DEPARTMENT OF
PRIMARY INDUSTRIES

Review of long-term agronomic experiments in Victoria

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Summary

DPI Victoria, through its Grains Program, funds and manages ten long-term agronomic experiments (LTAEs) in the grain producing areas of the state. These experiments were established for a range of purposes and have different histories, yet collectively they represent a major ongoing investment by DPI. In order to better integrate the experiments within the one project, and to prepare a management plan for the future, an internal review of the experiments was undertaken in late 2000/early 2001. The review team comprised four senior DPI scientists who inspected the experiments, examined relevant literature, interviewed the custodians, reviewed submissions from internal and external stakeholders and made recommendations.

Recommendations were made at two levels: general—relating to the overall management of the experiments as an integrated project, and specific—relating to specific recommendations for each individual experiment. Eighteen general recommendations were made regarding the areas of funding, general management, data collection and management, data and site access, analysis and reporting, and communication. Specific recommendations were made on each experiment. In summary, seven of the LTAEs should be continued and three should be terminated. The 18 general recommendations are summarised below:

Recommendation 1

That the LTAE network be co-funded on the basis of a 50:50 split of current (2002–2003) funding levels by the DPI Grains Program and individual institutes.

Recommendation 2

That RGL6, SR1, SCRIME, LR1, MC14, MM1 and the 'Deep Drainage Lysimeter trial' be continued and that SR2, SR3 and SR5 be terminated.

Recommendation 3

That funding be provided at least to the level to maintain the ongoing experiments and to collect the basic data required to maintain the integrity of the dataset.

Recommendation 4

The LTAEs should be managed as a network, with a designated network coordinator or project manager. Under the current structural arrangements, this role should be carried out by the Key Project Manager for Grains Natural Resources.

Recommendation 5

Each site should have a scientist as the primary custodian who oversees the operations, data collection and storage, interpretation and access to the experiment at a local level.

Recommendation 6

The custodian needs to take the advice of a management or advisory group when making strategic decisions about the experiment. This group should consist of other scientists (at the location or elsewhere) and advisors and/or farmers. To enable some consistency across the network, the network coordinator will be a member of all management groups.

Recommendation 7

Each site should have a technical officer designated to carry out all the day-to-day operations and measurements.

Recommendation 8

Protocols for each experiment need to be well documented and adhered to. Significant variations need to be referred to the advisory group.

Recommendation 9

Each site should have a weather station nearby that collects climate data that allows the results of the trials to be modelled. This includes the need for solar radiation data.

Recommendation 10

Data storage and retrieval must be improved for most sites. All data should be transferred to Access databases to allow security of storage and easy retrieval, especially after current custodians move on.

Recommendation 11

A program of soil and grain archiving needs to be implemented for all continuing sites.

Recommendation 12

It needs to be recognised that the intellectual property associated with each of the experiments belongs to the State of Victoria.

Recommendation 13

Other scientists (DPI and external) should be given access to data and/or sites, but only after individual agreements have been reached. These agreements need to consider a range of issues including the purpose for which the intellectual property is being used and the acknowledgment/co-authorship of DPI scientists.

Recommendation 14

Depending on the nature of the access and its use, this agreement may involve a payment by an external agency to DPI to help cover operating costs.

Recommendation 15

When considering access by external parties, a general principle to be adopted is that the most cost-effective way to manage a site is to maximise its outputs, not maximise the returns or income. This highlights the need to use the data already available and publish it where possible, in a journal or report.

Recommendation 16

The advisory group for each site should determine what is the best method of collating, analysing and reporting the progress of the experiment, and ensure that it is published where appropriate.

Recommendation 17

An annual report should be submitted to the Key Project Manager and relevant advisory group for each site.

Recommendation 18

Communication and publicity of the LTAEs need to be increased. They should be promoted as the 'Victorian Long-term Agronomic Experiments Network.' Summary sheets should be prepared for each LTAE and this information placed on the external DPI website.

Contents

Abbreviations

APSRU	Agricultural Production Systems Research Unit
ASPAC	Australian Soil and Plant Analysis Committee
CCN	Cereal cyst nematode
CRC	Cooperative Research Centre
GRDG	Grains Research and Development Corporation
LWA	Land and Water Australia
LWRRDC	Land and Water Resource and Development Corporation
NSCP	National Soil Conservation Program
VFF	Victorian Farmers Federation
WCFA	Wimmera Conservation Farming Association

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The custodians of the experiments (Roger Armstrong, Ivan Mock, Phil Newton and Bill Slattery) were extremely helpful to the review team in providing background information, hosting the review team during their visits, and providing follow-up information and comment where necessary. The support and cooperation of other staff at Rutherglen, Horsham and Walpeup is also gratefully acknowledged. Our thanks also go to those who provided submissions to the review, sometimes in great detail. The expert input of Dr John Ryan of the International Centre for Agricultural Research in Dryland Areas (Syria) is particularly appreciated. The review received great support from DPI's Grains Management Team, led by Phil Haines. In particular, the support of Dr Pauline Mele, as the new Key Project Manager of Grains Natural Resources, is recognised. Thank you to Kath Ferrari for word processing assistance and Leisa McCartney for editing.

Review of long-term agronomic experiments in Victoria

Michael Crawford, Rob Sonogan, Murray Unkovich and Isa Yunusa

1 Introduction

DPI Victoria, through its Grains Programs, funds a number of long-term agronomic experiments (LTAEs) throughout Victoria. These experiments are located at Horsham, Rutherglen and Walpeup and have a diversity of purpose and history. Collectively, these 10 experiments represent a major investment by DPI, yet in recent years, have had no rigorous examination of their current or potential value.

The advantage of long-term experimentation is that it allows the quantification of the impacts of management practices on soil processes which may be relatively slow in terms of change (i.e. pH, soil organic matter, microbial diversity) but are extremely important in terms of sustainable agriculture. Consequently, they are an important resource for the Grains Natural Resources key project with its objective of monitoring and minimising the impact of cropping practices on the environment.

The disadvantages of these long-term experiments are that because management practices change over time, they do not always reflect current farming practice. Further, because they have no defined 'end' to the project, many results have not been adequately published or disseminated in a form suitable for extension. A major disadvantage is their cost relative to their perceived returns.

Following a national workshop in 1994, Grains Research and Development Corporation (GRDC) and Land and Water Resources and Development Corporation (LWRRDC) (now Land and Water Association (LWA)) commissioned a review of long-term agronomic experiments in Australia (GRDC 1998). This review highlighted many similar issues (albeit at a national scale) picked up by this Victorian review. However, because of its national scale and focus, the GRDC review lacked detail of the Victorian experiments. Nonetheless, arising out of this project was the publication 'Guidelines for long-term agronomic experiments in Australia' (GRDC 1997) which provided much useful advice.

A paper was recently published in the journal *Science* (Rasmussen et al. 1998) giving LTAEs an international context and highlighting their importance 'for evaluating biological, biogeochemical and environmental dimensions of agricultural sustainability; for predicting future global changes; and for validating model competence and performance.' Both the Longerenong 'long-term rotation' experiment and the Rutherglen 'permanent top dressing' experiment are included in a list of 13 'classical' LTAEs worldwide, thereby illustrating their importance in an international context.

In order to identify an appropriate strategy for the future funding and management of Victoria's LTAEs, an internal review was undertaken in late 2000/early 2001. The following report is a summary of that review and the recommendations that have been made by the review panel. A summary description of the relevant LTAEs is found in Appendix 1.

2 Methodology

The terms of reference endorsed by DPI's Grains Management Team were as follows:

1. To document and assess the limitations and opportunities associated with experimental design, site representativeness, relevance of treatments, accuracy and adequacy of data collection, usefulness of datasets and data management strategies for each of the experiments.
2. To make recommendations regarding the prioritisation, management, data collection, and reporting requirements of existing long-term experiments.
3. To make recommendations regarding site and data access (including intellectual property issues), charges to external users, and future funding arrangements of existing long-term experiments.

The review was led by:

Dr Michael Crawford Key Project Manager (Grains Natural Resources) Rutherglen

With the support of the review team:

Mr Rob Sonogan	Senior Extension Agronomist	Swan Hill
Dr Murray Unkovich	Senior Research Scientist	Walpeup
Dr Isa Yunusa	Senior Research Scientist	Rutherglen

Input was provided to the final report by Dr John Ryan, Soil Fertility Specialist at the International Centre for Agricultural Research in Dry Areas (ICARDA) in Syria. Dr Ryan visited the LTAEs in July 2002 and provided feedback on the draft recommendations made by the review team.

In summary, the process involved a number of steps:

1. Preparation of background material and experiment descriptions
2. Inspection of experiments and interviews with custodians and other key stakeholders
3. Formulation and circulation of draft recommendations for comment
4. Submission of comments by stakeholders across Australia
5. Review of recommendations by international expert, Dr John Ryan
6. Drafting of final report.

This final report containing the recommendations of the review panel is being submitted to the Grains Industry Coordinator for his consideration.

3 General recommendations

3.1 Funding

The DPI LTAE network represents a significant scientific asset to the State of Victoria. There was much support by stakeholders, both internally and externally, for the continued support of the network in general, with strong support for some specific sites in particular. The value of this network is both current (although largely underutilised at present) and future. Increasingly, the role of LTAEs has changed from servicing production related research issues to servicing environmental and sustainability related research issues. Whilst it is uncertain exactly what the future needs will be, historic analysis points to the opportunities that a LTAE network offers in terms of addressing questions that were not imagined a decade or two earlier.

In this context, the DPI LTAE network should be seen as an asset, which should be maintained in the long-term so that it can be used as a resource to address short-term questions. The extension of this is that the ongoing presence of LTAEs in Victoria can be used as an asset to attract and support short-term projects (i.e. 1–5 years). Consequently, in much the same way as other assets are supported by DPI, so too should our network of LTAEs.

