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Soil Nutrient Benchmarking on Tasmanian Organic Farms

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Soil Nutrient Benchmarking on Tasmanian Organic Farms

by G Stevenson and L Burkitt

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Foreword

Productivity benchmarks are an important aid for organic farmers in improving commercial outcomes. This report brings productivity data gathered under several previous projects within Tasmania (from 1995 to present) together with contemporary data. By the publication of these figures the report seeks to initiate a national 'standardisation' of benchmarking data units within the industry, with particular emphasis on soil nutrient levels.

This study also aims to utilise historical and current soil test results from 15 farms covering a broad sector of the industry (grazing, cropping and horticulture), together with contemporary nutrient budgeting, to improve knowledge of 'closed input' production systems.

The report suggests that the findings are typical of organic systems operating in south-eastern Australia. Evidence is given that the majority of organic enterprises in Tasmania have developed systems that depend on medium to high input levels to maintain productivity.

One of the major findings of the report is that zero and low input systems are generally restricted to grazing enterprises, and are not sustainable on most soil types. However, under certain circumstances, and on some soil types, it would appear that closed-input systems are able to maintain moderate to high yields over 20 to 30 years of operation.

A disturbing finding of the report is that many intensive organic horticulture enterprises risk over-fertilising, which impacts on farm efficiency and has potential environmental consequences.

This project was funded from RIRDC Core Funds which are provided by the Australian Government.

This report is an addition to RIRDC's diverse range of over 2000 research publications and it forms part of our Organics R&D program, which aims to deliver R&D to facilitate the organic industry's capacity to meet rapidly increasing demand, domestically and globally.

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Abbreviations

BD	Bio Dynamic
DSE	Dry Sheep Equivalents
DM	Dry Matter
FTU	Full-time Unit (labour)
IFOAM	International Federation of Organic Agricultural Movements
OCT	Organic Coalition of Tasmania
TOFAS	Tasmanian Organic Farming Advisory Service
TOFM	Tasmanian Organic Farm Monitoring

Plate 1 Tasmania's organic bounty

Contents

Foreword ..... **iii**

Acknowledgments ..... **iv**

Abbreviations ..... **iv**

Executive Summary ..... **vii**

Introduction **1**

Background 1
Project Objectives 2
Project Management 2

Methodology **3**

Historical benchmarking 3
Enterprise categories 3
Soil Sampling 3
Benchmarks 5
Nutrient Budgets 6

Results and Discussion **7**

Benchmarks 7
Soil Nutrients 9
Nutrient Budgets 16

Implications **21**

Recommendations **22**

References **23**

Appendices **25**

Tables

Table 1 Soil sampling protocols for both historical and current soil samples for farms listed in Table 2 4

Table 2 Farm/paddock details 5

Table 3 Farm productivity data (1995-1998) 7

Table 4 Financial Analysis, Tasmanian organic farms (TOFM; 1997-1998) 8

Table 5 Mean (and range) of productivity, reproductive and financial data, for eight Tasmanian organic beef farms (2003) 8

Table 6 Farm Productivity and Stocking rate (2007) 9

Table 7 Soil test results for selected elements for 2007 10

Table 8 Changes in P & K over time: selected farms (0-150mm depth) 11

Table 9 Available soil phosphorus (Colwell – mg/kg) on clay and clay loam soils over time, three paddocks, Farm E. 13

Table 10 Soil carbon values from 2007 soil test results 16

Table 11 Annual nutrient budgets for the five grazing farms 16

Table 12 Annual nutrient budgets for the cropping property 17

Table 13 Soil sample analysis of available P & K for two paddocks on Farm F. 18

Table 14 Annual nutrient budgets, berry and apple farms. 18

Table 15 Annual nutrient budgets – market gardens 18

Figures

Figure 1 Available phosphorous over time, two soil types, Beef Grazing (Farm B) (0-150mm depth) 12

Figure 2 Comparison of available P on farms D and E (pdk 21) on red basaltic clay loam soils (0-150mm depth) 13

Figure 3 Available P over time, farms K (open beds) and M, (0-150mm depth) 14

Figure 4 Available soil potassium for farms D and E over time, red basaltic clay loam,'zero input' systems (0-150mm depth) 15

Figure 5 Changes in available soil phosphorus, Farm L (0-150mm depth) 20

Executive Summary

What the report is about

A small, influential sector of the organic industry believes that organic farming systems should aim for zero inputs ('closed input' systems). In Tasmania, several leading farms have adopted this philosophy for over 20 years.

Furthermore, endorsing the philosophy of closed input systems, two outstanding northern hemisphere long-term comparative studies of organic and conventional farming included 'closed' or 'near closed' input systems in their research design (Fliessbach *et al*, 2000; Peterson, Drinkwater and Wagoner, 1999), and confirmed their viability with high levels of productivity.

Within Australia, and reflecting the broader industry attitude to inputs, the National Standard for Organic and Bio-Dynamic Produce (edition 3.3, July, 2007) states that organic farming systems aim for production systems that are "…as closed as possible".

From earlier projects in Tasmania (Stevenson and Tabart, 1998), it is clear that such ideals under Tasmanian conditions are totally dependent on the level of productivity sought by the grower, and that the majority of organic farms depend on moderate to quite high levels of allowed fertiliser inputs to sustain production.

Background

This project highlighted the need for long-term projects (at least 30 years) to fully investigate the consequences of closed input systems.

The second aspect of the project is therefore directly linked with the concerns expressed above.

If the organic industry has no idea of 'typical' levels of productivity, then how might growers determine where they sit as far as levels of inputs are concerned? Additionally, within the inspection system, assessors need to know typical industry production figures to enable them to assess the amount of product to be expected off a given area.

The industry therefore needs to develop benchmarks for production, stocking rate, soil nutrient levels and inputs.

On a wider scale, industry professionals (advisers, development officers and researchers) need benchmarks for such purposes as developing industry gross margins and preparing industry development proposals. Organic growers also require reliable benchmarks to seek financial loans.

Aims/Objectives

The aims and objectives of this study were to:

- collate historical benchmark production and soil nutrient data from previous Tasmanian projects;
- continue the long-term testing of soil nutrients, and to develop contemporary nutrient budgets, on representative organic farms;
- facilitate the national adoption of industry benchmark 'units', and
- further the investigation of the long-term feasibility of closed input, commercially viable, farming systems.

Methods used

Thirteen Tasmanian organic farms were classed as high-, medium-, low- or closed-input systems within three broad enterprise categories; namely, grazing, cropping and horticulture.

Historic data (inputs, outputs and soil tests) from eight properties were collected. Contemporary data (inputs, outputs and soil tests) from those eight properties, together with five 'new' properties were collated. Nutrient budgets were calculated for each of the 13 farms (with two paddocks included on two 'key' farms).

It is considered that these farms are representative of typical organic enterprises within the higher rainfall zones of south-eastern Australia.

Throughout the project, emphasis was given to phosphorus, because

- it is recognised as the most likely element to limit production, and
- together with nitrogen is the more soluble of the major soil nutrients, and therefore can be a threat to the environment if in excess.

Results/Key findings

The results and key findings of this work are:

- The continued development of an industry archive of enterprise benchmarks;
- Low input beef grazing enterprises, with moderate productivity, were gradually depleting soil available phosphorus;
- Zero input dairy, and dairy/cropping, enterprises with moderate to high productivity, on basaltic clay loams following years of high fertiliser use (prior to conversion to organic) seem to have reached a 'balance' in available soil phosphorus following 10 years of 'mining'; and
- High input/output market gardens (both vegetable and herb) have excessively positive nutrient balances. It is considered that the excess phosphate, in particular, may be a threat to surface and possibly underground waters.

Implications

This project adds to the already extensive research that casts doubt on the validity of zero/low input systems with acceptable levels of productivity. It also further illustrates how dependent the organic industry is on soil nutrient inputs.

From this study the only enterprises that seem capable of maintaining long-term zero inputs, with reasonable levels of productivity, are grazing or mixed grazing/cropping enterprises on soils with a high sorption capability or phosphorus buffer index (PBI), such as the *ferrosols*, that had previously high levels of available soil phosphorus.

This result has implications beyond organic farms when considering the amount of phosphorus stored within farming systems on high PBI soils following extended periods of phosphate applications.

Therefore, within the limitations of the soils predominant on the Australian continent, the industry is correct in maintaining a broad philosophy on closed input systems.

However, if resources of mineral suitable for agricultural use (particularly of phosphorus) diminish worldwide, the closed input systems may become extremely important in establishing the levels of productivity that can be expected various soil types.

The highly positive nutrient balances found on intensive horticultural enterprises could threaten local streams with eutrification due to nutrient surface runoff, and lead to excess carbon being volatilised into the atmosphere as CO_2.

Recommendations

1. In order to improve nutrient budget management; the recommendations of this work are: home-made and industry composts should be routinely analysed for nutrient content.

2. Growers and advisers should be encouraged to use nutrient budgets to determine the suitability of their intended input levels and recommendations.

3. Certification inspections require intensive organic market garden/horticultural systems to present an annual soil test of the availability of the major elements to determine if nutrient 'leakage' is likely.

   Where mandatory soil tests indicate that nutrient 'leakage' is likely, growers should be asked to prepare a full nutrient budget to show where this 'leakage' is most likely to occur and how it might best be rectified.

We recommend that points 1 and 3 should be built into the certification program, acknowledging that there may be a need for training within the industry on nutrient budget procedures.

