth of irrigations would proportionately reduce the salt loading onto those paddocks and reduce K imbalances. The other participant is also considering this strategy.

Sulphur: Marginal-or-low levels of S were recorded on 45% of tested paddocks this year (58% in the previous year's study). Deficiencies were recorded on both sandier and heavier soil types, encompassing both dryland and irrigation paddocks, across the study farms. This is in spite of many participating farmers applying over 20 kg S/ha p.a. to their paddocks (usually as single super in autumn plus NPKS fertilizer in late winter).

Over the last two year, project staff and participating farmers discussed how the widespread S deficiencies **might** be due to either;

- Only 2 or 3 applications of S each year allowing for significant leaching losses (though this level of split applications would have previously been thought to be adequate to avoid such losses)
- Most S fertilizer types being used (e.g. super, NPKS blends) supply S in the soluble '*sulphate'* form, which may be increasing the risk of leaching losses
- Significant changes to our dairy pasture systems (i.e. higher overall fertilizer inputs, more intensive block grazing, more winter-active annual ryegrasses, higher nitrogen fertilizer usage) may be increasing the demand or requirement for S in our pastures
- Strong acidity reducing the availability of sulphur in our soils (Lewis, 1984).

Affected participants are considering strategies that may improve S levels in currently deficient paddocks;

- Redirecting fertilizer expenditure away from P and to extra S on several farms
- Applying less 'up-front' S fertilizer at the start of the season; instead applying smaller, less frequent applications of S during the growing season (usually as regular applications of sulphate of ammonia (SOA)).
- Considering a switch of fertilizer types, perhaps to fertilizers that supply S in the less soluble '*elemental-sulphur'* form.
- Applying more lime to correct soil acidity problems, and make existing S reserves more available in their soil.

However, in managing sulphur fertility on their farms, farmers need to be aware that SOA and elemental-S containing fertilizers have stronger acidifying effect on the soil than most other fertilizer types (Kealey, 1992). They should have an effective soil acidity management program in place prior to increasing their reliance on these fertilisers.

4. KEY MESSAGES ON INDIVIDUAL FARMS

In reviewing soil test results for individual participants, it was apparent that the key messages and resulting management changes were necessarily going to be different from farm to farm. The following notes summarise the key messages and action change suggestions for each farm;

Farm 1

- Soil acidity is NOT a problem over the farm. However this may (in part) be due to groundwater salts in the irrigation water applied to many study paddocks, which may be displacing H^+ ions from these soils.
- This is likely given many paddocks also tested as moderately saline.
- Virtually all paddocks tested low for K, again possibly due to irrigation salts displacing K^+ ions from these soils.
- Increased K fertilizer inputs are suggested for increased productivity, taking care with smaller, more frequent applications to minimize leaching losses and avoid metabolic problems in grazing cattle.
- However, partial irrigation was suggested for consideration, to reduce the total amount of irrigation water (hence irrigation salts) being applied to paddocks.
- 25% of paddocks tested low for S. Consequently, one suitable K fertiliser here could be <u>sulphate of potash</u>.
- All but one study paddock tested high for P, so there is scope here to divert fertilizer expenditure away from P to extra K and S.

Farm 2

- The soil types on this farm are prone to acidity problems, with extra risks here due to high N fertilizer inputs.
- Nevertheless, all tested paddocks tested with only moderate levels of acidity.
- This farm is a good case study where regular <u>lime</u> applications have corrected and maintained satisfactory soil pH.
- All paddocks tested satisfactory-to-high for P and there is scope to reduce (or stop) P inputs in selected paddocks without any loss in productivity for a year or two.
- K and S deficiencies were recorded on paddocks remote from the dairy shed; especially those that are cut annually for conserved silage or hay.
- Increased K and S fertilizer inputs are suggested for these remote paddocks if seeking increased productivity.
- An additional suggestion is to rotate paddocks which are used for conserved fodder each year, to reduce the K and drain on remote paddocks, and to exploit the good soil K levels in some of the nearby paddocks.

Farm 3

- Irrigation soils are slightly acidic to moderately alkaline, due to watering with known 'hard' irrigation water.
- As for Farm 1, application of 'hard' water is thought to be largely responsible for K deficiencies on 70% of irrigation paddocks.
- Soil S was low in 50% of irrigation paddocks.
- Increased K and S fertilizer inputs are justified on most irrigation paddocks, but use multiple, smaller applications during the year to minimize leaching losses and avoid metabolic problems in grazing cattle.
- Most irrigation paddocks tested very high for P, so there is scope to redirect fertilizer expenses away from P to extra K and S.
- Most dryland paddocks were strongly acidic and with low levels of P, K and/or S. Liming is justified on dryland paddocks, as are regular applications of P, K and S fertilizer, if seeking extra productivity here.

