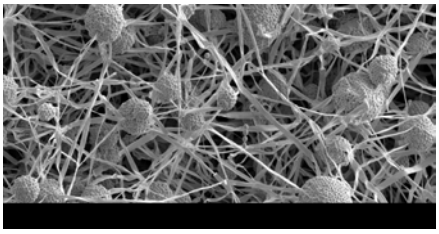
GRDC investment in soil biology
(2009 and beyond)

"Harnessing the biological potential of cropping soils"

Draft report prepared By Dr Pauline Mele (DPI-Vic)



Background. GRDC is the largest rural industry investor in soil biology RDE (1992-2008). The Soil Biology initiative (2000-2006) and co-investments with MLA (Soil Biology in Pastures) and LWA (Healthy Soils for Sustainable farming; HSSF) have significantly enhanced knowledge of the role of soil biology in soil health and plant productivity. Specifically, the soil biology initiative (2000-2006) was successful for generating a significant knowledge bank on regional soil biology issues and much of this has been captured in scientific papers, conference and workshop proceedings and in training modules (developed as part of HSSF). Another measure of success was in the building of capability in soil biotechnology and in providing cross-discipline interaction (eg deliberate strategy to adopt an agronomist to lead projects). A recognised shortcoming of the initiative was the level of integration across projects which created some fragmentation of outcomes. Greater consensus on standardisation of protocols and experimental design would have enhanced outcomes. The development of a National Science RDE framework may provide the imperative for a more coordinated (less fragmented) approach to soils investment in Australia (current LWA-led DAFF CFOC bid). Currently soil biology R&D in Australia is in a 'holding pattern'. The challenge is to identify major investment opportunities. The rapid and recent emergence of 'enabling technologies and processes' such as metagenomics, nano-SIMs, NMR, synchrotron and web-based tools present significant new opportunities to develop vastly superior information systems related to farming systems management impacts and soil rejuvenation practices, as well as new biological products. GRDC is in the driver seat to provide the coordination and leadership to ensure integration of these biotechnologies and associated science disciplines to achieve productivity, efficiency and environmental objectives.

To capture new Soil biology RDE investment opportunities and reframe existing issues in a biotechnology context, GRDC together with LWA conducted a workshop **"Next Generation Soil Biology RD&E** in December 3rd -4th 2008. The workshop included scientists and potential investors from Rural Industry Research and Development Corporations and from agribusiness with specific interests in soil biological sustainability and management. The workshop drew upon the knowledge and experience generated from previous investments:

- GRDC Investment in Soil Biology- A Review (Projects from July 2001-June 2008)
- LWA/GRDC investment in Healthy Soils for Sustainable Farming (HSSF)
- GRDC Soil Biology Workshop (12 & 13 December 2006, Canberra)
- RIRC (DA, HAL, GRDC,MLA) & ARC project investment profiles (1991-2007)
- LWA National Soils Workshop (20 & 21 November 2008, Canberra)

Initially 10 themes were proposed based on gaps and opportunities developed by a small subcommittee of senior soil scientists/agronomists from several research organisations (Dr Dan Murphy, UWA; Dr Kathy Ophel-Keller, SARDI; Prof Peter Grace, QUT; Dr David Herridge, DPI-NSW and Dr Pauline Mele, DPI-Vic). Six themes were described as functional themes and 4 were enabling themes.

1. *Monitoring (modelling)*
2. *Management and agronomy*
3. *Soil-borne disease*
4. *Nutrient availability for plant productivity*
5. *Microbial Products (inoculants)*
6. *Enhanced Rhizosphere*
7. *Education & knowledge transfer (marketing)*
8. *Biotechnology platforms*
9. *Building research capacity*
10. *Strategic discovery*

Using these themes, a 15 year GRDC investment profile for soils was developed (Figure 1) and presented for discussion.