4. Intensive market garden enterprises should be encouraged to recapture, and recycle, surface runoff.

5. The assumption of the long-term viability of closed input systems, particularly in relation to phosphorus budgets, should be further considered by the organics industry, and

6. Closed input systems on high PBI soils should be further reviewed.

Plate 2 Intensive cropping - high input

Introduction

Background

Closed Input systems

While the National Standard for Organic and Bio-Dynamic Produce (Edition 3.3, July, 2007) states that organic farming aims for production systems that are "as closed as possible", many sectors of the industry firmly believe that organic systems should be entirely closed. However, others are virtually practising 'input substitution' with high levels of inputs to maintain high levels of productivity.

Research conducted in the northern hemisphere suggests that intensive, closed- to low-input organic cropping systems are economically viable over the long term (Fliessbach *et al,* 2000; Peterson, Drinkwater and Wagoner, 1999). However, research conducted in Australia suggests otherwise.

Small, McDonald and Wales (1994), researching both conventional and low input organic dairy farms in northern Victoria, reported that the low input systems were in negative phosphorus balance. Burkitt *et al* (2007) confirmed this judgement.

Similar findings were reported by Penfold *et a*l (1995), Evans *et al* (2003), and Derrick and Dumeresq (1999) in studies of broad-acre cropping systems in Australia.

All of the above studies highlight concerns over soil available phosphorus in low input organic broad-acre systems. Penfold (2000) endorsed this concern with a detailed study of phosphorus management in broadacre organic systems.

Cornish and Hollinger (2002) went further and claimed that the philosophy of closed nutrient cycles is an illusion.

Work in Tasmania (Stevenson and Tabart, 1998), suggested that closed input organic grazing systems (both beef and dairy) were 'mining' soil available phosphorus on some soil types. Notably, this study highlighted two properties that had consistently high levels of phosphorus fertiliser applications in the years prior to their conversion to organic farming.

The study by Stevenson and Tabart (1998) also showed steep increases in soil available phosphorus on intensively-managed market garden properties over 5 to 10 year periods. Furthermore, the project highlighted the need for long-term projects (at least 30 years) to fully investigate the consequences of zero/low input systems.

Benchmarking

While benchmarking more often involves financial indicators, physical farm records are important first steps in undertaking various types of detailed performance indicator assessments (Fleming et al, 2006).

Because productivity is closely linked with the level of inputs required, benchmarks of both productivity and soil nutrient levels are essential for growers to better determine the type of farming system they wish to achieve.

To be effective, such benchmarking should use uniform, nationally accepted, units to enable cross-region comparisons.

The report by Stevenson and Tabart (1998) was the first attempt to publish organic farm productivity data from within Tasmania. The publication of this information assisted in elevating the industry onto a professional agricultural platform.

Nutrient budgets

Nutrient budgets (statements of farm nutrient inputs and outputs) are also an important technique to assist in nutrient/productivity benchmarking.

There are now many studies within Australian and New Zealand reporting soil nutrient budgets from organic farms (e.g. Nguyen *et al*, 1994; Watson *et al*, 2002; Cornish and Hollinger, 2002; Berry *et al*, 2003). All of these studies have emphasised the trend for organic farms to deplete soil nutrient status, particularly available phosphorus.

In other countries, depletion of soil potassium as well as phosphorus has been recorded on a variety of organic farms (Le Clech, 2002); Askegaard M and Eriksen J, 2002; Watson *et al.* 2002; Berry *et al*. 2003) .

A detailed analysis of nutrient budgeting techniques on organic farms in temperate regions was given by Watson *et al* (2002), and emphasised the need to delineate budget boundaries in both space and time, and the need to cover 'complete' rotations.

However, few of theses studies have provided the link between the nutrient budgets and corresponding soil tests in order to demonstrate the actual, as opposed to theoretical, changes in soil nutrients over time. Availability of such complete data sets has been referred to as being of assistance to the interpretation of nutrient budgets by (Watson *et al.* 2002).

Project Objectives

The objectives of the project were to:

- collate historical benchmark and soil nutrient data from previous Tasmanian projects
- continue the long-term testing of soil nutrients, and develop contemporary nutrient budgets, on and for representative organic farms
- facilitate the national adoption of industry benchmarks and benchmarking 'units' and
- further the investigation of the long-term feasibility of closed-input farming systems that have reasonable levels of productivity.

Project Management

Thirteen Tasmanian organic farms were classified as high/medium/low – or closed-input systems within three broad enterprise categories (grazing, cropping and horticulture).

All farms were selected on the basis of being representative of the industry, and having been farming organically for at least five years.

Historic data (inputs, outputs and soil tests) from 8 properties were collated. Contemporary data (inputs, outputs and soil tests) from the historic properties (if still operational), together with those for five 'new' properties were collected. Nutrient budgets were calculated for each farm.

Methodology

Historical benchmarking

Tasmanian Organic Farm Monitoring Project (TOFM)

The Tasmanian Organic Farm Monitoring project (partially funded by the Natural Heritage Trust) ran from 1995 to 1998.

One of the first objects of the project was to recover data from a Department of Agriculture trial that was commenced on an organic dairy farm in 1976, some eight years after the farm had converted to organic production in 1968. Subsequent samples were taken on the same location in 1991 and 1997, and details of farm milk sales and stocking rate were recorded.

Over the life of the project 61 organic farms were visited, and soil samples (single samples from representative areas with no replicates and using similar techniques as listed in Table 1) were collected from 35 farms and analysed for pH, salinity, available P, K and S, and organic carbon. On some properties 'virgin' samples were collected from adjacent, undeveloped soils with similar characteristics.

Tasmanian Organic Farm Advisory Service (TOFAS)

From 1999-2002, with a further grant from NHT, the Tasmanian Organic Farming Advisory Service (TOFAS) continued the monitoring on a select sample of 11 properties from the monitoring project.

Several properties had been sold after their involvement in the TOFM, or had moved into other organic enterprises, leaving eight that were available for the current project (including two with two replicates). These data, together with five additional (contemporary) farms, allowed 13 farms (or 15 'paddocks') to be examined in detail for this project.

Enterprise categories

The farms which were divided into 3 broad enterprise groups (grazing, cropping, horticulture) as outlined in Table 2. Apart from farms B and C, all were fully dependent on the income generated by the enterprise.

All 13 farms/paddocks were considered to be representative of the organic agricultural industry in Tasmania, and had been farming organically for at least five years (with a median time of 18 years).

Soil Sampling

Details of the protocols for soil sampling, including both the historical and current samples, are outlined in Table 1. Farms D & E were converted from conventional production, so historical samples from earlier dates (Column (A), Table 1.) were used to establish a pre-organic benchmark of soil nutrients.

Table 1 Soil sampling protocols for both historical and current soil samples for farms listed in Table 2.

Protocol	(A) Historic samples (two farms - D & E)Before 1995	(B) Historic samples: (farms B, D, E, F, G, K, L & M) 1995-2006	(C) Current samples: (farms included in (B) plus 5 additional farms) 2007
Sample collection	Dept. Ag. Staff	G Stevenson	G Stevenson
Sample depth (25mm dia. core)	100mm	150mm[a]	150mm[a]
Sampling transect[b]	Zig zag	Zig zag	Zig zag
Sample replicates	Farm E: 9, Farm D: 1	3	3
Sample preparation	Sub-sampled	Sub-sampled	Sub-sampled & dried
Analysis	Colwell P & K, %OM, pH (w) & EC	Same as (A) plus S, pH (c), Ex. Cations, CEC & total P (farm E only)	Same as (B) plus Olsen P & K, P buffer and total P
Laboratory	Tas. Gov't. labs	Tas Gov't. labs	Incitec Pivot Ltd., Werribee[c]

[a] Sampling depth was increased to allow for the inclusion of cropping enterprises which commonly sample to a depth of 150mm.
[b]Transects on farms which had been previously sampled were at locations as close as possible to the historical sample site (column A).
[c]The change of laboratory was due to the closure of the Tasmanian Government laboratory.

The study includes two paddocks on two of the 13 farms because of their particular significance.

Farm E (closed input mixed dairy/cereal) has two major soil types while farm F (high input broadacre vegetables) had two paddocks with two different crops (carrots and brassicas) with varying associated cropping rotations.

Sample cores (15-20 cores per 'sample') were taken in a zig-zag fashion across sites. Each farm site was approximately 2ha (one paddock) on all of the larger properties with each replicate being from sites of approximately 0.2ha within that paddock. Specific garden beds were sampled on the intensive horticultural properties. The same transect locations were maintained for both samplings (B) and (C).

All samples were collected in mid winter (at soil moisture saturation). All samples were crumbled while wet, and mixed thoroughly with a 300g sub sample submitted for analysis. The current samples were dried to 40^0C for approximately 72hrs before shipment.

P Buffer index is a measure of the sorption of phosphorus in the soil (Burkitt et al, 2002).

Samples were analysed for Colwell (Colwell, 1963) and Olsen (Olsen *et al.* 1954) extractable P, pH (H_2O and $CaCl_2$) (ratio of 1:5 soil:water and 0.01 M $CaCl_2$) (Rayment and Higginson, 1992), cation exchange capacity and exchangeable aluminium (Gillman and Sumpter, 1986), organic carbon (C) content (Walkley and Black, 1934; Rayment and Higginson, 1992), total P (Kjeldahl N digest with Se catalyst; Rayment and Higginson, 1992).

Soil sulphur was measured using the KCl extraction method (Blair *et al.* 1991), and potassium was measured using the Colwell extraction method (Colwell, 1963).

Farm maps, GPS readings, and sketches (where necessary) were made to determine the location of all sample sites for future reference.