In determining who within DPI should be funding the LTAEs, the question of who would potentially benefit from this investment was considered by the panel. The main beneficiaries would be the Victorian grains industry, as represented by the DPI Grains Program, and the individual research institutes at which the LTAEs are located. The Victorian grains industry would benefit through the ability to answer emerging production and environmental issues in a timely and scientifically relevant manner. The individual institutes would benefit because the presence of these experiments at their locations gives them a competitive advantage in attracting projects (and hence revenue) to their institutes.

The response of GRDC to this review is relevant to this discussion, and serves as a useful model for funding. In their response, GRDC stated:

> GRDC accepts such experiments can provide an important component of infrastructure for experimental work, but we believe maintenance of this infrastructure is a responsibility of research providers rather than funders. Hence, the GRDC policy is not to provide general or core funding to long-term experiments. However we are prepared to contribute to maintenance of long-term sites when they are used for projects funded by the Corporation. In this case, we are willing to negotiate with research providers a proportional contribution to the continued management and use of sites during the course of the project.

Applying this model within Victoria, the Grains Program is considered a funder and the institutes as research providers. However, in a larger context, the Grains Program would be seen externally as inextricably linked with the research provider (i.e. DPI). Consequently, the most equitable arrangement should be a cost-sharing arrangement between the Grains Program and the individual institutes. In the first instance, this should be negotiated on the basis of a 50:50 split of current (2002–2003) funding levels.

Recommendation 1

That the LTAE network be co-funded on the basis of a 50:50 split of current (2002–2003) funding levels by the DPI Grains Program and the individual institutes.

In the context of limited funding, there is a very relevant issue as to which individual experiments need to be supported into the future and which experiments should be terminated. Decisions regarding this were made after considering a wide range of factors as listed in the terms of reference. It is recommended that RGL6, SR1, SCRIME, LR1, MC14, MM1 and the Deep Drainage Lysimeter Trial be continued, albeit with some alteration in some cases and with increased scrutiny and accountability in the future. In the case of MC14 and the Deep Drainage Lysimeter Trial in particular, there is a case for further review in the next two years as the results to date are analysed. It is recommended that SR2, SR3 and SR5 be terminated for reasons outlined in Section 4 (Specific recommendations).

Recommendation 2

That RGL6, SR1, SCRIME, LR1, MC14, MM1 and the Deep Drainage Lysimeter Trial be continued and that SR2, SR3 and SR5 be terminated.

The extent to which each of these experiments needs to be funded is a specific question that requires ongoing negotiation between the Grains Industry Coordinator, the relevant Key Project Manager, and the relevant custodians and Institute Directors. In negotiating this funding, a key principle should be to maintain the site and to collect the basic data required to maintain the integrity of the dataset.

Recommendation 3

That funding be provided at least to the level to maintain the ongoing experiments and to collect the basic data required to maintain the integrity of the dataset.

3.2 Management

The overall coordination and integrated management of DPI's LTAEs can be enhanced by the appointment or identification of a sub-project manager or network coordinator. There is potentially a lot of strength in managing the LTAEs as a network rather than a disparate collection of experiments. A key part of this role would be coordinating communication internally and externally, data management and access, and funding and reporting.

Recommendation 4

The LTAEs should be managed as a network, with a designated network coordinator or project manager. Under the current structural arrangements, this role should be carried out by the Key Project Manager for Grains Natural Resources.

A key issue identified by the review panel was the inconsistency of scientific supervision of sites across Victoria. In some cases, the management of the experiments have been left to technical officers or farm staff who are not well acquainted with the required scientific standards and processes. The value of LTAEs is in the consistent application of a treatment and the consistent collection of resulting datasets. This value can soon become compromised if the experiments are not well supervised at a local level.

A further consideration is that in some cases the interpretation of experiments has been ignored for years, as there is no designated scientist who has 'ownership' of the experiment. Furthermore, access to the site and to the data needs to be coordinated by one person at each site. The emphasis is on the word 'coordinated'. This does not mean that access is 'limited' to that one scientist, nor should the same scientist necessarily be solely responsible for its analysis and interpretation.

Recommendation 5

Each site should have a scientist as the primary custodian who oversees the operations, data collection and storage, interpretation and access to the experiment at a local level.

Placing the responsibility for custodianship in the hands of one person imparts on that person a high level of responsibility, both to current and to future generations of scientists. Given that some experiments have been going for more than half a century, we owe it to the scientific and farming community to ensure that significant decisions that affect the long-term credibility and integrity of a site are not made ill-advisedly.

To address this, an advisory group needs to be established for each location, to advise the custodian about management of the sites. This advisory group can be especially useful in advising on relevant weed control, disease suppression strategies or cultivar choice. In making recommendations about weed control, the need for rotation of herbicides needs to be especially considered so as to avoid the development of herbicide resistant weeds in the experiments.

Recommendation 6

The custodian needs to take the advice of a management or advisory group when making strategic decisions about the experiment. This group should consist of other scientists at the location or elsewhere, and advisors and/or farmers. To enable some consistency across the network, the network coordinator will be a member of all management groups.

With a view to maintaining the integrity of experiments and ensuring consistency of management and data collection, protocols need to be well documented for each site, and a technical officer identified at each location whose responsibility it is to carry out the day-to-day operations and measurements. These protocols need to be well adhered to, and significant variations should be referred to the advisory committee for consideration.

Recommendation 7

Each site should have a technical officer designated to carry out all the day-to-day operations and measurements.

Recommendation 8

Protocols for each experiment need to be well documented and adhered to for each experiment. Significant variations need to be referred to the advisory group.

3.3 Data collection and management

One of the most valuable aspects of the LTAEs are the datasets that they provide. These datasets are particularly important for the development and validation of computer simulation models. The use of simulation modelling in agriculture continues to increase, both for research purposes and to assist in decision support for graingrowers. It is important that these models have a high degree of accuracy and the use of long-term datasets assists in this.

Comprehensive meteorological datasets are also particularly useful when using LTAE datasets to develop or validate models, as it is important to relate the results to the climatic conditions under which they were derived. Whilst surrogate meteorological datasets can be derived from nearby Bureau of Meteorology stations, accuracy is improved when data is obtained from the site. Data that is generally required for simulation modelling including rainfall, maximum and minimum temperature and solar radiation on a daily basis.

Recommendation 9

Each site should have a weather station nearby that collects climate data that allows the results of the trials to be modelled. This includes the need for solar radiation data.

The compilation and management of datasets is also important in interpreting the results from LTAEs. Where scientists are interpreting results from LTAEs, references are made to results that were obtained many years before, often by scientists or technical officers that have long since moved on. The data is often stored in a variety of formats, both in hard copy and electronically. The security of this storage, especially when in hard copy, is not generally acceptable, given the value of the data.

Transfer of all data to a common electronic format (i.e. Access database) will allow for greater security of storage, and easier retrieval for the purposes of both interrogation by scientists and use in simulation modelling.

Recommendation 10

Data storage and retrieval must be improved for most sites. All data should be transferred to Access databases to allow security of storage and easy retrieval, especially after current custodians move on.

As new scientific questions emerge, and as technology and analytical techniques evolve, there can be value in using the LTAEs to examine trends over time. To do this effectively, it is necessary to have an archived collection of soil and grain material kept in a secure and accessible state. This does not exist for most of the sites. It is recognised that this archiving can put a huge demand on storage space, so a program needs to be developed for each location reflecting available storage capacity. However, at a minimum, the soil samples should be archived every five years.

Recommendation 11

A program of soil and grain archiving needs to be implemented for all continuing sites.

3.4 Data and site access

The Victorian network of LTAEs represent a unique asset that can provide an opportunity to investigate scientific questions in a way that is not normally available to scientists. Because of this, conflict can arise with respect to access to both the data (for further interrogation) and to the site (for sampling and/or further experimentation). There is considerable intellectual property associated with the LTAEs that has been built up through the long-term investment of state government funds. The consequence of this is that the intellectual property does not belong to any one individual, nor research institute. Nor does it belong to the scientific community in isolation.

Recommendation 12

It needs to be recognised that the intellectual property associated with each of the experiments belongs to the State of Victoria.

Recognition of the intellectual property as belonging to the State of Victoria should not limit the use of, or access to, the data or the sites. However, access to this intellectual property should only be granted after an agreement has been reached which ensures the terms of access are clear to all parties. Some of the issues to be considered in such an agreement should include (but not be limited to) the purpose for which the site or data is being used, the private benefits being derived, the reuse of the data or samples beyond their original intended use, quality assurance, the rights of DPI, recognition and acknowledgment of DPI and its scientists, and co-authorship of any resulting publications. These agreements should apply to all users of the data and/or sites, including other DPI scientists.

Recommendation 13

Other scientists (DPI and external) should be given access to data and/or sites, but only after individual agreements have been reached. These agreements need to consider a range of issues including the purpose for which the intellectual property is being used and, the acknowledgment/co-authorship of DPI scientists.

In granting access to other organisations, it also needs to be recognised that there are considerable past and ongoing costs associated with the LTAEs. These costs are related to both the management of the sites and of the data. Therefore, the agreement discussed in Recommendation 13 should also consider the size and nature of any payment to DPI associated with the access. Where the nature of the access by an external party requires that DPI incurs extra costs, over and above the ongoing management of the sites and the data, then these costs should also be met by the external party. It may be agreed that other forms of compensation may be substituted for a cash payment (i.e. access to a simulation model or to other data and sites, or co-authorship on publications).

Recommendation 14

Depending on the nature of the access and its use, this agreement may involve a payment by an external agency to DPI to help cover operating costs.

The comments and recommendations above are not designed to exclude the use of sites and/or data by external parties. In fact, it is recognised that in many cases, the best way to most effectively utilise the LTAEs is to encourage their widespread use. In some cases to date, their wider use has been hampered by the lack of reporting and publication of the sites by DPI. This should not be a deterrent to their wider use.