Farm 4

- Four irrigation paddocks with sandy topsoils were strongly acidic, and were also low in K and S.
- These paddocks should ideally be treated with <u>lime</u>, and justify increased K and S fertiliser inputs.
- In contrast, irrigation paddocks with heavy soils are not acidic and recorded high-to-very levels of major nutrients.
- There is opportunity to temporarily reduce (or stop) P, K and S inputs on these heavier paddocks without production losses. But several of these paddocks tested to be moderately saline, justifying the merit in partial (not full) irrigation practices here.
- Three of the 4 dryland paddocks tested were strongly acidic and ideally should be treated with <u>lime</u>.
- But most of these dryland paddocks were otherwise fertile.

Farm 5

- The two tested irrigation paddocks were not acidic and recorded high levels of P, K and S. There is opportunity to reduce (or top) PKS fertiliser inputs here for a year without any loss in productivity.
- But irrigation soils were moderately saline.
- All dryland paddocks tested satisfactory-to-high for P and S; no doubt due in part to a solid supering history here.
- But K was low in 80% of dryland paddocks. Extra dryland K inputs are justified if seeking extra productivity, but consider multiple, smaller applications to reduce K leaching losses.
- Certainly there is scope to redirect fertiliser expenditure away from P and S to extra K on dryland paddocks here.

Farm 6
- In spite of a solid liming history, half of paddocks still tested as strongly acidic.
- There is merit on this farm for an ongoing liming program, with those low pH paddocks identified as priorities.
- In spite of the light sandy soils here, fertilizer practices have achieved good P levels in most paddocks.
- But 70% of paddocks tested low for either K and/or S.
- Increased K and S inputs are justified if seeking extra productivity. Multiple, lighter fertiliser applications are suggested here to reduce leaching losses of these nutrients.
- Switch to deeper-rooted perennial pastures, again to reduce leaching losses.

Farm 7
- There are widespread soil acidity problems here, and a widespread, ongoing liming program is justified.
- All paddocks tested satisfactory-to-high for P, are there seems scope to reduce P inputs on many paddocks.
- Deficiencies of K and S were found in the same 45% of paddocks. This is largely expected if these paddocks are cut every year for silage and hay.
- If so, consider rotating paddocks which are cut for fodder each spring.
- Consider extra K and S inputs on those infertile paddocks if seeking extra productivity.
- Salinity was not a problem on this farm.

Farm 8
- 60% of dairy paddocks remain strongly acidic, encompassing dryland and a few irrigation paddocks.
- So again a widespread, ongoing liming program appears justified on this farm.
- Most paddocks, except four of the sandier, remote paddocks, have satisfactory P levels.
- However 70% of paddocks tested with serious deficiencies of the leachable nutrients K and S.
- Extra K and S inputs are justified if extra productivity is sought, but consider multiple, lighter applications to reduce leaching losses.
- Consider any options for deeper-rooted perennial pastures to reduce leaching losses on the sandy soils prevalent on this farm.

Farm 9
- The soil type on this farm is prone to acidity problems, with extra risks here due to high N fertilizer inputs.
- Nevertheless, all tested paddocks tested with only moderate levels of acidity.
- This farm is another good case study where regular liming has corrected and maintained satisfactory soil pH.
- All paddocks tested satisfactory-to-high for P and there is scope to reduce (or stop) P inputs in selected paddocks without any loss in productivity for a year or two.
- Potash deficiencies were recorded on 38% of paddocks. These are paddocks remote to the dairy shed, and most are cut every year for silage.
- Unfortunately there are limited areas suitable for fodder cutting on this farm, locking in those paddocks which HAVE to be cut.
- In this situation, extra K inputs are definitely justified on these paddocks if seeking increased productivity.

Farm 10
- Half of paddocks tested were strongly acidic, again justifying lime applications here.
- P and S levels were satisfactory-to-high over all paddocks, reflecting a solid supering history on this farm.
- There is opportunity to temporarily reduce (or stop) P inputs in some areas without any loss in production.
- However half of paddocks tested marginal-to-low for K. Most were remote or sandy paddocks.
- Increased K inputs are justified on these areas if seeking increased productivity.
- But consider options to reduce K losses on these paddocks (e.g. rotating hay paddocks each year, using multiple smaller K applications and sowing deep-rooted perennial pastures to reduce K leaching losses).
- Moderate salinity was recorded on 40% of paddocks.

Farm 11
- The majority of paddocks have moderately acid soils. Whilst satisfactory for now, an ongoing liming program is justified on the farm, where soils are ironstone-derived and prone to high aluminium levels (a plant toxin).
- 40% of paddocks were low in P, 50% were marginal-or-low in K, and 75% low for S.
- And most of the more fertile paddocks had only satisfactory (not high) levels for these nutrients.
- So P, K and S fertilisers should be applied at least at 'maintenance' rates over most paddocks.
- Extra fertiliser inputs are justified on the more infertile paddocks if seeking extra productivity.
- Soil salinity was not a problem on this farm.

5. FARM NUTRIENT MAPS

The following pages present a series of maps for each participating farms, denoting the distribution of soil acidity and P, K & S fertility levels on each property. Additional maps are also included, denoting the 'Nutrient Loss Index' ranking for N and P for each paddock.

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