Table 2 Farm/paddock details

Enterprise type	Farm/paddock	Soil type	Years organic	Organic input philosophy
Grazing				
(i) Beef	A	Red clay loam & coastal sand	14	medium
	B (BD)	Red clay loam & coastal sand	18	low
	C	Yellow clay	9	low
(ii) Dairy	D	Predominantly red clay loam	30	zero
(iii) Mixed	E (Dairy/Cereal)	Red clay loam	22	zero
	(i) pdk 21			
	(ii) pdk 35	Heavy black clay	22	zero
Cropping				
Broadacre veg	F	Red clay loam	8	high
	(i) pdk. F4 South			
	(ii) pdk. F4 North	Red clay loam	8	high
Horticulture				
(i) Berry	G	Yellow clay	17	low
(ii) Apple	H	alluvium	5	high
	I	Yellow clay	5	medium
	J	Yellow clay	25	low
(iii) Market garden	K	'manufactured'	30	high
	L (BD)	'manufactured'	18	high
(iv) Herb	M (BD)	'manufactured'	26	high

(BD – Biodynamically managed)

Farms D and E were the only fully closed-input farming systems operating in Tasmania (of a total of approximately 120 certified farms) at the time.

The 'manufactured' soils referred to in Table 2 comprised primarily of years of compost added to the original soil (Farms L and M), and alluvium added to the original clay/compost with large 'capital' dressing of lime and gypsum (Farm K).

Benchmarks

Stocking rate

Stocking rates are expressed as dry sheep equivalents (DSE) representing the amount of feed required to maintain a 48kg body weight wether.

Grazing areas are calculated as those 'available' for grazing, by excluding areas of roads, shelterbelts, dams, shed and house areas from total site areas.

Productivity

Productivity is expressed as tonnes (wet weight)/hectare.

Nutrient Budgets

Outputs

The estimates of nutrient contents of products were primarily sourced from Food Standards Australia New Zealand, NUTTAB (2006), which uses data based on wet weight samples.

Other sources of information for product nutrient content wwere as follows:

- Sheep and cattle liveweight gain; 'Soil Analysis: an interpretation manual, CSIRO (1999).
- Linseed; 'Mineral content of common ruminant stockfeeds, crops and pastures, NSW DPI Primefact 522 (2007)'.
- Peppermint; Tabatabaie and Nazari, (2007).
- Sulphur contents; Masters and McCance (1939).

Inputs

The nutrient content of inputs was determined from the manufacturer's analysis, if available.

Compost was the most difficult to determine as the nutrient content varies widely, particularly if it is self-made. If reliable analysis was not available, the nutrient content of compost manufactured by Soil First (aerobic compost, certified organic; Hobart, Tasmania) and/or Powranna feedlot (predominantly cow manure and sawdust) were used.

In reports on results from soil samples, as with the nutrient budgets, major emphasis was given to phosphorus content because, from past experience and literature (e.g. Penfold, 2000; Evans *et al*, 2003), it is considered that this element is likely to be the most limiting in organic farming throughout Australia, as well as the most labile of the major elements.

The study also placed a further emphasis on potassium and sulphur because together with phosphorous, they are seen as likely limiting factors in organic farming in the Tasmanian environment. Because nitrogen soil test results were considered less reliable, little emphasis was placed on reported levels of that element.

For dairy farms, the worksheet in NutriMatch (DPI, Victoria) was utilised.

Budgets

The duration over which the nutrient budgets were calculated varied from one to six years.

A one year duration budget was chosen as being appropriate for those enterprises with simple farming systems (such as the grazing properties) which did not have crop rotations, and where there were no major changes to the farm operation.

For other situations, especially where there was a lengthy crop rotation involved (e.g. five years on farm E), or a short-term perennial planting (such as peppermint on farm M) then longer durations were thought to be necessary to best give an overview of the soil nutrient situation.

Results and Discussion

Benchmarks

Historical data

Productivity benchmark data from the TOFM Project (Stevenson and Tabart, 1998) is presented in Table 3. That data was gathered from a survey of 61 certified organic farms.

The project also collected financial data on selected properties, as summarised in Table 4. The study utilised the techniques suggested in the 'Cash Crop' and 'Livestock Enterprise Budgets for High Rainfall Districts (DPIF Tasmania, 1997) and 'Farm Business Planning' (National Bank of Australia).

All five farms surveyed in that project (see Table 4) had been organically operated for at least 5 years. Of the five farms, four were predominantly dependent on the farm enterprise for their living.

Table 3 Farm productivity data (1995-1998)

Enterprise		**No. of farms/samples**	**Stocking rate**	**Productivity (wet weight)**	
				Product	**Rate**
Grazing	Beef	6	16.7 DSE/ha		
	Dairy	3	29.6 DSE/ha	Milk fat	176.5 kg /ha
Cropping	Broadacre veg	1		Carrots:	27t/ha
	(i) Dryland potatoes	6 samples 9 samples		Kennebec Brownell	9.1 t/ha 12.9 t/ha
	(ii) Irrigated potatoes	1 sample 4 samples 7 samples 43 samples		BismarkRusset Burbank Kennebec Brownell	21.6 t/ha 28.3 t/ha 28.4 t/ha 34.9 t/ha
	(iii) Cereals	1 sample 2 samples 4 samples 4 samples 3 samples		Barley (husk less) Rye Oats (husk less) Wheat Linseed	3.2 t/ha 5 t/ha 3.2 t/ha 4.5 t/ha 2.8 t/ha
Horticulture	Market gardens	3		Mesclan salad	2.2 kg/m^2
		1		Carrots:	120 kg/m^2
		1		Garlic:	20 kg/m^2
		1		Broccoli:	0.5 kg/m^2
		1		Cauliflower:	6.9 kg/m^2
		1		Tomatoes (hothouse):	7.5 kg/m^2
	Berry	1			Blueberries: 3600 kg/ha

A further project conducted as part of the Tasmanian Organic Farm Advisory Service (TOFAS), with Natural Heritage Trust funding, collected productivity and reproductive data from eight beef farms as outlined in Table 5. Of the eight farms surveyed, only one was fully dependent on the beef enterprise earnings. All eight farms were operated as either zero- or low-input systems.

Table 4 Financial Analysis, Tasmanian organic farms (TOFM; 1997-1998)

Enterprise	Output ($/ ha)	Variable Costs ($ /ha)	Gross Margin ($/ha)	Overhead Costs ($/ ha)	Operating Costs ($/ha)	Operating Surplus ($/ha) ($/ ha)
(i) CSA Market Garden (veg) Zero input	43,750	2,939	40,811	12,281	7,063	21,469
(iii)Market garden (veg) Medium input	36,079	1,680	34,399	4,057		30,342
(iii) Blueberries (irrigated) Medium input	18,075	7,037	11,038	*	*	*
(iv) Beef, self replacing Low input	399	149	250	142	*	64
(v) Dairy Zero input	644	145	499	*	*	*

[* indicates data that was unavailable, or unreliable]

Table 5 Mean (and range) of productivity, reproductive and financial data, for eight Tasmanian organic beef farms (2003).

Item	Mean (and ranges)
Years organic	7.4 (5 – 11)
Production area (ha)	141.7 (32 - 405)
Labour units utilised (FTU's per year)	0.96 (0.4 – 1.5)
Stocking rate (dse/ha)	17.5 (2 – 32.4)
Replacement rate (%)	19.6 (8.3 – 35.2)
Calving duration (weeks)	9 (5 – 13)
Calving concentration (%) of all calves born	
1st 3 weeks	63.1 (29 – 88)
2nd 3 weeks	28.8 (13 – 63)
3rd 3 weeks	13.1 (0 – 30)
Variable costs per grazing area ($/ha)	408 (45 – 595)
LW sales (kg/ha)	342

Contemporary data (2007/2008 RIRDC funded project)

Single paddocks were chosen for soil sampling sites on each of the grazing farms as it was considered these would be representative of the overall management of such enterprises.

Two sites were chosen for Farms A and B as those beef farms had two dominant, and significantly different, soil types.

A further two farms had two paddocks included in analyses; these were considered to represent individually valuable data sources, on the basis of having different soil types (in the case of Farm E, a 'closed input' farm), or different crop rotations of significance (in the case of Farm F).

A summary of the benchmark data (productivity and stocking rate) collected during the present study, and specifically relevant to the nutrient budgets of the farms involved, is given in Table 6.

Table 6 Farm Productivity and Stocking rate (2007)

Enterprise		Farm/ paddock	Stocking rate*	Productivity Units/ha/yr
Grazing	Beef	A	27.5	470 kg lw
		B	20	395 kg lw
		C	7	78 kg lw
	Dairy	D	26	3,800 litres milk
	Mixed (dairy/cereal)	E (i)	31	4,530 litres milk Oats: 2.5tonnes Linseed: 2.0tonnes
		E (ii)		Oats: 3.0tonnes Wheat: 4.5tonnes
Cropping	Broadacre veg	F (i)		Cauliflower: 32.8tonnes
		F (ii)		Carrots: 62.0tonnes
Horticulture	Berry	G		7.6tonnes
	Apple	H		15.0tonnes
		I		33.2tonnes
		J		13.5tonnes
	Market garden	K		29.9tonnes
		L		35.6tonnes
	Herb	M		Peppermint: 30.0tonnes

*DSE/effective ha
LW

Soil Nutrients

A summary of the soil test results (for the major aspects and elements only), for the samples and analyses in the current study is presented in Table 7.

There was little variation between the three replicate samples on each of the farms, a test of the variation of the available (Colwell) phosphorous for the three replicate samples indicated a 'p' value of 0.99 (model: two-way analysis of variance of phosphorus including 'farm' and 'replicate' as sources of variance).