Recommendation 15

A general principle to be adopted in considering access by external parties is that the most cost-effective way to manage a site is to maximise its outputs, not maximise the returns or income. This highlights the need to use the data already available and publish it where possible, in a journal or report.

3.5 Analysis and reporting

A major difference between short-term experiments and long-term ongoing experiments is that the endpoint is quite clear in short-term experiments, whereas it is not in ongoing experiments. The endpoint provides a trigger for reporting or documenting the experiment, and this endpoint does not exist in long-term experiments. As a consequence, many of the Victorian LTAEs have not been scientifically reported for a number of years. This failure to scientifically assess and interpret the results limits the usefulness of the LTAEs.

Recommendation 16

The advisory group for each site should determine what is the best method of collating, analysing and reporting the progress of the experiment, and ensure that it is published where appropriate.

Along with investment comes accountability. In past years, considerable investment has been made in the LTAEs, but there has been little accountability. Each site should be reported upon annually to the relevant Key Project Manager. This report needs to summarise results obtained, the uses of the experiments for other purposes, the communication and publications associated with the sites, and any significant issues or problems that arose throughout the year. This report should also be submitted to the relevant advisory group.

Recommendation 17

An annual report should be submitted to the Key Project Manager and relevant advisory group for each site.

In undertaking this review, what became obvious was the difficulty in assessing whether an experiment had met its original objectives, when the original objectives were sometimes unknown, but more importantly, when no in-depth scientific assessment of the experiment had been undertaken for some time. Ideally, this assessment needs to be taken across all the experiments in unison, so that themes (i.e. crop yields, soil water, nutrient dynamics, organic matter, soil acidification, stubble management, soil biology, pests, diseases) can be considered holistically. An approach such as this would bring out the commonalities of the trials and highlight where discrepancies or contradictions exist. Such an integrated assessment may produce a different perspective in each trial and serve as a more reliable basis for considering the ultimate fate of the trials.

3.6 Communication

In recent years, the communication of findings from most sites to the farming and scientific communities has been inadequate. This has largely been because sites have been conducted in maintenance mode and/or no scientist has played an active role in their analysis and interpretation. There is also a difficulty in reporting LTAEs to the farming community in that some of the LTAEs are no longer directly relevant to the farming community’s interest in the latest technology and ways to increase profitability. There is often the criticism that ‘we saw this last year’ and there is nothing new coming from the experiments. Whilst this is partly true, the challenge is to interpret the lessons about natural resource management and long-term sustainability that these experiments can deliver in a way that is relevant to the farming community.

An opportunity exists to manage, promote and communicate the experiments as an integrated Victorian Long-term Agronomic Experiments Network. A report that includes the site summaries and material prepared for this review should be collated and made generally available. A series of information sheets (one double side A4 page for each of the continuing trials) can be used for visitors and interested scientists. They should be bannered under the “Victorian Long-term Agronomic Trials Network” to give some cohesion across trials. This information should also be listed on the DPI website.

Recommendation 18

Communication and publicity of the LTAEs need to be increased. They should be promoted as the Victorian Long-term Agronomic Experiments Network. Summary sheets should be prepared for each LTAE and this information placed on the external DPI website.

4 Specific recommendations

The following section details some strengths and weaknesses of each individual experiment (as judged by the review panel) along with specific recommendations. Further detail regarding each experiment can be found in the site descriptions in Appendix 1. The adoption and implementation of specific recommendations needs to be considered in consultation with the management or advisory group that is set-up for each experiment as outlined in Recommendation 6 above.

4.1 SR1

Stubble management and tillage under continuous cropping and best bet pasture-crop rotations.

Rutherglen *Established 1981* *Custodian: Phil Newton*

Strengths

- Stubble management treatments maintained for 20 years (although crops have varied).
- Has been used for a number of papers (see list in Appendix 1).
- Good quality data collected over an extended period.
- High number of replications – 8.
- Surface drain around experiment prevents excessive run-on of water.

Weaknesses

- Some plots/blocks in Reps 2, 4, 6 and 8 compromised by wet (seepage?) areas.
- Indeterminate rotations.
- Canola failure in 2000.

Recommendations

1. Define the protocols for decisions about crop rotations. Define a clear objective for the ongoing operation of the experiment.
2. Look for complementarities between SR1 and RGL6.
3. Keep Reps 1, 3, 5 and 7 as a constant – stick with a rotation.
4. Use Reps 2, 4, 6, and 8 as a different trial to examine different crop rotations under the same stubble management, especially to control herbicide resistance.
5. Maintain a legume/wheat rotation in each of the three stubble treatments, but vary crops in the other rotations to maximise production and organic carbon inputs.
6. Widen management/advisory group beyond Phil Newton and Bill Slattery.

4.2 SR2

Short-term subclover-wheat rotations under different stubble management regimes.

Rutherglen *Established 1986* *Custodian: Phil Newton*

Strengths

- Important to help understand interaction of stubble management and short-term pasture on nitrogen availability and crop yield.

Weaknesses

- Aims and objectives have changed over the years – long-term experiment value has been compromised by change of objectives and change of crops.
- Complicated design.

Recommendations

1. The treatments on this experiment have changed a number of times in response to different funding sources and objectives, and its value as a long-term experiment has been compromised as a result. Consequently, no further investment should be directed to the ongoing maintenance of this experiment. It should be terminated.
2. A final analysis of the results to date should be made and the results published in a journal paper.

4.3 SR3

Urea topdressing in the non-legume phase of a grain legume-cereal rotation under different stubble management and tillage.

Wilby (near Rutherglen) *Established 1985* *Custodian: Phil Newton*

Strengths

- No particular strengths were recognised.

Weaknesses

- Inconsistent management (i.e. Rotation changed in 1996, canola introduced in 1999, entire site burnt in 2000).
- Weed problems – herbicide resistant ryegrass.
- No security of tenure.
- Distance from Rutherglen – difficult to manage.

Recommendations

1. The treatments on this experiment have changed a number of times in response to different funding sources and objectives, and its value as a long-term experiment has been compromised as a result. The presence of herbicide resistant ryegrass, its insecurity of tenure and its distance from Rutherglen Research Institute also count against its value as a LTAE. Consequently, no further investment should be directed to the ongoing maintenance of this experiment. It should be terminated.

2. A final analysis of the results to date should be made and the results published in a journal paper.

4.4 SR5

Grain legume-cereal rotation under different stubble management and tillage.

Boweya (near Rutherglen) *Established 1987* *Custodian: Phil Newton*

Strengths

- No particular strengths were recognised.

Weaknesses

- Been in pasture since 1996.
- Weed problems – wild radish and herbicide resistant ryegrass.
- No security of tenure.
- Run-on problems – not hydrologically isolated.
- Distance from Rutherglen – difficult to manage.

Recommendations

1. This experiment has been in pasture ley since 1996 in an effort to control herbicide resistant ryegrass and wild radish. Therefore its value as a LTAE has been compromised. Further, its distance from Rutherglen Research Institute and its insecurity of tenure are major disadvantages. Consequently, no further investment should be directed to the ongoing maintenance of this experiment. It should be terminated.

4.5 RGL6

Rotations with grain legumes

Rutherglen *Established 1975* *Custodian: Bill Slattery*

Strengths

- Unique site for studying long-term impacts of pulse/cereal rotations, especially on acidification.
- Well replicated.
- Long history – 26 years.
- Good archiving of old soil samples.
- Good quality data over long period.

Weaknesses

- Lupins not widely grown anymore.
- Lupins suffering from disease and competition from herbicide resistant ryegrass.
- Small plot sizes (15 x 1.5 m).

Recommendations

1. Control weeds through the use of different herbicides.
2. Control the weeds and then reassess the vigour of the lupins in two or three years time.
3. Include root disease testing in protocols.
4. If no change in lupin growth, change from lupins to another pulse.

4.6 SCRIME

Sustainable Cropping Rotations in Mediterranean Environments

Longerenong *Established 1998* *Custodian: Roger Armstrong*

Strengths

- Good replication and large plot size.
- Treatments are relevant to contemporary cropping practices.
- Baseline soil data collected.
- Data collection designed to satisfy needs of modellers.
- Designed to answer range of questions (both known and future) on disease, nutrition, and weeds.
- Wimmera Conservation Farming Association (WCFA) involved in designing 'farmer driven treatment'.
- Continued support from WCFA.

Weaknesses

- Large number of treatments (10) leads to complexity of analysis.
- No specific question being answered.
- Short history (4 years) — no long-term trends yet.

Recommendations

1. Clearly define and document current questions and aims for benefit of future custodians.
2. Review varieties and other agronomic practices every three or six years in conjunction with private and public agronomic advisers to ensure best practice is being adopted.
3. Include assessment of nutrient removal in the 'cut and remove pasture' in baseline dataset.
4. Limit data collection to key datasets only. Definition of this to be considered by management committee.

4.7 LR1

Permanent long-term rotation (Longerenong Rotation No.1)

Longerenong *Established 1916* *Custodian: Roger Armstrong*

Strengths

- Long history – oldest cropping rotation experiment in Australia.
- Unique treatments (i.e. continuous wheat for 86 years!).
- Well known and regularly used by external agencies.
- Long-term yield trends summarised by Hannah and O'Leary (1995).
- Split into two blocks allows comparison of historic Cereal Cyst Nematode (CCN) susceptible varieties with latest CCN resistant varieties, allowing study of yield trends.
- Good value for studying soilborne diseases and organic carbon trends.

Weaknesses

- Roots of sugar gums on east side of trial impacting on Rotation 1 and 2.
- Some treatments not relevant to contemporary farming practices (may be irrelevant given the presence of SCRIME across the road).
- Historical significance has been compromised with recent change to canola from oats.
- Herbicide resistance emerging in continuous wheat.
- Poor record of sampling protocols and data storage.

Recommendations

1. Reverse decision to change from oats to canola and maintain remainder of trial as is.
2. Undertake root pruning of trees to eliminate influence on trial (this will have an effect for only a short period of time and will have to be done again, unless a physical barrier to 1 m could be installed).
3. Formalise and supervise access by Longerenong students.