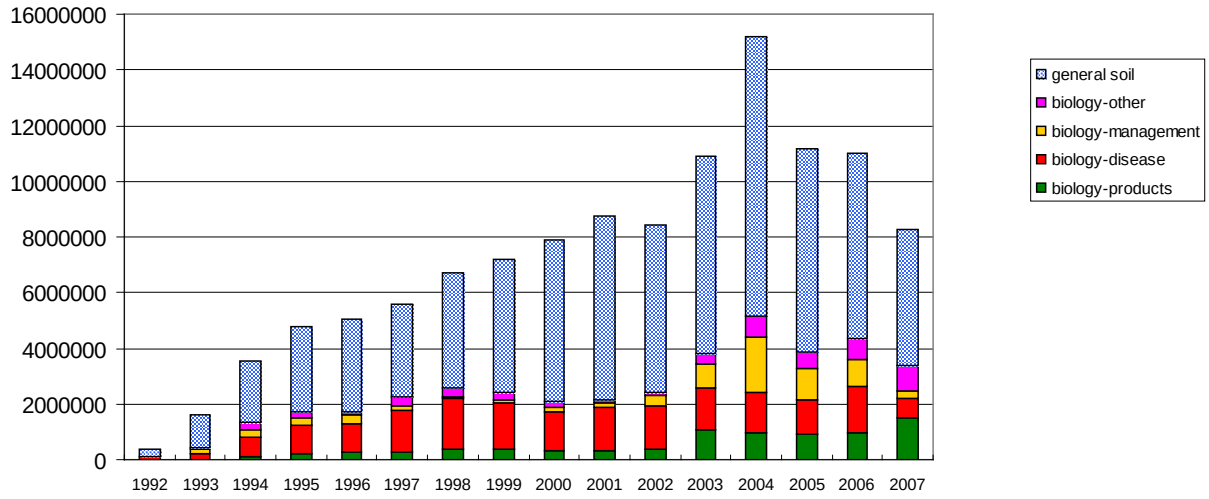


Figure 1. GRDC investment $ per year for soil RDE as per expenditure reports contained in annual operational plans. The blue segment represents general lsoil investment across GRDC program investment areas whilst the coloured segments reflect soil biology investment by 'major' theme areas.

Figure 1 highlights the focus on disease-related RDE (identification, detection and control), the fluctuating investment in management and agronomy (herbicide impacts, earthworms, biological constraints, impact of tillage, H gas effects, and pasture soil biology) and the growing investment in biological products. In the category listed as 'other' the themes of monitoring (modelling), rhizosphere, nutrient availability, and education and knowledge transfer. There is negligible investment in the 'enabling technologies' such as Biotechnology platforms, Building research capacity or Strategic discovery.

From the analyses of the 10 proposed theme areas, the following 7 RDE themes and associated aims are proposed (see appendix for detail). These can be used as potential project areas for Soils Biology RDE (Table 1).

Table 1. Potential areas for investment in soil biology RDE (derived from workshop **"Next Generation Soil Biology RD&E** in December 3rd -4th 2008).

1. **Monitoring and modelling.** Establish a national biological monitoring program that incorporates function and biodiversity with a focus on new tools for detecting major and focal groups of soil organisms & their contribution to plant health (short term) and soil health (rejuvenation & sustainability; mid-long term). Foundational biological data will form critical baseline for assessing impacts of land management (cropping practices) and recovery.

2. **Management systems.** Pre-emptive research to capture the benefits of soil biology in novel farming systems with the aim of improving productivity, efficiency & minimizing environmental damage. This project area links with project 3.

3. **Soil borne diseases.** Identify microbial communities & functions that drive naturally suppressive soils.

4. **Rhizosphere: Managing the biology to maximize productivity & resource management (combining 4, Nutrient availability and 6, Rhizosphere).** Enhance resource use efficiency (water, nutrient) in managed & natural systems.

5. **Microbial products.** Apply biotechnology tools for enhanced selection of more effective microbes, strain quality indicators, & a route to market for new technologies.

6. **Education and training.** Develop a structured nationally-coordinated program to educate advisors and land managers on soil biology and assessment tools that can be applied on farm and through laboratories. Interpretive limits based on sound science will be established.

7. **Building research capacity.** Establish a program for more effective application of soil biology in agriculture.

Biotechnology Platforms (8) & Strategic Discovery (10) themes were considered to be closely related and easily combined. Both of these themes were identified as required for all theme areas and specifically, theme 1 (monitoring), theme 2 (management systems), theme 3 (Soil borne diseases) and them 5 (microbial products). Theme 6 (modified to incorporate theme 4) did not identify specific biotechnology requirements.

APPENDIX

NB: these notes represent the combined efforts of leading Australian scientists from a diverse range of disciplines (biology/microbiology/pathology/biotechnology/economics/policy/ chemistry) who nominated to work in the modified theme areas. It is intended that this information is used in soils-related investment decision processes.