Noteworthy points from data include Table 7:

- The soil on Farm K is best described 'manufactured' (Table 1), being made up of the original clay and added compost, alluvium and large 'capital' dressings of lime and gypsum. Its soil characteristics differed significantly from those of other farms in the following test results:

  – mean pH readings of 7.3 and 7.6 (water), potentially due to the large inputs of both lime and gypsum;

- The hothouse soil on Farm K was also of a 'manufactured' tuype, and thisis also thought to be responsible for the high electrical conductivity, sulphur and total phosphorous results (0.37 dS/m, 66 kmg/kg sulphur and 2600 total P).

- The PBI results were closely associated with the soil types on each sample site. Burkitt *et al.*. (2002) classed PBI readings of 281-840 as 'high'.

- Very low PBI figures were recorded for the native pasture paddock on Farm C, and samples from the black coastal sands of Farms A and B.

- Results from Farm G showed high levels of aluminium (0.43 Meq/100g) and sulphur (18.3 mg/kg). The soil type (yellow clay derived from dolerite) is thought to have been associated with high levels of aluminium, however there is no ready explanation for the high sulphur levels.

Table 7 Soil test results for selected elements for 2007

Enterprise	Farm	Sample ID	pH (1:5) water	pH (1:5) $CaCl_2$	Total P mg/kg	P Colwell mg/kg	P Olsen mg/kg	PBI Buffer Index	K Colwell mg/kg	Sulfate sulfur (KCl) mg/kg	Organic carbon %
Grazing											
Beef	A (i)	Sand	6.4	5.6	390	12	6.4	26	106	6.1	7.2
	A (ii)	Clay loam	6.4	5.7	2967	95	18.9	587	470	7.0	6.1
	B (i)	Sand	6.8	6.0	503	8	4.2	44	117	5.3	4.6
	B (ii)	Clay loam	6.2	5.4	1100	16	5.2	390	427	6.9	4.8
	C		5.9	5.0	250	5	2.7	76	247	2.4	2.7
Dairy	D**		5.9	5.4	*	48	*	*	181	*	7.5
Mixed	E (i)	Clay loam	5.8	5.0	1800	40	10.4	537	833	7.7	4.4
dairy/crop	E (ii)	Black clay	5.8	5.1	1133	25	6.5	607	457	8.2	4.4
Cropping	F (i)	south	6.4	5.7	1400	75	19.6	590	210	16.0	3.5
	F (ii)	north	6.4	5.7	1400	76	18.2	690	270	17.0	3.8
Horticulture	G		5.6	4.8	870	86	25.0	477	150	18.0	4.5
Apple	H		6.1	5.4	1667	290	88.0	150	483	7.4	2.5
	I		6.9	6.2	413	88	32.0	102	247	4.4	2.4
	J		6.1	5.4	1173	167	55.9	127	523	8.6	5.8
Mkt Garden	K (i)	hot house	7.6	7.1	3433	730	159.0	480	483	66.0	5.3
	K (ii)	open beds	7.3	6.7	2600	523	144.0	283	367	7.8	3.3
	L		6.3	5.6	910	240	71.5	110	420	5.4	3.3
	M		6.4	5.8	2567	427	117.0	317	637	4.5	5.9

[* not analysed] **historical data

Changes over time

Results of soil tests for phosphorous and potassium levels on four farms at different sample times are summarised in Table 7. Note that only selected farm test results are shown in order to highlight important trends.

Table 8 Changes in P & K over time: selected farms (0-150mm depth).

Farm/paddock		**Element: Test results (colwell – mg/kgm)**				
Farm B		**1997***		**2007**		
(i) Coastal sand	P	17		8		
	K	110		117		
(ii) Clay loam	P	36		16		
	K	442		427		
Farm D		**1976***		**1991***		**1997***
	P	81		38		48
	K	292		285		181
Farm E		**1979***	**1997***	**1999***	**2002***	**2007***
(i) pdk 21	P	69	61	39	38	40
	K	234	452	428	453	833
Farm K		**1997**		**2007**		
Open beds	P	320		523		
	K	109		367		
Farm M		**1997***		**2007***		
	P	352		427		
	K	548		637		

[*G Stevenson, unpublished data]

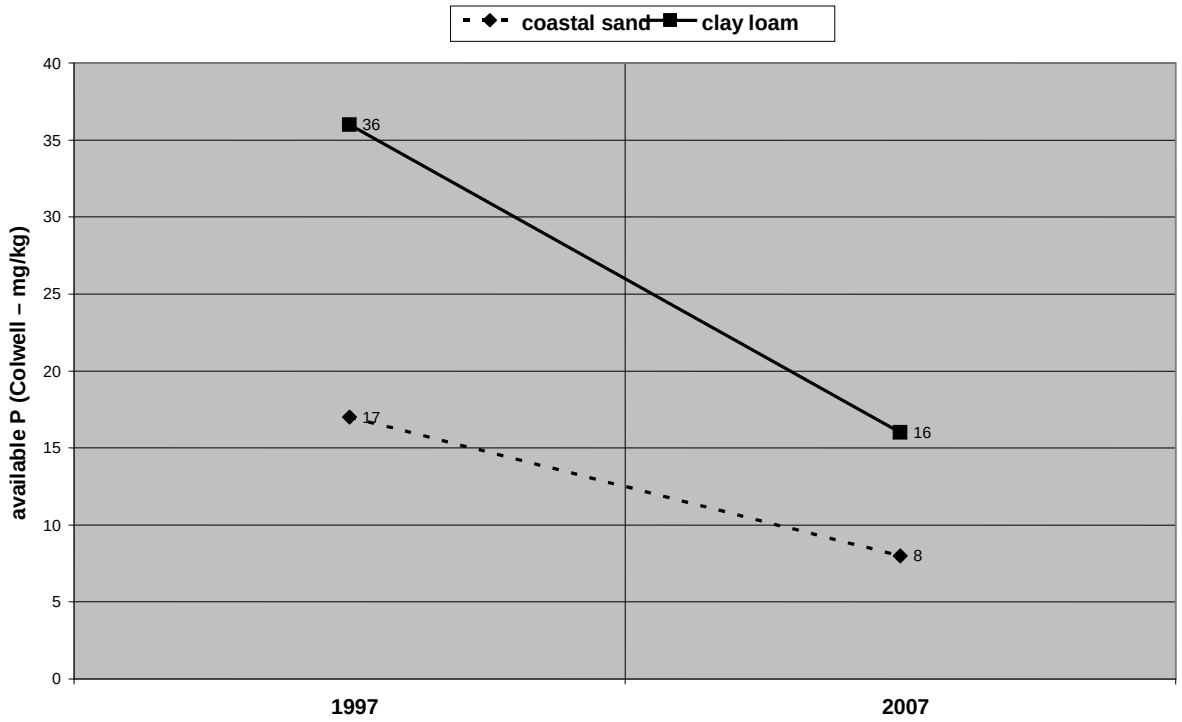
Phosphorous

We propose that three distinct trends in soil phosphorous levels can be distinguished from these data.

Trend A: Soil phosphorus depletion.

On the low-input beef enterprise (Farm B, both soil types) available phosphorous is being depleted steadily (Figure 1).

Figure 1 Available phosphorous over time, two soil types, Beef Grazing (Farm B) (0-150mm depth)



Trend B: 'Equilibrium' in available phosphorus on closed input systems?

There is evidence from Farms D and E, including from three separate sample sites on Farm E (paddocks 1, 21 & 33), that a 'balance' in available soil phosphorus may have been attained following a steep decline over a period of approximately 15 years after conversion to organic farming (Figure 2).

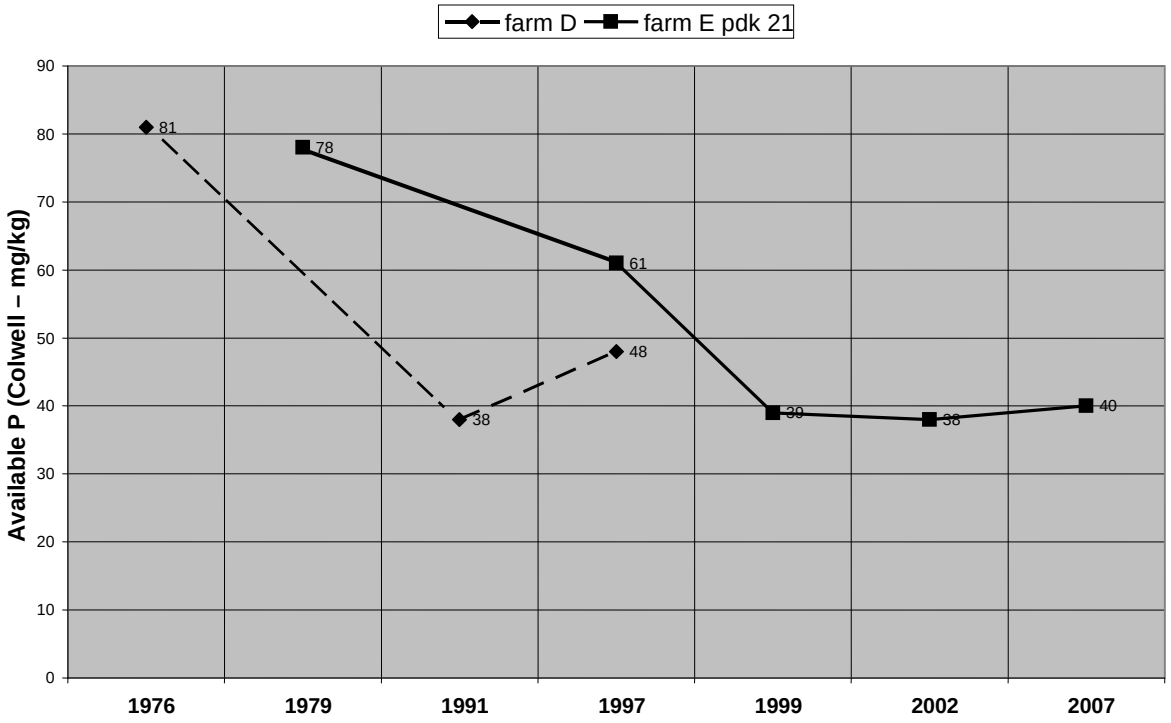
There are several points to be noted for sample sites on both farms D and E;

- the soils at both sites red basaltic clay loams (*ferrosol*), known to have high levels of phosphorus retention (the P buffer indexes for Paddock 21 is 537);
- both sites started with high levels of available phosphorous (Colwell, 81 & 78 mg/kg) after use under conventional farm practice regimes preceding their conversion to organic systems;
- each paddock had initial sharp declines in soil phosphorus (over a period of approximately 15 years following conversion to organic farming systems, and
- declines at both sites appeared to have then levelled out (as suggested on Farm D, and confirmed with three subsequent soil tests on Farm E in subsequent years.