4.8 MC14

Long-term comparison of rotation and fallow management practices in the Victorian Mallee

Walpeup *Established 1982* *Custodian: Ivan Mock*

Strengths

- Opportunity to look at changes in soil physical properties and organic carbon.
- Well reported by O'Connell, O'Leary and Incerti (1995) and Incerti, Sale and O'Leary (1993a, 1993b).
- Good information on chloride profile in 1990, giving information on deep drainage from 1982–1990.

- Good experimental design.
- Treatments still relevant.
- Data currently being analysed by biometrician.

Weaknesses

- No archived soil or grain samples.
- No grazing of pasture phases.
- Fallow treatment is imposed too late to be representative of farmer practice. It is 1–2 months later than farmer practice and misses out on a lot of potential extra water storage.

Recommendations

1. Analyse and report production and economic data.
2. Deep sample for chloride profile to give information on deep drainage from 1990–2000.
3. Conduct intensive sampling for physical and organic carbon properties.
4. Continue to maintain experiment as is.
5. Reassess future in two years time, after sampling.

4.9 Deep Drainage Lysimeter trial

Walpeup *Established 1993* *Custodian: Ivan Mock*

Strengths

- One of only a few lysimeter trials that exist.
- Unique opportunity for direct measurement of deep drainage.
- Newly installed automatic data loggers.
- Simple comparison of two rotations which are still relevant.
- Opportunities exist for monitoring water, nutrient and chemicals draining beyond root zone.

Weaknesses

- Unsure if system for collection of leachates is still working in the lysimeters.
- No designated scientist responsible for trial.

Recommendations

1. Need to establish if lysimeters are still working. This may require the removal of one or more lysimeter for checking and replacement in order to make an inference about the remaining lysimeters.
2. Continue experiment to validate modelled drainage.
3. Change rotations to establish drainage rates under different systems.
4. Continue for 10 years to fully quantify episodic recharge events.

4.10 MM1

Long-term permanent fertiliser experiment

Walpeup *Established 1940* *Custodian: Ivan Mock*

Strengths

- Long history of continuous fertiliser treatments.
- Large differences in Olsen phosphorus now exist (2 µg/g vs. 10 µg/g).
- Very good for looking at phosphorus dynamics – application, fixation, release-rates and processes.
- Same wheat variety (Insignia) grown since 1960 – allows potential separation of environmental from genetic influences on yield.
- Detailed paper published by McClelland (1968).
- Good replication.
- Low cost to maintain.

Weaknesses

- No archived soil or grain samples.
- Past soil sampling of surface soil only (except 1997 0–60 cm).
- No baseline or initial levels of organic carbon or Olsen phosphorus.
- No recent collation or reporting of data.
- Contamination of 'no medic' plots with medic due to communal grazing.
- Potential nutrient transfer from communal grazing.
- Eelworm now present in cereal phase.
- Single superphosphate applications not relevant to current practice.
- Herbicide resistant ryegrass.
- Narrow plots (2 m) compromise fertiliser-wheat yield response.
- Significant runoff during rainfall events.

Recommendations

1. Continue to maintain experiment as is.
2. Collate and report results to date.
3. Change variety to include eelworm resistance.
4. Undertake microbial studies related to phosphorus dynamics.
5. Remove all communal sheep grazing from the experiment to eliminate nutrient transfer.

4.11 PTD

*Permanent top dressing experiment**

Location: Rutherglen *Established 1914* *Custodian: Bill Slattery*

**not funded by Grains Program, this was included in the review at the request of the custodian.*

Strengths

- Long history of continuous fertiliser treatments vs. native pasture (87 years!).
- Large differences in Olsen phosphorus now exist.
- Very good for looking at soil acidification and phosphorus dynamics – application, fixation, release-rates and processes.
- Detailed papers published by Ridley et al. (1990a, 1990b).

Weaknesses

- Protocols poorly understood by, or communicated to, farm staff.
- UDPIplicated
- Animal movements poorly documented in recent years.
- Potential nutrient transfer from communal grazing.
- Data is all on paper. Needs to be transferred to electronic format.
- Trees at southern edge of trial influence about 10–20% of area through litter drop (nutrients) and water uptake.

Recommendations

1. Continue to maintain experiment as is.
2. Clearly define management protocols and ensure farm staff clearly understand the importance of this trial.
3. Remove all communal sheep grazing from the experiment to eliminate nutrient transfer.

References

GRDC (1998) Assessment of long-term agronomic experiments in Australia. Report of a Project commissioned by GRDC and LWRRDC. Grains Research and Development Corporation/Land and Water Resources Research and Development Corporation.

GRDC (1997) Guidelines for long-term agronomic experiments in Australia. Compiled from a Project commissioned by GRDC and LWRRDC. Grains Research and Development Corporation/Land and Water Resources Research and Development Corporation.

Hannah MC and O'Leary GJ (1995) Wheat yield response to rainfall in a long-term multi-rotation experiment in the Victorian Wimmera. *Australian Journal of Experimental Agriculture* **35,** 951-960.

Incerti M, Sale PWG and O'Leary GJ (1993a) Cropping practices in the Victorian Mallee 1. Effect of direct drilling and stubble retention on the water economy and yield of wheat. *Australian Journal of Experimental Agriculture* **33,** 877–883.

Incerti M, Sale PWG and O'Leary GJ (1993b) Cropping practices in the Victorian Mallee 2. Effect of long fallows on the water economy and the yield of wheat. *Australian Journal of Experimental Agriculture* **33,** 885–894.

McClelland VF (1968) Superphosphate on wheat: the cumulative effect of repeated applications on yield response. *Australian Journal of Agricultural Research* **19,** 1–8

O'Connell MG, O'Leary GJ and Incerti M (1995) Potential groundwater recharge from fallowing in north-west Victoria, Australia. *Agricultural Water Management* **29,** 37–52.

Rasmussen PE, Goulding KWT, Brown JR, Grace PR, Janzen HH and Körschens M (1998) Long-term agroecosystem experiments: Assessing agricultural sustainability and global change. *Science* **282,** 893–896.

Ridley AM, Slattery WJ, Helyer KR and Cowling A (1990b) Acidification under grazed annual and perennial grass based pastures. *Australian Journal of Experimental Agriculture* **30**, 539–544.

Ridley AM, Slattery WJ, Helyer KR and Cowling A (1990a) The importance of the carbon cycle to acidification of a grazed annual pasture. *Australian Journal of Experimental Agriculture* **30,** 529–537.

Appendix 1. LTAE descriptions

Description of individual long-term agronomic experiments (based on what was prepared by custodians for this review in 2000).

SR1

Crop productivity and changes in soil carbon due to stubble management and tillage under continuous cropping and best bet pasture-crop rotations.

Location: Rutherglen Established: 1981 Custodian: Phil Newton

Objectives

- To examine the long-term changes in soil organic carbon (modified Walkley-Black/Heanes method) under direct drilling and stubble retention compared to stubble burning and minimal tillage.
- To determine the long-term effects of stubble management on crop yields and crop agronomy.
- To determine long-term changes in soil structure, biology and properties due to stubble retention and stubble burning under different crop rotations.
- To publish and present findings to appropriate audiences.

Design

- Randomised complete blocks with non-orthogonal treatment representation—three plots of each main treatment and a single control treatment (seven treatments) and eight replicates (blocks).
- Main plots are randomised within each block. Plot size is 4.5 m wide by 20 m long.

Treatments

The two main treatments are direct drilled with stubble retention and direct drilled with stubble burnt. Stubble burnt at lifting of fire restrictions in April each year. Tillage commonly consists of two passes of a Konskilder scarifier within a week of sowing.

History

Stubble Retention 1 (SR1) began as Soil Fertility 10 (SF10) in 1981 with Wheat Research Council funding. Agriculture Victoria personnel included Ken Boundy, Tim Reeves, Phil Haines and Tony Ellington (deceased). Graham Steed supervised the experiment as SR1 from 1981, with wheat-lupin, lupin-wheat rotations and a continuous wheat treatment. In 1989 these treatments reverted to a grain legume-wheat rotation across all stubble and tillage treatments in each year. Visiting scientist Martin Carter published several papers with Graham Steed resulting from a two-year visit (1990–1992). GRDC funding (1993–1995) focused on investigating the 'Effects of stubble management on duplex soils' (DAV213). Phil Newton was delegated site supervision in 1994 under this project. On-going Grains Program funding of conservation cropping systems commenced in 1996, which currently includes maintenance of the long-term sites.

Excess water has affected the site in wet years. Surface drains were installed around individual plots in 1998, and interception sub-surface drains around the experiment in 2000, these have alleviated the excess water problem. The site was sown with a Ryan disc drill until 2000, when a five rank Agrowplow tyne seeder was used.

Quality of datasets

Datasets are held by the people who have worked at the site over the years. These datasets are often represented in published papers. The annual yield data and semi-regular soil data from selected replicates are available on hardcopy and computer file, and some soils are archived in long-term storage. Selected datasets from particular treatments and replicates (e.g. replicate numbers 1, 3, 5, and 7) are a better quality as there has been evidence of waterlogging damage due to runoff down the slope of the site. *Ad hoc* measurements have been taken during various times in the course of the experiment, such as agronomic variables (e.g. disease, plant numbers, weeds, dry matter) and soil strength, pH and mineral nitrogen.

Potential uses

- The current primary use of SR1 is to test the 'Carbon Manager OC' model in the measurement of changes in organic carbon for continuous cropping of grain legumes and cereal compared to the reversion to a short-term pasture phase in the rotation, which includes canola.
- The data on organic carbon is also being used to refine modelling of soil carbon changes with the 'Rothamstead OC' model as part of an international study of greenhouse gases that CSIRO is contributing to.
- Selection processes imposed by treatments could be assessed on the basis of soil microbial changes and disease levels, soil fertility requirements could be measured in conjunction with productivity.
- Examination of causes for failure of canola establishment under stubble could be linked to CSIRO research on this topic.
- Reference site for greenhouse gases.