1) RD&E Theme: **Monitoring and modelling**

Development team members:
Tim Sawbridge, Helen Hayden, Ken McGrath, Fran Hoyle, Alan Richardson, Pauline Mele

Objectives:
Establish a national monitoring program that includes biological function and biodiversity with a focus on new tools for detecting what major groups of soil organisms are present and their prevalence and contribution to plant health (short term) and soil sustainability and recovery (mid-long term).

This objective will provide the fundamental knowledge to underpin decision support systems including what to monitor when and why and ultimately what management practices need to be implemented to enhance soil functionality and resilience.

Establish key working group and facilitate adequate scoping of project proposal.

Key methodological considerations; outline of main RD&E activities:
A monitoring package (eg www.soilquality.org.au) that can be applied immediately with consideration of the next level of investigation that is required.

Standardisation (need agreed sets of standards, principles and approaches).

Need validation and interpretation back to the value to industry.

Identify key functional traits that are required on a national basis.

Specific examples are:

- nitrogen process rates
- biodiversity – resilience measure – but need to connect to outcomes for growers i.e. does this reflect greater ability to withstand changes in temperature for example? Or disease expression or functionality of the soil (i.e. redundancy)
- package traits to address questions at different resolutions and for different purpose
- measure key functional genes (ie associated with enzymes) in C and nutrient cycling

Investigate potential tools for high throughput of soil traits/process traits that are important.

Investigate the methods that could be utilised to change a biological parameter; what's the consideration in comparisons against regions; need to understand relationships between different measures.

Require fundamental genome sequencing of microorganisms and other soil biota to facilitate understanding of population structure, function and dynamics. Preliminary analysis of the soil (meta) genome from 2 contrasting soil types (ferrosol and calcarosol) indicates that "we don't know what

majority of the bacteria are to a degree where we would feel comfortable to make strong functional calls" (DPI-Vic-Venter Institute USA collaboration).

DNA probe and primer development for microarray and quantitative PCR for the quantification of key soil functions – Can fit to other soil metadata to extend the value of research.

Development of a national database that could be integrated with other soil resource databases and/or use in individual industries.

Indicative resources and cost / benefit (including environmental and economic benefits):

- $100K to fund the facilitation of a working group/coordinator for a scoping exercise (preliminary and immediate requirement).

- $5 million/year for 5 years is required (should include contributions from a number of partners – national framework and includes infrastructure, hubs of excellence, and operational costs).

Benefits -

- At different levels.
- National understanding of soil resource condition relative to land capacity (building on current capacity).
- Deliver to farmers an understanding of the impact of agriculture on soil at the paddock level in terms of management and the spatial/temporal changes in soil biological properties
- With the establishment of 'proof of concept' there is highly likely to be an economic outcome and reduced risk for growers.
- Will provide carbon accounting framework and validation.
- Will provide contribution of land management change to GGE.
- Requires communication and integration strategy to enable a national focus and reduce duplication of activities.
- Strategy to enable a national focus and reduce duplication of activities.

Risk analysis (ie key risks and actions to mitigate them):

1. Piecemeal investment generates fragmented and piecemeal data sets that significantly reduce the value of the data.

Action: Cross industry coordination of soil biological monitoring approaches to ensure that rigorous standards to protocol selection and interpretation are applied.

2. Inappropriate technology and interpretation regimes. Developing technologies has a resource (time and hardware) cost but 'going it alone' is even less resource efficient.

Action: Investment to support strategic national and international linkages that integrate across organisational research groups or skills base hubs.

Skills/capacity/partnerships:

Skills:

1. Metagenomics and nanotechnology (including synchrotron) approaches that underpin tool design that will generate meaningful data on soil microbial function, structure and dynamics.

2. Bioinformatics. The 'how to process the information', and then 'how to interpret the information' is an enormous challenge, particularly for bioinformatics associated with soil metagenomics. It requires skilful and rigorous data management.
3. Bioeconomics. Route to market for technology requires cross discipline integration linking strategic and applied investigations to adoption.

Capacity:

1. Data collection& interpretation tools are currently available (eg (soilquality.org format). Adequate resourcing would ensure integration of fundamental and applied science outcomes to add value to landholders.
2. Bioinformatics pipelines to process soil genetic sequence information is rudimentary. Establishment of a pipeline for depositing, interpreting and outputting genomics data must be developed to ensure generation of useful information that meets individual industry needs.