Undoubtedly, as both farms had high levels of available phosphorus at the commencement of organic farming, there was a high level of phosphorus adsorbed to the clay in these *ferrosol* soils (in 1996 Paddock 21 (Farm E) had a total soil phosphorus concentration of 1377 mg/kg G Stevenson, unpublished data).

Unfortunately it was not possible to determine if Farm D would follow the trend of Farm E as it was sold in 1998, and is no longer farmed organically.

Figure 2 Comparison of available P on farms D and E (pdk 21) on red basaltic clay loam soils (0-150mm depth)



The observed 'levelling out' in available soil phosphorus may be an indication that both farms had reached an equilibrium in the soil phosphorus cycle of outputs and inputs.

Two other paddocks on Farm E that have also been sampled (Paddocks 1 – clay/loam soil type and 33 - heavy clay soil type), showed a similar trend to Paddock 21. The data for all three are listed in Table 9.

Table 9 Available soil phosphorus (Colwell – mg/kg) on clay and clay loam soils over time, three paddocks, Farm E.

Year	**Paddock 1** Basaltic clay loam	**Paddock 21** Basaltic clay loam	**Paddock 33** Heavy black clay
1979**	69	78	*
1997**	64	61	28
1999**	30	39	23
2002**	32	38	24
2007	*	40	25

* data unavailable
** source : G Stevenson, unpublished data

Over its 30 years of organic operation, Farm D is estimated to have exported >100,000 kg phosphorus. Two possible explanations are put forward to explain how it may have therefore attained an 'equilibrium' of around 40mg/kg available phosphorus without the use of fertilisers, namely:

- the practice of 'lax' grazing (with post-grazing residues of well over 1500kg dm/ha) and the presence of deep rooted species (particularly *Plantago lanceolata* and *Trifolium pratense*) in what

would generally be termed a ‘weedy’ pasture, allowed deep root penetration to access sub-soil nutrients, and/or

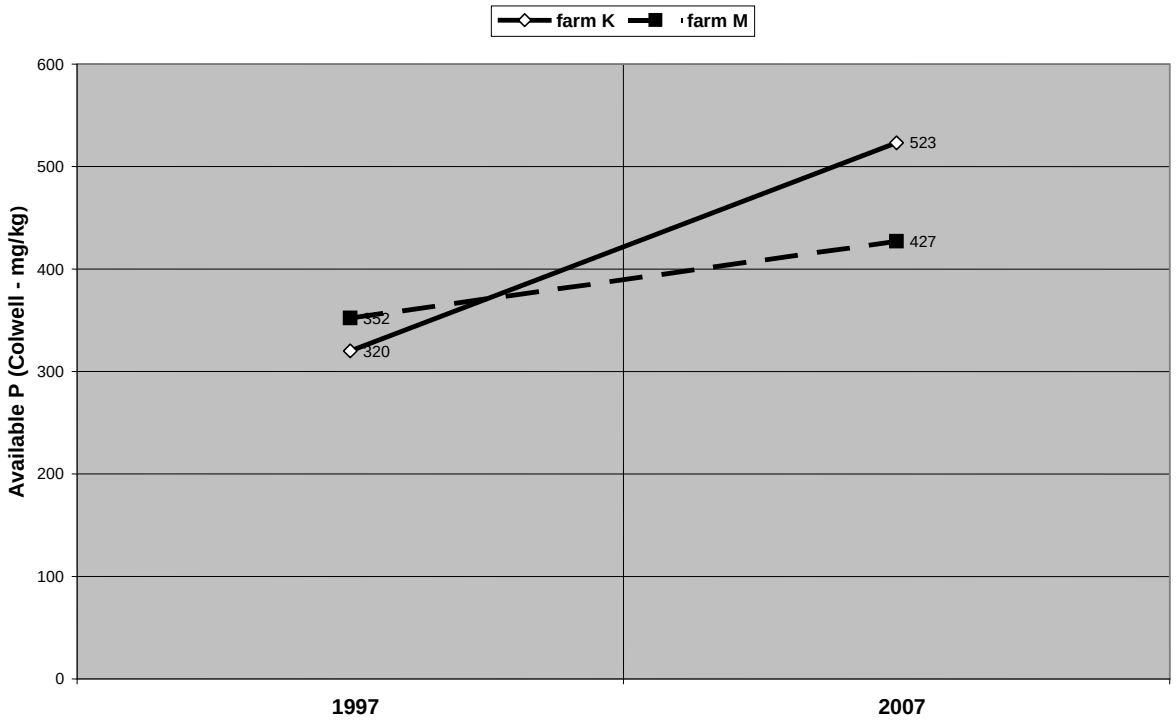
- the absence of pesticides and herbicides (and soluble fertilisers), while not perhaps making a significant difference in the total mass of microflora/fauna, might promote the mineralisation of soil phosphorus, particularly by soil mycorrhizal fungi (Ryan *et al*. (2000).

Total soil phosphorus readings for Paddocks 21 and 33 in 1997 were 1377 and 1800 (mg/kg) respectively, while tests in 2007 showed levels of 1800 and 1133 mg/kg (G Stevenson, unpublished data).

Trend C: Excessive soil available phosphorus on market gardens

The three intensively managed market gardens all showed substantially increased levels of phosphorus over the test period. This steady increase is illustrated in Figure 3. The inputs (kg/ha/yr), and implications, are outlined in the nutrient budgets (Table 10) and discussed in that section.

Figure 3 Available P over time, farms K (open beds) and M, (0-150mm depth)



Potassium

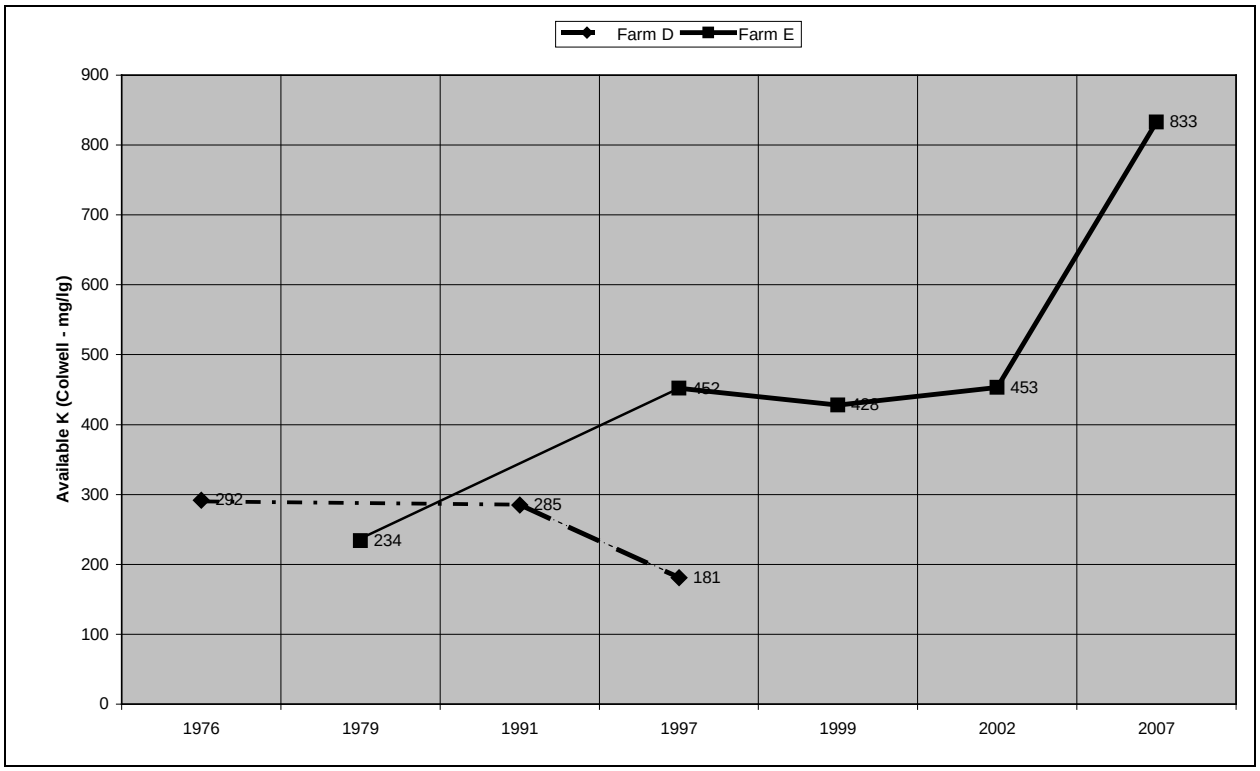
On the two grazing farms sampled over time Farms B [coastal sand, low input] and D [clay loam, zero input]; Table 8) available soil potassium declined slightly over the time of the soil tests.