Key findings

- Surface hydraulics and infiltration of water into stubble retained treatment more than twice that of stubble burning (Carter and Steed 1992).
- Changes of soil organic carbon (Carter et al. 1993)
- Microbial biomass and worm populations (2.5 times) greater under stubble retention than burnt and cultivated control.
- Transport of water through large pores faster under stubble retention (Carter et al. 1994)
- Significant changes in populations of soil microbes due to stubble retention and stubble burning (Mele & Carter 1999).
- Role of stubble management, tillage and grain legume-wheat rotations in foliar disease of wheat (De Boer, Steed & Macauley 1992).
- Organic carbon changes similar whether stubble is retained or burnt under direct drilling .
- The results of stubble management and tillage practices on pH, nutrient distribution and yields have been widely communicated via different publications to a range of audiences.

Relevant references

De-Boer RF, Steed GR and Macauley BJ (1992) Effects of stubble and sowing treatments on take-all of wheat in north-eastern Victoria. *Australian Journal of Experimental Agriculture* **32**, 641–644.

Carter MR, Mele PM, Steed GR (1994) The effects of direct drilling and stubble retention on water and bromide movement and earthworm species in a duplex soil. *Journal of Soil Science* **157**, 224–231.

Carter MR, Parton WJ, Rowland IC, Schultz JE and Steed GR (1993) Simulation of soil organic carbon and nitrogen changes in cereal and pasture systems of southern Australia. *Australian Journal of Soil Research* **31**, 481–491.

Carter MR and Steed GR (1992) The effects of direct-drilling and stubble retention on hydraulic properties at the surface of duplex soils in north-eastern Victoria. *Australian Journal of Soil Research* **30**, 505–516.

Gardner WK, Fawcett RG, Steed GR, Pratley JE, Whitfield DM and van Rees H (1992) Crop production on duplex soils in south-eastern Australia. *Australian Journal of Experimental Agriculture* **32**, 915–927.

Mele PM and Carter MR (1999) Impact of crop management factors in conservation tillage farming on earthworm density, age structure and species abundance in south-eastern Australia. *Soil Tillage Research* **50**, 1–10.

SR2

Nitrogen supply from short-term subclover-wheat rotations under different stubble management regimes.

Location: Rutherglen Established: 1986 Custodian: Phil Newton

Objectives

- To determine the nitrogen inputs from ungrazed subclover subjected to similar management as applied to crop stubbles (stubble retention compared to stubble burning and cultivation) for following crops of wheat.
- To determine the effects of short-term pasture stubble management on changes in soil organic carbon (modified Walkley-Black/Heanes method) after one or two years of un-grazed subclover pasture crop.
- Determine short-term changes in soil structure, disease, biology and soil properties due to stubble retention and stubble burning under different crop rotations.
- To determine the feasibility of subclover regeneration increase from recruitment of hard seeds in the residue of the previous pasture crop and subclover growth beneath the wheat crop.
- To publish and present findings to appropriate audiences.

History

Located in paddock 33 at AV Rutherglen, SR2 began in 1986 as part of the NSCP funding by Tony Ellington (deceased) and Graham Steed. It was originally designed for evaluating the efficacy of different seeders and has a range of plot widths (smallest 3 m wide x 15 m long). Visiting scientist Martin Carter published several papers resulting from a two-year visit (1990–1992), that included this site. GRDC funding (1993–1995) was to investigate 'Effects of stubble management on duplex soils' (DAV213). Phil Newton was transferred site supervision in 1994 under this project. On-going Grains Program funding commenced in 1996, which currently includes maintenance of this long-term site. Since seeder evaluation, a Duncan triple disc has been used to sow all plots at the site.

Treatments

The four main treatments are:

- direct drilled stubble retained standing
- direct drilled stubble retained shredded
- direct drilled stubble burnt (stubble burnt at lifting of fire restrictions in April each year)
- stubble cultivated into the soil with rotary hoe or offset disc plough.

Each main treatment was split for one or two years of subclover in rotation with wheat in 1995, when all plots were sown to the cultivar Trikkala.

Rotation	1995	1996	1997	1998	1999	2000
Sub-wheat	Sub	Wheat	Sub	Wheat	Sub	Wheat
Sub-sub-wheat	Sub	Sub	Wheat	Sub	Sub	Wheat

Design

Randomised complete blocks with non-orthogonal treatment representation—three adjacent pairs of plots (six plots) of each unburnt main treatment, a randomised pair of the burnt treatment and a single control burnt treatment (nine treatments). The single control is selectively excluded from analysis. There are four replicates (blocks) of the treatments. Main plots are randomised within each block and split plots randomised within each main treatment.

Quality of datasets

Datasets are held by the people who have worked at the site over the years. These datasets are often represented in published papers. The annual yield data are available on file, and some soils are archived in long-term storage. Since 1995 the focus has been on productivity and changes in available nitrogen under the subclover-wheat rotations, however, not all soil and plant data were collected in each year. Other data includes irregular measurements of penetrometer resistance, pH, rooting depth of subclover, pasture/grass biomass and subclover emergence.

Longer term datasets include repeat sampling of soil fertility during the experiment and continuous record of grain yields. Climatic data at the Rutherglen Research Institute weather station (800 m) is relevant to the site.

Potential uses

- The current primary use of SR2 is to evaluate the productivity and supply of nitrogen from ungrazed subclover residues for following crops of wheat. The current year is the last envisaged for this purpose, as the wheat rotations aligned in 2000.
- Data on organic carbon are useful for evaluating the capture of carbon in short-term rotations of ungrazed pasture.
- Disease or microbial associations with adverse effects of stubble management (wheat on subclover and subclover on wheat) in the selection processes imposed by treatments could be assessed on the site.
- The efficacy of short-term subclover pasture-wheat rotations for removal of grass weeds (herbicide resistant?) would provide a useful extension of these treatments.
- The importance of understorey growth of subclover beneath wheat in regeneration of the pasture each alternate year has yet to be determined.
- Site information has provided useful data for benchmarking rotation scenarios in the 'PRISM NE' model.

Key findings

- Crop stubble management influences subclover growth and productivity. Stubble burning increases subclover production compared to stubble retention above ground.
- Surface hydraulics and infiltration of water into stubble retained treatment more than twice that of stubble burning (Carter and Steed 1992).
- Changes of soil organic carbon (Carter et al. 1993)
- Stubble and pasture residue burning has resulted in higher wheat and pasture yields than the stubbles retained above ground and stubbles cultivated into the soil (Newton 1998).
- Mineral nitrogen availability at sowing from subclover residues is not as large as expected on the basis of plant biomass and nitrogen fixed (nitrogen tie-up is possibly due to slowly degraded subclover seed banks and clover burr). This is in contrast with findings elsewhere of more rapid mineralisation from legume residues in grazed subclover.

Relevant references

Carter MR, Parton WJ, Rowland IC, Schultz JE and Steed GR (1993) Simulation of soil organic carbon and nitrogen changes in cereal and pasture systems of southern Australia. *Australian Journal of Soil Research* **31**, 481–491.

Carter MR and Steed GR (1992) The effects of direct-drilling and stubble retention on hydraulic properties at the surface of duplex soils in north-eastern Victoria. *Australian Journal of Soil Research* **30**, 505–516.

Newton PJ and Steed GR(1998) Stubble management influences nitrogen uptake and yield in subterranean clover/wheat rotations In: *Proceedings at the 9th Australian Agronomy conference*, Wagga Wagga.

SR3

Urea topdressing in the non-legume phase of a grain legume-cereal rotation under different stubble management and tillage.

Location: Wilby (near Rutherglen) Established: 1985 Custodian: Phil Newton

Objectives

- To determine the effect of urea top dressing on the crop productivity management as applied to crop stubbles (stubble retention compared to stubble burning and cultivation) for following crops of wheat.
- To determine short-term changes in soil structure, disease, biology and soil properties due to stubble retention and stubble burning under different crop rotations.
- To publish and present findings to appropriate audiences.

History

SR3 is located at Wilby and began in 1985 as part of the NSCP funding by Tony Ellington (deceased) and Graham Steed. It represents a duplex red-brown earth at the border of the plains and low foothills of north-east Victoria. A grain legume-cereal rotation was implemented. The plot size is 3 m wide and 20 m long. Visiting scientist Martin Carter published several papers resulting from a two-year visit (1990-1992), that included this site. GRDC funding (1993–1995) was to investigate 'Effects of stubble management on duplex soils' (DAV213). Phil Newton was transferred site supervision in 1994 under this project. On-going Grains Program funding commenced in 1996, which currently includes maintenance of this long-term site. The site has suffered from increasing ryegrass infestation since 1996 and was linked to the project 'Management of herbicide resistance in ryegrass and other weed species in cropping systems in south-east Australia' (DAV 266R). An attempt was made to remove ryegrass seed with a screening device on the header in 1996. Seed collected from plots in 1996 was tested for resistance and the only resistance found was in ‘fops’. Canola was introduced to the rotation in 1999 to allow further opportunity to control ryegrass. It was decided to resort to intermittent burning across all treatments in 2000 to resume wheat in the rotation after canola.

Treatments

The four main treatments are:

- direct drilled stubble retained standing
- direct drilled stubble retained shredded
- direct drilled stubble burnt (stubble burnt at lifting of fire restrictions in April each year)
- stubble cultivated into the soil with an offset disc plough.

Each main treatment was split for 50 units of nitrogen applied as top-dressed urea post sowing commencing in 1995.

Design

Randomised complete blocks with non-orthogonal treatment representation—three adjacent pairs of plots (six plots) of each unburnt main treatment, and a randomised pair of the burnt treatments. There are four replicates (blocks) of the treatments. Main plots are randomised within each block and split plots randomised within each main treatment.