Partnerships:

1. Bioinformatics specialists in related disciplines (eg USC-CAMERA pipeline applied to marine metagenomics, JGC-California).
2. NEIS (replacing audit).
3. DAFF soil C program inventory – establish linkages to ensure capture of soils in appropriate manner within current program for possible future biological/DNA analysis. This needs to happen soon as program will be underway from February 09.

Likely locations / spread of work:

National.

Across organisational project delivery where you could consider the development of specialist hubs.

Linkages to other landscape groups to maximise efficiencies.

Outputs - what the work would deliver including non-financial deliverables:

- National database development.
- Feed into other national database frameworks.
- Will contribute carbon accounting framework and validation.
- Will provide an understanding of contribution of land management change to GGE.
- Development of functional DNA probes.
- Key monitoring tools for biological indicators.
- Continued development/support of www.soilquality.org program.
- Development of a model to predict biological status and soil behaviour.
- Increased knowledge of soil microbes, and link through to potential outcomes for agricultural and other land uses.
- Increased collaboration and communication.
- Standardisation of techniques.

2) RD&E Theme: **Management Systems**

Development team members:
Richard Simpson, John Kirkegaard, Martin Blumenthal, Geoff Baker, Shane Powell, Ross Chapman, Nicki Seymour, Mark Allaway

Objectives:

Pre-emptive research to capture the benefits of soil biology in novel farming systems with the aim of improving productivity, efficiency and minimizing environmental damage.

Key methodological considerations; outline of main RD&E activities:

- Get all RIRC's /agencies on board – develop a common understanding of the value of this approach.
- Multi-disciplinary and integrated approach using appropriate soil biology tools (eg. microarray, traditional pathology, DNA etc) to generate region-specific outcomes.
- Baseline of existing biology defined (linked to monitoring).
- Understand cause and effect of management interventions.
- Beneficial soil biology preserved and/or enhanced (assumes that we know what these are).
- Stimulate soil biology to reduce inputs.
- Cost/benefit analysis of the outcomes that can be attributed to soil biology.

Indicative resources and cost / benefit (including environmental and economic benefits):
e.g. Move cropping to HRZ

- Team: soil biologists including root disease specialists working with crop agronomists, grazing systems specialists and leading farmers involve NRM planners, pest managers , water/hydrology specialists.
- National co-ordination to ensure cross-industry synergies developed.
- Tools (Traditional and novel tools as required/appropriate to answer system management questions). Molecular tools (diversity & function), traditional pathology (disease impacts), agronomy and modelling (whole-farm productivity), interaction with new databases for baseline information (with new data to be returned to these).
- Resources: need to tap appropriate research capacity; longer term projects with appropriate stop/go steps to allow analysis of farm system $4-5M pa nationally.
- Cost/benefit: Gains in TFP (+20% crop yields; +25% grazing system productivity feasible on basis of est. constraints in current systems), higher production for existing resource base, more resilient systems, optimal production-NRM outcomes, positive environmental "flows"

Risk analysis (ie key risks and actions to mitigate them):
Cannot get players to agree/invest in a systems approach – culminating in "horribly fragmented" outcomes.

If take no action – failure to capture new soil biology opportunities and to capture gains in TFP.

Failure to deal with complexity will lead to similar mistakes as in past.

Risk that research capacity will have been eroded.

Skills/capacity/partnerships:
See above: "Teams"

Likely locations / spread of work:

National/ cross industry approach to achieve region-specific benefits.

Outputs - what the work would deliver including non-financial deliverables:

- A national network of linked multi-Industry farming systems groups focussed on capturing benefits from soil biology via:

  (a) New ways to manage systems and natural resources
  (b) Productive and resilient novel farm systems (new areas, systems, climate)
  (c) Increased production from the existing resource base
  (d) Reduced inputs, Improved profitability, Positive environmental "flows"
  (e) Efficiency in research delivery through multi-agency national approach
  (f) **Australian agriculture "girt" and "gruntled"**

- An expert "filter" to assess and prioritise the impacts of proposed soil biology research.
- Less fragmented research effort, economies from shared staff, facilities, outcomes.
- Rich training opportunities for students, PhDs.
- A more clean-green image for agricultural industries and possibly market benefits.