On Farm D (see Figure 4) despite the removal of 13 crops of hay from the paddock between 1976 and 1997, the results show a reduction in potassium levels far below what would be expected. This may support the observations of Burkitt *et a*l (2007) showing that organic/biodynamic zero-input practices maintained soil potassium concentrations within acceptable industry levels.

The rollercoaster changes in available potassium on Farm E (paddock 21, red clay loam, Figure 4) is difficult to explain.

Consistent with the increase in available phosphorus on the three market gardens, the reading of available soil potassium also increased reaching peak readings of 730, 548 and 808 (mg/kg Colwell) on farms K, L and M respectively.

Figure 4 Available soil potassium for farms D and E over time, red basaltic clay loam,'zero input' systems (0-150mm depth)



Sulphur

All readings were normal (mean of 8.3 mg/kg, excluding Farm K) apart from the very high reading on the 'manufactured' hothouse soil on Farm K (66 mg/kg) which has had a history of high sulphur readings which are assumed to have been caused by the ingredients, particularly gypsum (17% S).

Soil acidity

Apart from Farm K, most farms do not regularly apply lime and yet maintain low soil acidity with an overall mean pH (in water) of 6.3.

The soil acidity results from the Organic Farm Monitoring project (105 samples analysed in 1996) was 5.8 (in water).

Following the only application of lime soon after conversion to organic systems in 1976, the soil tests from Farm D indicated pH readings slowly increasing over 20 years with tests indicating pH: water of 1997: 5.7, 1991: 5.8 and 1997: 5.9. This reduction in acidity may be due primarily to the slow release of surface spread lime rather than any 'natural' sweetening of the soil.

Organic carbon

The 2007 soil test results for soil carbon are listed in Table 10

Table 10 Soil carbon values from 2007 soil test results

Enterprise	Mean soil carbon (%)	Range soil carbon (%)
Grazing	5.1	2.4 – 8.3
Cropping	3.6	3.3 – 4.1
Market gardens	4.7	3.1 – 6.3

The highest value for the grazing enterprises (8.3%) was recorded on black coastal sands.

The soil carbon test for the grazing properties is a possible indication of their carbon storage equilibrium for their specific soil type under organic management (Sparling *et al*. 2003).

Nutrient Budgets

To enable comparisons, all budgets have been reduced to an annual figure, despite the duration of the budget (see budget calculation in Appendices).

Grazing and mixed grazing/cropping farms

Table 11 Annual nutrient budgets for the five grazing farms

Farm	Budget duration (years)	Inputs kg/ha/yr				Outputs kg/ha/yr				Nutrient budget kg/ha/yr			
		N	P	K	S	N	P	K	S	N	P	K	S
A	1	3.4	13.3	15.3	3.5	9.9	3.4	0.9	0.7	-6.5	9.9	14.4	2.8
B	1	1.7	0.4	7.1	1.8	8.3	3.2	0.7	0.6	-6.6	-2.8	6.4	1.2
C	1	3.7	0.4	2.5	0.4	8.2	3.1	0.7	0.6	-4.5	-2.7	1.8	-0.2
D	1	0	0	0	0	38.3	9.7	21.4	3.2	-38.3	-9.7	-21.4	-3.2
E (i)	5	0	0	0	0	40.5	7.2	8.8	2.6	-40.5	-7.2	-8.8	-2.6
E (ii)	5	0	0	0	0	26.9	8.8	11.8	3.6	-26.9	-8.8	-11.8	-3.6

Nitrogen

All 5 farms (six paddocks) are negative for nitrogen. This may be in part because the budgets do not take into account the nitrogen fixed by legumes in pasture (and green manures), a point highlighted by Nguyen *et al* (1995) in a study of nutrient balances on organic mixed farms in New Zealand, and by Watson *et al* (2002) in their review of organic nutrient budgeting techniques.

The higher figures for Farms D and E are indicative of their higher levels of productivity (dairy and mixed farming systems).

Phosphorus

All farms, apart from the moderate input Farm A, are negative for phosphorus. This trend has also been shown for farm B in the soil nutrient section (3.2).

The balance for dairy/cropping farms [Farms D, E(i) and E(ii)] is lower than that recorded by Burkitt *et al* (2007), which showed an average negative balance of -17kg P/ha/year for 10 low input dairy farms in northern Victoria and southern NSW. That study included losses of P in surface water runoff

and due to sorption reactions, which were not included in this study, and may therefore explain much of the difference.

The three zero input farms/paddocks, with reasonably high levels of production, and which have clay loam/clay soils [Farms D, E (i) and E (ii)] have smaller negative balances of phosphorus.

From the soil nutrient tests over time (Section 3.2), these soils seem to have reached an 'equilibrium' in their phosphorus cycles, adequately 'replacing' the lost phosphorus from soil mineralisation.

Potassium

The three beef farms (Farms A, B and C) have small surpluses for this element, while the dairy and mixed farms have moderate negative balance.

A major part of the loss of potassium on Farm D is most likely due to the non-recycling of the dung from the yards at milking. The cropping cycle on Farm E accounts for much of the potassium losses on those two paddocks.

The coastal beef properties (Farms A and B) would receive significant mineral depositions from sea spray, particularly potassium, a point emphasised by Watson *et al* 2002.

Sulphur

The two farms (three paddocks) with the highest stocking rates (Farms D and E) show moderate budget losses of sulphur. This may be significant over a longer time span as this element was always present in the superphosphate applied regularly before conversion to organic systems.

The two coastal farms (Farms A and B) have small sulphur balances as they are immediately adjacent to the beach and sea spray would add this element to their pastures.

Cropping farms

Table 12 Annual nutrient budgets for the cropping property

Farm	Budget duration (years)	Inputs kg/ha/yr				Outputs kg/ha/yr				Nutrient budget kg/ha/yr			
		N	P	K	S	N	P	K	S	N	P	K	S
F (i)	2	17.3	37.5	62.0	30.2	35.4	9.8	70.0	2.0	-18.1	27.7	-8.0	28.2
F (ii)	2	32.1	65.3	140.0	49.0	62.1	16.5	101.2	30.1	-30.0	48.8	38.8	18.9

These two paddocks have large nutrient divergences over the two years analysed, and undoubtedly reflect their position within the overall crop rotation on the property. A longer analysis (say 5 years) would be more appropriate.

These surpluses do not show up in the soil tests conducted since the conversion of the farm to organic systems as outlined in Table 7 (P colwell of 75 and 76 mg/kg) which suggest that the nutrient inputs and outputs, over the 7 years since conversion to organic systems, is being well managed within the high input/output philosophy.

Table 13 Soil sample analysis of available P & K for two paddocks on Farm F.

Paddock/year	P (mg/kg Colwell)	K (mg/kg Colwell)
F (i) 2000	69	160
2002	82	220
2007	75	210
F (ii) 2000	89	360
2002	92	350
2007	76	270

Horticulture – berry and apple farms

Table 14 Annual nutrient budgets, berry and apple farms.

Farm	Budget duration (years)	Inputs kg/ha/yr				Outputs kg/ha/yr				Nutrient budget kg/ha/yr			
		N	P	K	S	N	P	K	S	N	P	K	S
G	4	0.3	2.6	6.2	3.0	5.0	0.5	3.3	0.8	-4.7	2.1	2.9	2.2
H	6	40.7	28.8	18.7	13.4	7.5	1.2	13.7	0.6	33.2	27.6	5.0	12.8
I	1	13.0	9.0	5.0	3.0	16.6	2.7	30.2	1.2	-3.6	6.3	-25.2	1.8
J	6	4.8	2.5	2.1	0.9	1.1	0.2	2.1	0.1	3.7	2.3	0	0.8

The budget for the berry enterprise (Farm G) was taken over 4 years as there had been two owners over that period and the new owners were just settling into their own input regime.

The budget for Farm H was calculated over 6 years because the farm was in a phase of capital dressings (having been just recently converted to organic).

Unless there are significant changes occurring, one year budgets should be quite adequate for horticultural enterprises (similar to grazing farms).

Horticulture – market gardens

Table 15 Annual nutrient budgets – market gardens

Farm	Budget duration (years)	Inputs kg/ha/yr				Outputs kg/ha/yr				Nutrient budget kg/ha/yr			
		N	P	K	S	N	P	K	S	N	P	K	S
K	1	287	53	205	22	147	15	103	14	140	38	102	8
L	1	620	371	557	124	78	18	75	4	542	353	482	120
M	6	279	154	127	54	25	5	38	*	254	149	89	*

[* sulphur content of produce unavailable]

Actual application rates were difficult to determine as there were few current tests available for the nutrient content of the composts (the major input on all three farms), and the amounts applied were expressed as a volume rather than by weight.

Wells *et al* (1996) recorded similar N inputs (276 kgN/ha) and significantly higher P inputs (683 kg/ha), mainly as composted shredded wood and rock phosphate, for organic market garden research on sandy soils in NSW. The study was also concerned with nutrient leaching from such high inputs and warned of over-fertilising (Wells *et al*, 2002).