Quality of datasets

Datasets are held by the people who have worked at the site over the years. These datasets are often represented in published papers. The annual yield data are available on file and some soils are archived in long-term storage. Since 1995 the focus has been on productivity and available nitrogen under the urea fertiliser topdressing. However, not all soil and plant data were collected in each year. Other *ad hoc* data includes penetrometer resistance, pH, wheat/grass biomass and nitrogen content. Longer term data sets include repeat sampling of soil fertility during the experiment and incomplete record of grain yields.

Potential uses

- The current primary use of SR3 is to evaluate the responses of urea topdressing and methods of weed control under different stubble management and rotations.
- Evaluation of alternative ryegrass control options under continuous cropping other than a pasture restoration phase.
- To investigate importance of urea topdressing for nitrogen mineralisation and organic carbon depletion.
- Site information has provided useful data for benchmarking rotation scenarios in the 'PRISM NE' model.

Key findings

- Stubble burning increases efficiency of nitrogen uptake from top-dressed urea compared to stubble retention above ground (Newton 2001).
- Surface hydraulics and infiltration of water into stubble retained treatment is more than twice that of stubble burning (Carter & Steed 1992).
- Changes of soil organic carbon (Carter et al. 1993)
- Tie-up of mineral nitrogen tie in organic matter represented 15% of applied nitrogen regardless of stubble management.
- Apparent losses of nitrogen from applied fertiliser of 2050%.
- Considerable change in acidity and nutritional status of the soil with rapid change in depth for fine depth increments (2 cm) from 0–20 cm.

Relevant references

Carter MR, Parton WJ, Rowland IC, Schultz JE and Steed GR (1993) Simulation of soil organic carbon and nitrogen changes in cereal and pasture systems of southern Australia. *Australian Journal of Soil Research* **31**, 481–491.

Carter MR and Steed GR (1992) The effects of direct-drilling and stubble retention on hydraulic properties at the surface of duplex soils in north-eastern Victoria. *Australian Journal of Soil Research* **30**, 505–516.

Newton PJ (2001) Effect of long-term stubble management on yield and nitrogen-uptake efficiency of wheat topdressed with urea in north-eastern Victoria. *Australian Journal of Experimental Agriculture* **41**, 1167–1178.

SR5

Pasture ley after grain legume-cereal rotation under different stubble management and tillage.

Location: Boweya (near Rutherglen) Established 1987 Custodian: Phil Newton

Objectives

- To determine the effect of a pasture ley on the carry-over benefits of different stubble treatments (stubble retention compared to stubble burning and cultivation).
- To determine short-term changes in soil structure, disease, biology and soil properties due to stubble retention and stubble burning under different crop rotations.
- To publish and present findings to appropriate audiences.

History

SR5 is located at Boweya and began in 1987 as part of the NSCP funding by Tony Ellington (deceased) and Graham Steed. It represents a transitional soil between the granitic sand and duplex red-brown earth of the low foothills in north-east Victoria, (SR4 at Thoona represented the granitic sand of hillsides but was resumed by the farmer cooperator in 1999). A grain legume-cereal rotation was implemented. The plot size is 2.2 m wide and 20 m long. GRDC funding (1993–1995) was to investigate 'Effects of stubble management on duplex soils' (DAV213). Phil Newton was transferred site supervision in 1994 under this project. On-going Grains Program funding commenced in 1996, which currently includes maintenance of this long-term site. The site has suffered from increasing ryegrass infestation since 1996 and was linked to the project 'Management of herbicide resistance in ryegrass and other weed species in cropping systems in south-east Australia' (DAV 266R). An attempt was made to remove ryegrass seed with a screening device on the header in 1994. Seed collected from plots in 1994 was tested for resistance and the only resistance found was in ‘fops’. The site was spray topped and burnt in 1995 and sown to subclover cv. Trikkala ley. Grasses were controlled with winter cleaning until 1998, however, wild radish has emerged since and has required constant spraying with glyphosate. No soil sampling or agronomic measurements have occurred in the pasture phase. The site sufferers from severe surface runoff and runon, as evidenced by deposition of animal faeces from the surrounding paddock.

Treatments

The four main treatments are:

- direct drilled stubble retained standing
- direct drilled stubble retained shredded
- direct drilled stubble burnt (stubble burnt at lifting of fire restrictions in April each year)
- stubble cultivated into the soil with an offset disc plough.

Each main treatment was maintained as separate dual plots.

Design

Randomised complete blocks with non-orthogonal treatment representation—three adjacent pairs of plots (six plots) of each unburnt main treatment and a randomised pair of the burnt treatments. There are four replicates (blocks) of the treatments. Main plots are randomised within each block and split plots randomised within each main treatment.

Quality of datasets

The annual yield data are available on file and some soils are archived in long-term storage. Since 1995 the site has lapsed into a pasture phase with no agronomic data collection. Other *ad hoc* data includes penetrometer resistance and weed numbers.

Potential uses

- The current primary use of SR5 is to evaluate the effective carry over impact of previous stubble management and tillage after a pasture ley.
- Evaluation of alternative ryegrass and wild radish control options under a pasture ley.
- Site yield information will provide a useful benchmark for rotation scenarios in the 'PRISM NE' model.

Key findings

- Stubble burning reduction of ryegrass seed accessions and ryegrass weed population.
- Stubble burning increased the incidence of lupin root rot disease.

RGL6

Rotations with grain legumes

Location: Rutherglen   Established 1975   Custodian: Bill Slattery

Objectives

- To identify the long-term effects of acidification on plant growth and soil chemical and structural decline.
- To determine the long-term sustainability of cereal-legume rotations compared with continuous wheat and continuous lupin rotations.

Design

The site consists of 32 plots in four randomised blocks of eight treatments. Each plot measures 15 m x 1.5 m. The site commenced in 1975.

Treatments

Treatments are:

1. Continuous wheat…   Wheat only (no rotation)
2. Continuous lupins…   Lupins only (no rotation)
3. WWL followed by WL…
4. WLW followed by LW…
5. LWW followed by LW…
6. WLL followed by WL…
7. LWL followed by WL…
8. LLW followed by LW…

where W=wheat and L=lupins.

A wheat-lupin or lupin-wheat rotation was imposed on treatments 3-8 in year 4 (1979) after the initial 3 year rotation as indicated.

History

The site was originally set up to identify the benefits of including lupins in a cereal rotation—hence the title 'Rotational Grain Legumes' (RGL site #6 in the north-east). From this early work the value of lupins in the crop rotation was identified and promoted vigorously for the following 10–15 years. In 1991 Coventry and Slattery used this site to examine the effects of a long-term continuous legume crop on acidification of the soil. Soil acidification was identified in the surface 30 cm soil layer where pH had declined by 1.5 units over a 15 year period.

Quality of datasets

All data pertaining to this site is in published papers, in laboratory notebooks and filed in either paper or electronic format depending upon date of original collection. All soil data is of a high value adhering to ASPAC proficiency standards.

Potential uses

This site is invaluable for the continued understanding of soil acidification processes under cereal and legume crops. In addition, the potential value of monoculture crops (continuous wheat and lupins) cannot be underestimated given the long-term results found at Rothamstead (UK) on similar rotations.

Key findings

This site has shown:

- the value of including a legume in a crop rotation for N nutrition
- accelerated acidification rates where legumes are included in crop rotations
- acidification rates for wheat and legume crops
- acidification attributed to nitrate leaching, carbon cycle and product removal in wheat and lupin crops
- the influence of low molecular weight organic acids (LMWOAs) in reducing the effects of aluminium toxicity
- the release of succinate from lupin roots as a potential mechanism for aluminium tolerance.

Relevant references

Coventry DR and Slattery WJ (1991) Acidification of soil associated with lupins grown in a crop rotation in north-eastern Victoria. *Australian Journal of Experimental Agriculture* **42,** 391–397.

Reeves TGR, Ellington A and Brooke HD (1984) Effects of lupin-wheat rotations on soil fertility, crop disease and crop yields. *Australian Journal of Experimental Agriculture and Animal Husbandry* **24,** 595–600.

Slattery WJ and Burnett VF (1992) Changes in soil pH due to long-term storage. *Australian Journal of Soil Research* **30,** 169–175.

Slattery WJ, Edwards DG, Bell LC, Coventry DR, and Helyar KR (1998) Soil acidification and the carbon cycle in a cropping soil of north-eastern Victoria. *Australian Journal of Soil Research* **36,** 273–290.

Slattery WJ, Ridley AM and Windsor SM (1991) Ash alkalinity of animal and plant products. *Australian Journal of Experimental Agriculture* **31,** 321–324.

SCRIME

Sustainable Cropping Rotations in Mediterranean Environments

Location: Longerenong Established 1998 Custodian: Roger Armstrong

Aims

To provide information that enables farmers to select a farming system(s) for the Wimmera in terms of its effect on:

- the soil resource (chemical, physical and biological fertility)
- financial performance (short and long-term) of the whole farm enterprise
- pest (weed and insect) and disease management.

The treatments listed below are designed to help provide specific information about specific practices (e.g. green manuring on subsequent crops), rather than aiming to mimic exact rotations used by farmers in the region (which vary from farm to farm and year to year). The design also represents a balance between the need for scientific rigour (e.g. having a test-crop such as wheat common to all treatments) and relevance to both current and potential future farming practices.

Treatments

Treatments are:

1. wheat - wheat - wheat (control) :
2. wheat - wheat -wheat (high fertiliser input
3. pulse - wheat - barley
4. vetch/fallow (green manure) - wheat - barley
5. pulse - wheat - pulse
6. canola - wheat - pulse
7. canola - wheat - pulse (conventional tillage)
8. lucerne-lucerne-lucerne/fallow- canola - wheat - pulse
9. green manure - canola - pulse - medic - wheat - barley
10. spare (opportunity based on season break, commodity prices and disease diagnostics)

Three phase rotation, with all treatments replicated each year three times, except T8 and T9, which are six phase rotations (compared with two three year phases). T10 is a ‘farmer driven’ treatment (WCFA consulted) based on opportunity cropping taking account of when the season break occurs, current commodity prices and results of disease diagnostic tests. Plot sizes are 36 m long x 14 m wide. All treatments, except T7 and the termination of the pasture phases, are minimum tillage. The trial is located at Dooen (430 mm annual rainfall) on a grey cracking clay soil. Pulse treatments are rotated every three years so that don’t have any one pulse species closer than every six years. Main pulses for the first phase (1998–2000) are field peas and the secondary pulse is lentils. These will be replaced with faba beans and *Ascochyta* resistant chickpeas in the next phase.