3) RD&E Theme: **Soil Borne Disease**

Overall theme: Identify microbial communities and functions that drive naturally suppressive soils

Development team members:
Margaret Roper, Ian Porter, Simone Rochfort, Jacky Edwards, Kathy Ophel-Keller

Objectives:
To manipulate soil communities to manage and suppress soil-borne diseases and increase productivity by:

a) Characterising key drivers of the relationship between inoculum and expression of disease.

b) Understanding the mechanisms of disease suppression using an expanded range of tools and linking to management approaches (Management & agronomy).

c) Determining the importance of incidence of new disease or different expression of existing disease under changed climate and changed farming systems.

Key methodological considerations; outline of main RD&E activities:

1) Integrate classical, chemical, molecular and emerging technologies to understand the mechanisms of disease suppression.

2) Pool data from a range of trials and industries to look for common indicators of suppression.

3) Determine the benefit of diagnostics in the prediction of soil-borne disease and their regional interpretation.

4) Identify microbial communities and functions that drive naturally suppressive soils.

5) Identify soil, crop management and climatic conditions that promote suppressive communities.

Key methodologies: Classical microbiology & ecology; plant pathology; a range of DNA methodologies; microbial profiling; soil enzymes; antibiotics/antifungals.

Indicative resources and cost / benefit (including environmental and economic benefits):

Year 1- Planning/cross-industry data pooling.
Year 2-5. R & D phase.

1. Cross industry collaboration to
   a. develop common approaches to monitoring suppression and
   b. pool physical, chemical and biological information on characterised disease suppressive (and selected non-suppressive) sites. (activities 1&2).

   Resources: database development, time commitment for researchers. $250K.

2. Coordinated field and laboratory trials in different regions to address activities 1, 3, 4&5. Integrate closely with regional management and agronomy trials, and rhizosphere research.

Resources: Initial planning, cross-industry, and research phases up to $2-3 million per annum

Risk analysis (ie key risks and actions to mitigate them):

- Lack of trained pathologists and microbiologists.
- Difficulty in applying indicators across soil types, indicators and regions.
- Time frame of 5 years insufficient.

What skills / capacities would need to be involved/partnerships:

Key methodologies: Classical microbiology & ecology; plant pathology; a range of DNA methodologies; microbial profiling; soil enzymes; antibiotics/antifungals

Likely locations / spread of work:

National field trials with key groups supplying common methodologies as much as possible (eg one group does all microbial profiling; another group does pathogen DNA etc to ensure common methodologies and interpretation). Use of agreed protocols.

Outputs - what the work would deliver including non-financial deliverables:

Increased productivity resulting from reduced losses due to disease.

Reduced inputs of chemical fungicides and other inputs which are expensive and can be deleterious to soil microflora).

Specific Outputs:

- Networked national capability on disease suppression
- Decision tools to manage inputs for disease suppression
- Pooled, cross-industry knowledge of potential indicators of disease suppression
- A strategic plan identifying research needs in disease suppression
- Improved validation of DNA diagnostic tests/link to decision tools
- Increased knowledge of suppressive communities/identification of potential bio-fungicides.

4) Combined with Theme 6) Rhizosphere

6) RD&E Theme: **Managing the rhizosphere biology to maximize productivity and resource management.**

Development team members:
Michelle Watt, Gupta Vadakattu, Dan Murphy, Bruce P (Cotton), Catherine Phelps (Dairy), John Moreau, Mathew Denton, John Mullins (economics)

Objective:
To enhance resource use efficiency (water, nutrient) in managed and natural systems.

This will be achieved by (Key methodological considerations; outline of main RD&E activities):

a) Establishing a common focus on rhizosphere.

b) Establishing common priorities between research, industry and government partners to increase research efficiency and improved cross-industry integration.

c) Exploiting plant genetic variation in root development and exudates to drive rhizosphere biology.

d) Through focused field sites.

Some specific rhizosphere based research priorities:

- Unlocking the soil P bank.
- Enhancing biological nitrification inhibition.
- Maximizing BNF in non-leguminous plant systems.
- Optimizing pathogen-community interactions.
- Increased plant available water through soil structural improvement.
- Inoculum efficacy through specific exudates.
- Remediating toxic elements in soils.

Indicative resources and cost / benefit (including environmental and economic benefits):
Resources: $10M per year for 7 years (proposed breakdown for national theme: $5M from various Industry and Government partners from 5 states (~$1M per state), plus $5M in-kind from research organisations)

Benefits: Crops – Increased profit through decreased fertiliser application, improved nutrient use efficiency and/or yield.