Farms K and M had similar levels of inputs (application rates of compost were 20,280 and 20,833 kg/ha/yr) while Farm L was far greater with 136,500 kg/ha/yr. These different application rates are reflected in the budget surpluses.

Furthermore, Farm L had quite a low PBI level (110) allowing a greater portion of the excess P to be leached from the topsoil.

These results were endorsed by the soil sampling over the same period as the budgets. Farms K and M show a rate of available phosphorus increase of 20.3 and 7.5 mg/kg/yr respectively, over a 10 year period.

Following the 1996 tests, the grower on Farm L reduced levels of inputs, resulting in a drop in the available phosphorus levels from 805 to 240 mg/kg by 2007, which would still seem to be too high (see Fig. 5).

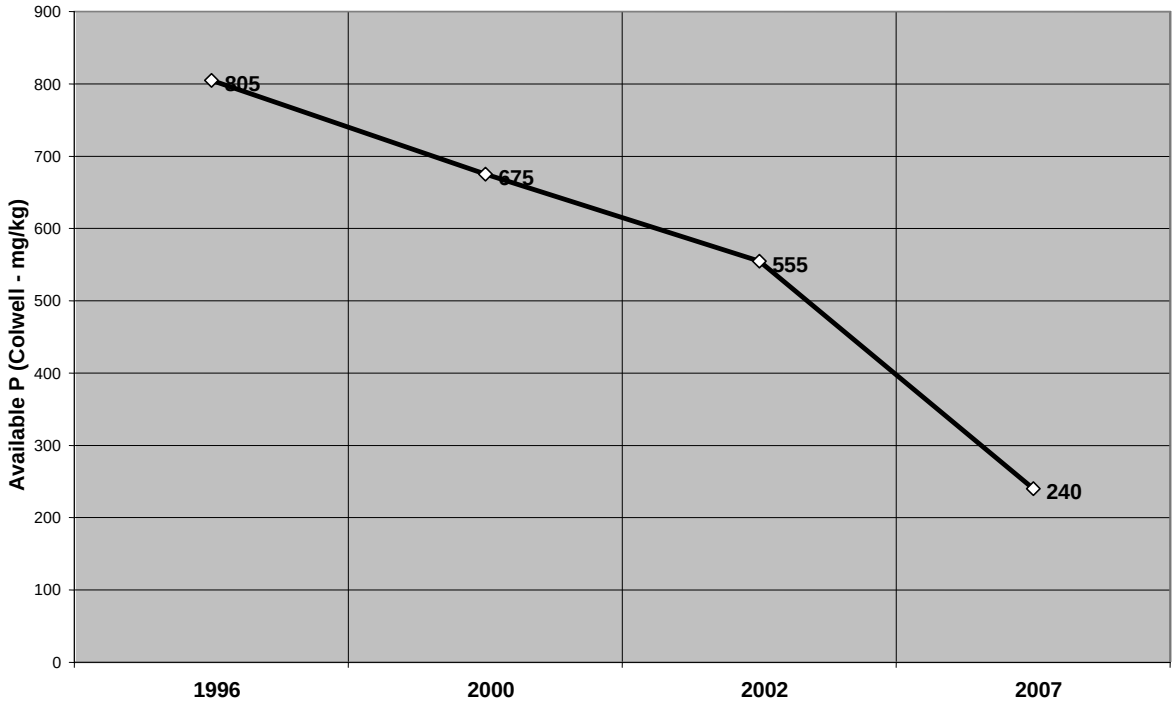
Interestingly, none of the farmers on these three farms (K, L and M) have any evidence of retarded plant growth or mineral deficiencies despite such high level of available phosphorus.

Soil tests on this area in both 1996 and 2007 showed quite normal sulphur levels (6 and 5.4 mg/kg respectively) despite the very high budget surplus (120 kg/ha S/yr). Perhaps much of this sulphur is in an organic form and is not reflected by the KCl test?

Irrespective of their input amounts, all three farms had exceedingly large nutrient budget surpluses resulting in very high levels of available phosphorus (523, 805 and 427 mg/kg Colwell).

Although nutrient budgets for carbon were not calculated, considering the uniformly high positive budgets for the major elements, it is suggested that carbon would also be in excess, and thereby leading to the release of carbon to the atmosphere as CO_2 (Cotching, *pers. comm*.)

Figure 5 Changes in available soil phosphorus, Farm L (0-150mm depth)



None of the three growers are aware of any problems with the growth of their crops at such high nutrient levels, with no indications of other element deficiencies.

Implications

This project adds to the already extensive research that casts doubt on the validity of zero/low input systems with acceptable levels of productivity. It also further illustrates how dependent the organic industry is on soil nutrient inputs.

From this study the only enterprises that seem capable of maintaining long-term zero inputs, with reasonable levels of productivity, are grazing or mixed grazing/cropping enterprises on soils with a high sorption capability (PBI), such as the *ferrosols*, that had previously high levels of available soil phosphorus.

This result has implications beyond organic farms when considering the amount of phosphorus stored within farming systems on high PBI soils following extended periods of phosphate applications.

Therefore, within the limitations of the soils that predominate on the Australian continent, the industry is correct in maintaining a broad philosophy on closed input systems.

However, if resources of mineral suitable for agricultural use (particularly of phosphorus) diminish worldwide, the zero input systems may become extremely important in establishing the levels of productivity that can be expected from various soil types.

The highly positive nutrient balances found on intensive horticultural enterprises could threaten local streams with eutrophication due to nutrient surface runoff and excess soil carbon may be volatilised as CO2.

Recommendations

1. In order to improve nutrient budget management; the recommendations of this work are: home-made and industry composts should be routinely analysed for nutrient content.

2. Growers and advisers should be encouraged to use nutrient budgets to determine the suitability of their intended input levels and recommendations.

3. Certification inspections require intensive organic market garden/horticultural systems to present an annual soil test of the availability of the major elements to determine if nutrient 'leakage' is likely.

   Where mandatory soil tests indicate that nutrient 'leakage' is likely, growers should be asked to prepare a full nutrient budget to show where this 'leakage' is most likely to occur and how it might best be rectified.

We recommend that points 1 and 3 should be built into the certification program, acknowledging that there may be a need for training within the industry on nutrient budget procedures.

4. Intensive market garden enterprises should be encouraged to recapture, and recycle, surface runoff.

5. The assumption of the long-term viability of closed input systems, particularly in relation to phosphorus budgets, should be further considered by the organics industry, and

6. Closed input systems on high PBI soils should be further reviewed.

Plate 3 Herb garden – low to moderate inputs

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Appendices

For details of each farm, refer to Tables 2, 3 and 6 in the Results and Discussion section..

Farm A

Nutrient Imports			kg/ha/yr	
	N	P	K	S
Kelp liquid (20l/ha) raw kelp at 8%	0.02	0.01	0.08	0.02
Kelp stock feed (270kg/ha)	3.24	0.7	14	3.5
Fish emulsion (5l/ha)hay pdks	0.13	0.07	1.25	
Gypsum + rock phosphate mix				
(100kg/ha/yr @ typical 12.5%P		12.5		
Total imports	3.4	13.3	15.3	3.5

Nutrient Exports			kg/ha/yr	
	N	P	K	S
Beef cattle sales				
470 kg lw/ha/yr	9.9	3.4	0.9	0.7
Total exports	9.9	3.4	0.9	0.7

Nutrient Balance			kg/ha/yr	
	N	P	K	S
	-6.5	9.9	14.4	2.8

Farm B

Nutrient Imports			kg/ha/yr	
	N	P	K	S
Kelp liquid (30l/ha) raw kelp	0.03	0.01	0.11	0.03
Kelp stock feed (130kg/ha/yr)	1.62	0.4	7	1.8
Total imports	1.7	0.4	7.1	1.8

Nutrient Exports			kg/ha/yr	
	N	P	K	S
Beef cattle sales (dressed weight)				
395 kglw/ha	8.3	3.2	0.7	0.6
Total exports	8.3	3.2	0.7	0.6

Nutrient Balance			kg/ha/yr	
	N	P	K	S
	-6.6	-2.8	6.4	1.2

Farm C

Nutrient Imports			kg/ha/yr	
	N	P	K	S
purchased hay (ave. over 4 years)				
149kg dw/ha/yr	3.7	0.4	2.5	0.4
Total imports	3.7	0.4	2.5	0.4

Nutrient Exports			kg/ha/yr	
	N	P	K	S
Beef cattle sales (live weight)				
392kg/ha (ave. over 4 years)	8.2	3.1	0.7	0.6
Total exports	8.2	3.1	0.7	0.6

Nutrient Balance			kg/ha/yr	
	N	P	K	S
	-4.5	-2.7	1.8	-0.2

Farm D

Nutrient Imports			kg/ha/yr	
	N	P	K	S
fertilisers	0	0	0	0
bought in feed	0	0	0	0
Total imports	0	0	0	0

Nutrient Exports			kg/ha/yr	
	N	P	K	S
3,800l/yr	16	3.8	5.3	1.2
culls: 20 cows at 400kg/yr	8	3	0.7	0.6
dairy effluent lost	14.3	2.9	15.4	
Total exports	38.3	9.7	21.4	3.2

Nutrient Balance			kg/ha/yr	
	N	P	K	S
	-38.3	-9.7	-21.4	-3.2

Farm E (i)

Nutrient Imports			kg/ha/5 years	
	N	P	K	S
cropping	0	0	0	0
dairying	0	0	0	0
Total imports	0	0	0	0