Data collection

A minimal dataset is collected in five key treatments, viz. soil water at sowing, anthesis and grain maturity; mineral nitrogen at sowing; establishment; disease scores; dry matter and grain yield (all plots), and nitrogen concentration of grain and straw. Each plot was intensively soil sampled prior to trial commencement and samples archived for future analysis. Pasture plots were grazed in 1998 but a 'cut and remove' regime has subsequently been employed.

Potential uses

Data from this trial will be used to construct/verify existing simulation models (e.g. APSIM/Connor & O'Leary models). This will have major implications for the datasets (for example PAW at planting, anthesis and grain maturity; soil mineral nitrogen at planting and grain maturity; dry weight at key physiological times; straw/grain nitrogen concentrations at maturity) detailed climatic data (maximum/minimum temp, rainfall, solar radiation), and a comprehensive soil characterisation prior to implementing treatments and archiving these soil samples for future referral. A 6 ha block of land has been set aside adjacent to the main trial to allow for detailed investigation of issues arising from the main trial.

Key findings

There has been no major analysis of datasets to date. The trial is effectively in a 'maintenance mode' pending determination of its future.

LR1

Permanent Long-term Rotation Longerenong Rotation No.1

Location: Longerenong Established 1916 Custodian: Roger Armstrong

Aim

To investigate the suitability of various cropping rotations within the Wimmera, and the impact of these rotations on soil fertility.

Location

Wimmera Research Station, Dooen - alkaline grey self mulching clay (Ug 5.24).

Plot size and design

Plots are 50 m x 14 m. Treatments are phase but not spatially replicated. There are seven main plots corresponding to seven rotations. Each main plot is split longitudinally into a number of subplots equal to the number of courses in the rotation. Each course of each rotation appears exactly once in each year. In 1998, the trial was split laterally into two 'blocks': the first (south bay) contains Cereal Cyst Nematode (CCN) resistant varieties whilst CCN susceptible varieties sown in the north bay.

Treatments

Treatments are:

1. continuous wheat
2. wheat fallow
3. medic - fallow - wheat
4. barley - peas - wheat
5. canola - peas - wheat
6. canola - fallow - wheat
7. oats - medic - fallow - wheat

Block one contains CCN susceptible varieties (Ghurka wheat; Gairdner barley and Swan oats) whereas block 2 contains CCN resistant varieties (Goldmark wheat; Barque barley; Potoroo oats).

The trial was split into the two blocks (CCN resistant and susceptible) in 1998. Oats (grazed) was replaced by medic, and oats (grain) was replaced by canola in 2000.

Data collection

Root disease testing (CCN, *Rhizoctonia, Pratylenchus*, Take-all), dry matter and tiller counts at maturity; grain yield (header), grain size, and grain protein data is collected. Detailed weather data is collected 500 m away by Longerenong College.

Key findings of experiment

Long-term yield trends up to the early 1990s are summarised in the publication of Hannah and O’Leary (1995)

Potential uses

Because of its longevity (longest running continuous trial site in Australia), the trial has been regularly used by external agencies, including Bernard Doube (CSIRO: microbiological sampling), Jan Skjemsted (CSIRO: Carbon balance) and The University of Melbourne for undergraduate teaching purposes. Approaches have also been made by the CRC for Greenhouse Accounting who want to use the site as a reference for a remote sensing project.

Relevant references

Hannah MC and O'Leary GJ (1995) Wheat yield response to rainfall in a long-term multi-rotation experiment in the Victorian Wimmera. *Australian Journal of Experimental Agriculture* **35,** 951–960.

Oades JM (1967) Carbohydrates in some Australian soils. *Australian Journal of Soil Research* **5,** 103–115.

O'Connell MG, O'Leary GJ and Incerti M (1995) Potential groundwater recharge from fallowing in north-west Victoria, Australia. *Agricultural Water Management* **29,** 37–52.

MC14

Long-term Comparison of rotation and fallow management practices in the Victorian Mallee

Location: Walpeup Established 1985 Custodian: Ivan Mock

Objectives

- To compare the influence of rotation and fallow management practices on wheat production in the Victorian Mallee.
- To assess the long-term impact of these treatments.

Site location

A field experiment was located at the Mallee Research Station (lat. 35° 08' S., 142° 01' E., elevation 107 m).

The site is part of the Central Mallee land system on a plain landform, known locally as a 'swale'.

Soil classification

The soil type is gradational calcareous earth, classified as Gc 1.22. Locally it is referred to as mid-Mallee sandy loam which has a clay content increasing from 14% in the top 10 cm to 30% at 100 cm.

Experimental design

The experiment has been conducted over 15 years (1985–1999) in a split plot design with three rotation treatments as main plots and two fallow management treatments as subplots. The three rotation treatments were pasture/fallow/wheat (PFW), fallow/wheat (FW) and pasture/wheat (PW). The two fallow management treatments were conventionally cultivated fallow (CC) and chemical fallow (CF). Each treatment was a replicated three times in a randomised block design with all phases of the rotations represented each year. The main plot size was 8 m x 40 m and they were divided longitudinally into 4 m x 40 m subplots.

Measurements

Crop production

Biomass production was measured for all treatments at anthesis and harvest (1985–1989). Grain was harvested at maturity from the centre rows of each plot with a 1.4 m wide plot harvester (1985–1999).

Water balance

Soil water to a depth of 120 cm was measured from two aluminium access tubes in each plot in the wheat crops at sowing and harvest. Measurements were made at 20 cm intervals on the 20–120 cm profile (1985–1999).

Crop water use and water use efficiency

Water use efficiency (WUE, kg/ha/mm) was calculated for grain yield per growing season (1985–1999). Soil nitrogen and grain protein

Total soil nitrogen was determined by the micro Kjeldahl digestion technique in 1985, 1988 and 1987. Grain protein content was determined for each wheat plot (1985–1989).

Soil borne pathogens

The extent of Rhizoctonia Root Rot (*Rhizoctonia soloni*) and Take-all (*Gaeumannomyces graminis* var. *tritici*) damage to the wheat crops was determined in 1985, 1986 and 1987. The incidence of Cereal Cyst Nematode (CCN) (*Heterodera avenae*) in wheat plots was determined after anthesis in 1985, 1986 and 1987.

Potential uses

1985–1999 data provides an excellent source of soil, moisture and yield data from which the long-term impact of fallow and rotation management practices on a Mallee farming system can continue to be monitored.

Quality of datasets

All 1985–1999 data collated.

Key findings

Data is currently being analysed by biometrician to assess suitability and key findings for possible scientific publications. Continuation of trial past 2000 and any additional data required will also be determined.

Relevant references

Bissett MJ and O'Leary GJ (1992) Effects of conservation tillage and rotation on water infiltration in two soils in south-eastern Australia. *Australian Journal of Soil Research* **34,** 299–308.

Incerti M, Sale PWG and O'Leary GJ (1993a) Cropping practices in the Victorian Mallee 1. Effect of direct drilling and stubble retention on the water economy and yield of wheat. *Australian Journal of Experimental Agriculture* **33,** 877–883.

Incerti M, Sale PWG and O'Leary GJ (1993b) Cropping practices in the Victorian Mallee 2. Effect of long fallows on the water economy and the yield of wheat. *Australian Journal of Experimental Agriculture* **33,** 885–894.

O'Connell MG, O'Leary GJ and Incerti M (1995) Potential groundwater recharge from fallowing in north-west Victoria, Australia. *Agricultural Water Management* **29,** 37–52.

O'Leary GJ and Incerti M (1995) A field comparison of three neutron moisture meters. *Australian Journal of Experimental Agriculture* **35,** 59–69.

Deep Drainage Lysimeter trial

Location: Walpeup Established 1993 Custodian: Ivan Mock

Objectives

- Compare crop water use, deep profile drainage and soil moisture flux under a continuously cropped rotation and a rotation containing a fallow phase.
- Determine the relationship between crop production, soil moisture and rotation system.

Site Location

A field experiment was located at the Mallee Research Station (35^{o} 07' S., 141^{o} 58' E.; elevation 85 m). The site is part of the Central Mallee land system on a plain landform, known locally as a 'swale'.

Soil classification

The soil type is gradational calcareous earth, classified as Gc 1.22. Locally referred to as mid-Mallee sandy loam which has a clay content increasing from 14% in the top 10 cm to 30% at 100 cm.

Experimental design

This field study was set-up to compare long fallow and continuously cropped rotations. The trial was established in 1993 and is still be used for data collection today (2000). The cropping systems compared were two three phase rotations: 'fallow' (long fallow-wheat-field peas) and 'continuously cropped' (Indian mustard-wheat-field peas). Each phase was represented each year. Three replicates were arranged in a blocked design, plots size was 20 m x 21 m with a 5–10 m buffer area. Wheat, field peas and Indian mustard were sown at 60, 120 and 6 kg/ha, respectively, with 75 kg/ha of double super phosphate(0:17:0:4). Weeds, pest insects and mice were controlled with appropriate pesticides at manufacturer-recommended rates. Fallow weed control was implemented in August.

Datasets

Deep drainage via lysimeter wick and rain gauge system.

Neutron moisture meter readings

Leaf area measurements

Water infiltration measurements

Light inception measurements

Crop Production

Biomass production was measured for all treatments at anthesis and harvest.