Pasture and dairy- increased sustainability through improved nutrient use efficiency and reducing GHG contribution.

Increased revegetation of degraded and contaminated soils (Improved success of revegetation efforts???), reduced run off (possible interest from mining industries, natural resource management government agencies).

Both managed and natural systems – reduced green house gas emissions.

Environmental and productivity benefits through reduced nutrient and soil losses in both managed and natural systems.

Quicker output delivery with broad ranging applications.

Other benefits – effective links with new products (inoculum effectiveness) program.

Training, soil biology research not in isolation from other disciplines.

Australian capability maintained and advanced in soil biology area.

Risk analysis (ie key risks and actions to mitigate them):

Resource efficiencies not achieved; mitigated by focus on rhizosphere, a key centre of biological activity in Australian soils, coordinated network and field sites to incorporate soil biology within other soil and management factors.

What skills / capacities would need to be involved/partnerships:

Network would source the necessary skills, capabilities and infrastructure.

An emphasis on using technologies that allow linkage between plant growth, rhizosphere processes and resource use, in both the field and controlled conditions that mimic field soil conditions.

Technologies to track plant growth and resource use would include non-destructive water and nutrient sensors, non-destructive imaging methods and destructive chemical methods.

Quantification of microbial functional groups and resource use processes will be done using

- stable isotope probing (process rates),
- profiling and probing extracted microbial DNA and mRNA (diversity and functional capability),fluorescence tagging and tracking of specific organisms (eg, inoculants) using microscopy, culturing and
- chromatography and GC-MS methods for exudates and rhizosphere signals

Skills in plant physiology, breeding and molecular biology would be sourced to generate genetic variation in root architectures and root exudates to drive specific rhizosphere biology. In crops, conventional and marker-assisted breeding could be used, or novel gene insertions into plants by transformation. Natural variation in native plants would be used to optimise root-organism interactions for revegetation of non-agricultural land.

Likely locations / spread of work:
National representation in each region in five states across all industries. Specific research in each region will be based on the requirement of relevant industry.

Outputs - what the work would deliver including non-financial deliverables:
New practices or plant types to increase resource use efficiencies in managed or natural systems

Increased scientific capacity and improve Australia's competitiveness

Increased efficiency through synergies and common focal point

Commonality in protocols and approaches across individual projects/regions (establish standards)

Providing rigour and validation of research for IP.

5) RD&E Theme: **Microbial Products**

Development team members:
Paul Meibusch, Roz Deaker, Paul Harvey, Chris Franco, Sarah Anderson, Lambert Brau

Objectives:
1) Develop quality Indicators.
2) Design pathway to get new technologies to be market ready (linked to point one).
3) Compatibility of components of co inoculants.
4) Using biotech tools to select organisms that are more effective functionally, can also be used as a QC tool.
5) Do the chemicals used to inhibit N20 have a detrimental effect on key soil microbes?

Key methodological considerations; outline of main RD&E activities:

1) Collaboration between researcher/industry/ALIRU to develop a list of criteria both quantitative and qualitative.
2) Specification, manufacturing requirements, genetic stability,
3) Compatibility studies of new inoculants, biological, chemical, fertilizer.
4) Look for reduction in functionality of key soil microbe indicators.

Indicative resources and cost / benefit (including environmental and economic benefits):
1) Benefit $36m greater confidence in the industry, cost to set up QA/C system $300K annually.
2) Benefit – N use efficiency. Potential damage to soil ecology.

Risk analysis (ie key risks and actions to mitigate them):

1) Renegade companies not adhering to standards, loss of industry confidence.
2) If work isn't done will undo all the prior investment in inoculants. Farmers will have the tools to make an informed decision as to what they want to target.
3) Loss of nutrients efficiency x potential costs of a carbon trading system.

What skills / capacities would need to be involved/partnerships:
NRP, other universities/research bodies working with microbial inoculants in collaboration with ALIRU and industry.

Likely locations / spread of work:
Industry/ ALIRU other collaborators.

Outputs - what the work would deliver including non-financial deliverables:
1) Confidence in the market, product differentiation
2) Comprehensive compatibility table, management options

7) RD&E Theme: **Education and Training**

Development team members:
David Herridge (leader), Graham O'Hara, Catherine Viljoen, Cath Botta, Damian Bougoure, Mark Peoples, Susan Orgill.