Nutrient Exports			kg/ha/5 years	
	N	P	K	S
Dairy				
Milk at 4,520l/ha x 5 at 60%				
(40% of time to crop) = 13,560l	56.9	13.6	19.0	4.3
est 10% of effluent 'lost'	1.4	0.3	1.5	0.1
Cereals				
oats @ 3t/ha	56.4	12.3	9.4	4.5
wheat @ 4.5t/ha	87.8	10	14.3	4.2
Total exports	202.5	36.2	44.2	13.0
kg/ha/yr	40.5	7.2	8.8	2.6

Nutrient Balance			kg/ha/5 years	
	N	P	K	S
	-202.5	-36.2	-44.2	-13.0
kg/ha/yr	-40.5	-7.2	-8.8	-2.6

E (ii)

Nutrient Imports			kg/ha/5 years	
	N	P	K	S
cropping	0	0	0	0
dairying	0	0	0	0
Total imports	0	0	0	0

Nutrient Exports			kg/ha/5 years	
	N	P	K	S
Milk at 4,520 x 5 @ 40%				
(60% of time to crop) = 9,040l	37.9	9.0	12.7	2.9
est 10% of effluent 'lost'	1.4	0.3	1.5	
Cereals				
oats x 1.2 crops @ 2.5t/ha	56.4	12.3	9.4	4.5
linseed at 2,000 kg/ha		18	29	8.7
winter wheat @ 2t/ha	39	4.4	6.3	1.9
Total exports	134.7	44.0	58.9	18.0
kg/ha/yr	26.9	8.8	11.8	3.6

Nutrient Balance			kg/ha/5 years	
	N	P	K	S
	-174.3	-53.5	-72	-21
kg/ha/yr	-26.9	-8.8	-11.8	-3.6

Farm F (i)

Nutrient Imports			kg/ha/2 years	
	N	P	K	S
(1) COF @ 600kg/ha	19.2	19.2	19.8	60.0
(2) sheep manure @ 500kg/ha	15.0	5.0	10.0	0
(3) sulphate of potash @ 250kg/ha	0	0	130	37.5
(4) guano @ 500kg/ha	0	60	0	0
(5) rock dust @ 750kg/ha	0	0	22.5	0.3
(6) tripple 4 @ 750kg/ha	30.0	30.0	30.0	0
(7) potassium silicate @ 500kg/ha	0	16.3	67.5	0
Total imports	64.2	130.5	279.8	97.8
kg/ha/yr	32.1	65.3	140.0	49.0
Nutrient Exports			kg/ha/2 years	
	N	P	K	S
(1) cauliflower @ 18t/ha (50% of area)	65	18	139.5	14.7
(2) cabbage @ 31t/ha (50% of area)	45	12.4	52.7	34
(3) beetroot @ 37t/ha (say 10% of yield = 3.7t/ha)	10.4	1.4	9.8	11.1
(4) sheep grazing at 30dse/ha 180kg gain (at 50g/hd/d)	3.8	1.1	0.3	0.3
	124.2	32.9	202.3	60.1
kg/ha/yr	62.1	16.5	101.2	30.1
Nutrient Balance			kg/ha/2 years	
	N	P	K	S
	-60.0	97.6	77.5	37.7
kg/ha/yr	-30.0	48.8	38.8	18.9

Farm F (ii)

Nutrient Imports			kg/ha/2 years	
	N	P	K	S
Fertilisers				
(1) COF @ 600kg/ha	19.2	19.2	19.8	60.0
(2) sheep manure @ 500kg/ha	15.0	5.0	10.0	0
(3) potassium silicate @ 1250kg/ha	0	40.6	93.8	0
(4) kelp @ 25l/ha	0.3	0.1	1.3	0.3
Total imports	34.5	74.9	123.9	60.3
kg/ha/yr	17.3	37.5	62.0	30.2

Nutrient Exports			kg/ha/2 years	
	N	P	K	S
Product sales				
(1) carrots @ 50t/ha	65.0	18.0	139.5	3.5
(2) sheep grazing at 30dse/ha				
270kg liveweight gain (50g/d gain)	5.8	1.6	0.5	0.5
Total exports	70.8	19.6	140	4.0
kg/ha/yr	35.4	9.8	70.0	2.0

Nutrient Balance			kg/ha/2 years	
	N	P	K	S
	-36.3	55.3	-16.1	56.3
kg/ha/yr	-18.2	27.7	-8.1	28.2

Farm G

Nutrient Imports			kg/ha/4 years	
	N	P	K	S
44kg potassium sulphate			22	7.9
22 kg potassium humate			2.5	
87kg soft phosphate rock		10		3.9
52l fish emulsion	1.3	0.2	0.1	0.1
Total imports	1.3	10.2	24.6	11.9

Nutrient Exports			kg/ha/4 years	
Ernie only	N	P	K	S
Product sales (blueberries)				
est. annual yield = 5,750kg				
Ernie 87% of total area = 5,003kg				
total production (4 years) 20.012kg/ha	20	1.8	13.2	3.2
	20	1.8	13.2	3.2

Nutrient Balance			kg/ha/4 years	
	N	P	K	S
	-18.7	8.4	11.4	8.7

Farm H

Nutrient Imports			kg/ha/6 yrs	
(capital dressings)	N	P	K	S
Fertilisers				
2000: coversion to organic production				
2000:10t Soil First compost	134	74	61	26
2001:750kg Fertico	23	30	15	23
2002:600klg blood and bone	21	27	3	3
2003:750kg Fertico 4-2-2	30	15	15	23
2004:600kg Organic Life	24	18	12	3.6
2005:300kg Organic Life	12	9	6	1.8
2006: nil (severe frost - no harvest)				
Total imports	244	173	112	80.4

Nutrient Exports			kg/ha/6 yrs	
	N	P	K	S
Product sales (mixed apple varieties)				
total yield (15x6) = 90t	0.1	7.2	82	
	0.1	7.2	82	

Nutrient Balance			kg/ha/6 yrs	
	N	P	K	S
	244	166	30	

Farm I

Nutrient Imports			kg/ha/yr	
	N	P	K	S
(1) composted chicken manure @ 500kg/ha				
(2) fish emulsion (Vitec) 10l/ha (negligible)	13.0	9.0	5.0	3.0
Total imports				
	13.0	9.0	5.0	3.0

Nutrient Exports			kg/ha/yr	
	N	P	K	S
Product sales				
yield 33.2t/ha	16.6	2.7	30.2	1.2
	16.6	2.7	30.2	1.2

Nutrient Balance			kg/ha/yr	
	N	P	K	S
	-3.6	6.3	-25.2	1.8

Farm J

Nutrient Imports			kg/ha/6 years	
	N	P	K	S
Vitec fish emulsion @ 83l/ha/yr	2.1	0.3	0.1	0.1
Soil First compost @ 2,000kg/yr	26.8	14.8	12.2	5.2
Total imports	28.9	15.1	12.3	5.3

Nutrient Exports			kg/ha/6 years	
	N	P	K	S
1350kg from 0.1ha (13.5t/ha)	<0.1	1.1	12.3	
	<0.1	1.1	12.3	

Nutrient Balance			kg/ha/6 years	
	N	P	K	S
	28.9	14	0	5.3

Farm K

Nutrient Imports			kg/ha/yr	
	N	P	K	S
Fertilisers				
compost (20,280kg)	244	14.8	197	20.3
blood n bone (400kg)	18.0	18.0	2.0	2.0
dynamic lifter (630kg)	25.2	20	6.1	
Total imports	287.2	52.8	205.1	22.3

Nutrient Exports			kg/ha/yr	
	N	P	K	S
Product sales (mixed vegetables)				
production(kg)/ha = 29,900kg				
	146.5	14.7	103.2	13.7

Nutrient Balance			kg/ha/yr	
	N	P	K	S
	140.7	38.1	101.9	8.6

Farm L

Nutrient Imports			kg/ha/yr	
	N	P	K	S
Compost (self made) 13600 kg/ha/yr (based on Powranna Feedlot and Soil First data)	2021	647	1257	414
	2021	647	1257	414

Nutrient Exports			kg/ha/yr	
	N	P	K	S
mesclun salad 35,600kg/ha/yr	78	18	75	4
	78	18	75	4

Nutrient Balance			kg/ha/yr	
	N	P	K	S
	1943	629	1182	410

Farm M

Nutrient Imports			kg/ha/6 years	
	N	P	K	S
Fertilisers				
compost (125,000kg/ha over 6 years)				
(based on Soil First compost)	1675	925	763	325
	1675	925	763	325
kg/ha/yr	279	154	127	54

Nutrient Exports			kg/ha/6 years	
	N	P	K	S
Product sales (peppermint)				
2 harvests per year of 250g/m2 each				
240kg over 6 years off 80m2				
30,000kg/ha	150	31	229	*
	150	31	229	*
kg/ha/yr	25	5.2	38	*

Nutrient Balance			kg/ha/6 years	
	N	P	K	S
	1525	894	534	*
kg/ha/yr	254	149	89	*

[* data unavailable]

Soil Nutrient Benchmarking on Tasmanian Organic Farms

by G Stevenson and L Burkitt

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This report is an important addition to understanding the dynamics of organic agriculture. The report brings productivity data gathered under several previous projects within Tasmania (from 1995 to present) together with contemporary data. By the publication of these figures the report seeks to initiate a national 'standardisation' of benchmarking data units within the industry, with particular emphasis on soil nutrient levels.

One of the major findings of the report is that zero and low input systems are generally restricted to grazing enterprises, and are not sustainable on most soil types. However, under certain circumstances, and on some soil types, it would appear that closed-input systems are able to maintain moderate to high yields over 20 to 30 years of operation.

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