Grain was harvested at maturity from the entire plot with a 1.4 m wide plot harvester.

Water Balance

Soil water to a depth of 550 cm was measured from two PVC access tubes in each plot at sowing and harvest. Measurements were made at 25cm intervals from 0–200 cm and then at 50 cm intervals from 200–550 cm.

Previous uses

1993–1996 data used by O'Connell (1997, 1998).

Current and future uses

Established deep drainage rain gauges are used to determine when intensive monitoring is needed for alley farm project (alley farm situated along side lysimeter site). This is included in alley farm protocols for future research.

The *in situ* drainage lysimeters provide a unique facility to retrieve leachates and determine accretions to ground water.

Impact

Looks at phasing out fallow in rotations and use continuous cropping techniques to reduce ground water recharge.

Quality of datasets

All 1993–1999 data collated.

Key findings

A fallow phase significantly increases recharge. Major recharge events are episodic, occurring on average each 3–5 years.

Wheat growth, yield and water use was unaltered by fallowing in average growing seasons. However, in a drought year (1994), water conservation under fallow allowed adequate biomass and insured a significantly higher harvestable grain yield of wheat compared to a continuously cropped system.

Relevant references

Díaz-Ambrona CGH, O'Leary GJ, Sadras VO, O'Connell MG and Connor DJ (2003) Environmental risk analysis of farming systems in a semi-arid environment: effect of rotations and management practices on deep drainage. *Field Crops Research* (submitted)

O'Connell MG (1998) Fallow crop, water balance and recharge relationships in the Victorian Mallee. MAgrSc Thesis, The University of Melbourne, Victoria. 135 p.

O'Connell MG (1998) Water balance, growth and yield in Mallee fallow and continuously cropped rotations. In: *9th Agronomy Conference Proceedings*, Wagga Wagga, NSW.

O'Connell MG, Connor DJ and O'Leary GJ (2002) Crop growth, yield and water use in long fallow and continuous cropping sequences in the Victorian Mallee. *Australian Journal of Experimental Agriculture* **42**, 971–983.

O'Connell MG, O'Leary GJ and Connor DJ (2003) Drainage and change in soil water storage below the root zone under long fallow and continuous cropping sequences in the Victorian Mallee. *Australian Journal of Agricultural Research* **54**, 663–675.

Zhang L, Dawes WR, Hatton TJ, Hume IH, O'Connell MG, Mitchell DC, Milthorpe PL, and Yee M (1999) Estimating episodic recharge under different crop/pasture rotations in the Mallee region. Part 2. Recharge control by agronomic practices. *Agricultural Water Management* **42,** 237–249.

Zhang L, Hume IH, O'Connell MG, Mitchell DC, Milthorpe PL, Yee M, Dawes WR and Hatton TJ (1999) Estimating episodic recharge under different crop/pasture rotations in the Mallee region. Part 1. Experiments and model calibration. *Agricultural Water Management* **42,** 219–235.

MM1

Long-term permanent fertiliser experiment

Location: Walpeup Established 1940 Custodian: Ivan Mock

Objective

To determine the long-term effect of superphosphate on wheat yield response. The experiment commenced in 1940 and until 1959 was conducted on a three course rotation of fallow-wheat-oats, to which superphosphate was applied to the wheat only.

Treatments

The fertiliser treatments – single superphosphate at 0, 35, 67, 101 and 135 kg/ha were always applied to the same plots in the wheat course of the rotation. There were three separate sites, each with two replications of the five fertiliser treatments in a randomised block design. The variety of wheat grown was Ranee 4H and the plot size was 2.0 m x 7.0 m.

Commencing in 1956, the variety of wheat grown was Insignia, which is still grown in the experiment (as at 2000 sowing season). In 1960, the rotation was changed to a two-course fallow–wheat system. This rotation appeared likely to deplete nitrogen reserves in the soil, with the possible consequence that nitrogen may become a limiting factor in producing responses to phosphate. Thus, in 1960 plots were split for the application of nitrogen fertiliser.

In 1987, the plots were split and undersown with Paraggio medic, the level of response to phosphate can be compared between the two medic treatments. There are now two separate sites located in different paddocks, so in any given year, one trial is in crop or fallow.

Below is trial layout from experiment located in field no.2

North bay

Superphosphate application (kg/ha)									
Nil	67	101	135	34	Nil	135	101	34	67
- medic	+ medic	+ medic	- medic	- medic	+ medic	+ medic	- medic	- medic	+ medic

South bay

Superphosphate application (kg/ha)									
Nil	67	101	135	34	Nil	135	101	34	67
+ medic	- medic	- medic	+ medic	+ medic	- medic	- medic	+ medic	+ medic	- medic

Results

Grain yields and protein levels from each treatment are taken each cropping cycle. Soil surface analysis is also recorded for each treatment. An understanding of the effects of repeated applications of superphosphate over a long period is a desired out come from these long-term trials.

Also cadmium, which is a heavy metal found naturally in soils and deposits of rock phosphates from which phosphatic fertilisers are made, may build up in soils with continued use of superphosphate. However, as the soils are alkaline, only minimal plant uptake would occur.

Future

The results have been partly compiled for analysis. The effects on pasture production were compiled by Narelle Hill-Ferguson and Chris Korte although no further progress has been made since Hill-Ferguson left. Neil Vallance intends to compile the crop results although this may take time.

The trial could provide data on several soil factors (biota, heavy metals, organic carbon, pH, etc).

Relevant references

McClelland VF (1968) Superphosphate on wheat: the cumulative effect of repeated applications on yield response. *Australian Journal of Agricultural Research* **19,** 1–8

PTD

Permanent top dressing experiment

Location: Rutherglen | Established 1914 | Custodian: Bill Slattery

Objectives

To identify the long-term effects of fertiliser application on pasture and animal production.

History

The site was originally set up in 1914 to identify the benefits of different fertiliser application rates on pasture production and grazing management–hence the title 'Permanently top dressed' (PTD) site. From the long-term data sets Ridley and others (see Relevant references) have been able to identify acidification rates from grazed pastures at different stocking rates and with different production outputs. In addition, the movement of lime through the soil profile has been determined—the only long-term site in Australia that has been able to show the rate of calcium movement and pH effect as the lime moves into the subsoil.

Design

The site consists of six split plots in two blocks. Experiment commenced in 1914.

Treatments

Six treatments by two blocks.

Treatments are:

1. No fertiliser (control)
2. Superphosphate (125 kg/ha every 2nd year)
3. Superphosphate (250 kg/ha every 2nd year)
4. Superphosphate (125 kg/ha every 2nd year + lime at 1.25 t/ha every 4th year from 1914–48)
5. Basic phosphate (125 kg/ha)
6. Treatment 6 unclear possibly superphosphate with clover establishment (plots 1–5 on natural pasture)

Note the split plot design refers to hay cut and pasture grazed (this alternated between the splits and is documented in the records).

Quality of datasets

All data pertaining to this site is in laboratory notebooks and predominantly filed on paper. All soil data collected post-1990 is of high value adhering to Australian Soil and Plant Analysis Committee (ASPAC) proficiency standards.

Potential uses

This site is invaluable for the continued understanding of soil acidification processes under long-term pastures. In addition, this site provides continued datasets for the impact of sheep grazing on soil and pasture persistence over time. It also contains a native pasture from which time series comparisons can be made.

Key findings

This site has shown:

- Acidification rates for soil under long-term pasture rotations
- Long-term animal production on native and improved pastures.
- Acidification attributed to nitrate leaching, carbon-cycle and product removal in hay or animal product.

Relevant references

Hayes JE, Richardson AE and Simpson RJ (2000) Components of organic phosphorus in soil extracts that are hydrolysed by phytase and acid phosphatase. *Biology and Fertility of Soils* **31,** 279–286.

McLaughlin MJ, Stevens DP, Keerthisinghe G, Cayley JWD and Ridley AM (2001) Contamination of soil with fluoride by long-term application of superphosphates to pastures and risk to grazing animals. *Australian Journal of Soil Research* **39,** 627–640.

Ridley AM, Slattery WJ, Helyer KR and Cowling A (1990a) Acidification under grazed annual and perennial grass based pastures. *Australian Journal of Experimental Agriculture* **30**, 539–544.

Ridley AM, Slattery WJ, Helyer KR and Cowling A (1990b) The importance of the carbon cycle to acidification of a grazed annual pasture. *Australian Journal of Experimental Agriculture* **30,** 529–537.

Appendix 2. Submissions received

Submissions were received from the following:

Departmental

Roger Armstrong, DPI Horsham

Jim Crosthwaite, DSE Parks Flora and Fauna, Melbourne

Dale Grey, DPI Rutherglen

Murray Hannah, DPI Ellinbank

Ivan Mock, DPI Walpeup

Phil Newton, DPI Rutherglen

Mark O'Connell, DPI Tatura

Bill Slattery, DPI Rutherglen

Ian Smith, DPI Bendigo

Murray Unkovich, DPI Walpeup

External

David Connor, Institute of Land and Food Resources, University of Melbourne, Parkville

Mark Johns, Victorian Farmers Federation (VFF), Natural Resources Reference Group, Horsham

John Griffiths, Consultant, Horsham

John Harvey, GRDC Canberra

John Kirkegaard, CSIRO Plant Industry, Canberra

Mike McLaughlin, CSIRO Land and Water, Adelaide

Marion Murphy, Mallee Sustainable Farming Project Inc.

Bernard Noonan, Wimmera Conservation Farming Association Inc.

Rob Norton, ILFR, University of Melbourne, Longerenong

Garry O'Leary, CSIRO Land and Water, Walpeup

Mark Peoples, CSIRO Plant Industry, Canberra

Merv Probert and Brian Keating, APSRU/CSIRO Sustainable Ecosystems, Brisbane

Richard Simpson and Peter Randall, CSIRO Plant Industry, Canberra

Jan Skjemstad, CSIRO Land and Water, Adelaide

Harm van Rees, Consultant, Bendigo