Objectives:
To develop a structured national coordinated program to educate land managers on soil biology, to:

- Achieve better management and facilitate change in nutrient availability, soil structure and disease through an understanding of soil biological processes.
- Address i) relationships between soil biological processes and productivity and ii) issues surrounding products (biological and organic) i.e. decision making, trials and efficacy.
- Achieve scientific consensus on language, measurements and protocols for trialling strategies.
- Build on the outcomes of the HSSF Projects.

Key methodological considerations; outline of main RD&E activities:

- Collate outputs from RD activities.
- Build on the outcomes from the HSSF Projects; consolidate the generic national material.
- Book. Identify a leader and assemble the scientific knowledge panel (experts); workshop and focus on land manager outcomes through individual contributions and pool together comments for final product.
- Facilitate the extension of the product through consultation with local on-ground staff i.e. local extension team: grower groups, Government organisations, agribusiness.

Indicative resources and cost / benefit (including environmental and economic benefits):
Benefits:

- Better informed management of soil; particularly related to nutrient availability and soil borne disease.
- Value adding to previous investment (e.g. HSSF, GRDC soil biology initiative and other).
- Capacity building of land managers for improved resource management.
- Provides pathways to impact.

Risk analysis (ie key risks and actions to mitigate them):
Risks:

- Insufficient cross-industry support.
- Apathy in path to adoption (limitations of interest in management of the system in soil biology context).
- Static nature of information in book format; material outdated.
- Being too generic (i.e. not focussed) to be useful on-ground i.e. too complicated, not locally specific, not industry/enterprise specific.

Actions to mitigate:

- Engagement with industry; tailor information with industry.
- Engage on-ground staff for the rollout.
- Have pathways for the book to be updated. Focus on other resource materials; book is just one part of the resource pack.
- Clear messages: functionality and management rather than description of soil biological systems.

What skills / capacities would need to be involved/partnerships:
Eg Book: Soil biology experts in the field (co-authors).
Leadership
Communication
Extension skills
Partnerships: Cross industry RDC, national cooperation across RD providers (e.g. LWA), State Government, private and public extension networks, grower groups, farm advisors

Likely locations / spread of work:
National; primary industries focus.

Outputs - what the work would deliver including non-financial deliverables:
Resource pack.
Book.
TAFE Accredited course.
Presentations, speakers notes and handouts.

8) Biotechnology Platforms & 10) Strategic Discovery

These themes were considered to be closely related and easily combined. Both of these themes were identified as required for all theme areas and specifically, theme 1 (monitoring), theme 2 (management systems), theme 3 (Soil borne diseases) and them 5 (microbial products). Theme 6 (modified to incorporate theme 4) did not identify specific biotechnology requirements.

9) RD&E Theme: **Building Research Capacity**

Team member names:
David Herridge (leader), Graham O'Hara, Catherine Viljoen, Cath Botta, Damian Bougoure, Mark Peoples, Susan Orgill.

Objectives:
Program for more effective application of soil biology in agriculture through:

- National RD program; forum for lines of communication.
- Coordinated use of material (see #7).
- Building collaborative partnerships between different RD Programs.
- Building RD capacity to identify and answer questions with a coordinated approach.
- Facilitating transfer of knowledge across industry.

Key methodological considerations; outline of main RD&E activities:
1. Student programs e.g. post-graduate program and discipline approach through undergraduate training i.e. incorporation of resource material into CRC and university training
2. Network database that captures current efforts, focuses, research and funding
3. Knowledge sharing opportunity e.g. conference/forum/seminar/workshop
4. Shared experimental sites

Indicative resources and cost / benefit (including environmental and economic benefits):
Benefits:

- Facilitating transfer of knowledge across industry.
- Cost effective RD.
- Developing larger critical mass.
- Avoiding duplication.

Risk analysis (ie key risks and actions to mitigate them):
Risks:

- Competition for funds.
- Unwillingness to share RD ideas in an open forum.

Actions to mitigate:

- Activities to build collaborative relationships e.g. build trust and share project data

What skills / capacities would need to be involved/partnerships:

Coordinating body with nodes in each State.

Likely locations / spread of work:

National; primary industries focus.
Forum: State focus

Outputs - what the work would deliver including non-financial deliverables:
Database (network)
Conference

Outcome: research capacity enhanced