Cotton and Grains Farming Systems Seminar

4–5 August 1998
Dalby, Queensland

— PROCEEDINGS —

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GRDC
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Cotton and Grains
Farming Systems Seminar

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FOREWORD

The Cotton Research and Development Corporation (CRDC) and the Grains Research and Development Corporation (GRDC) are acutely aware that, increasingly, cotton and grain crops are being grown side by side and in rotation throughout northern Australia. Consequently, the two corporations share common issues and concerns.

GRDC and CRDC see potential benefits in coordinating their respective investments where common goals and objectives are identified. In particular, the corporations would like to foster better communication between research and extension staff within the two industries. This seminar was held to enhance links between the two industries and to start the process of identifying common ground.

The objects of the seminar were:

- To bring together research and extension staff from within the grains and cotton industries to exchange information about their respective research, development and extension programs
- To identify potential for synergy between respective programs
- To build better links between research and extension staff within the two industries

At the seminar, key research and extension staff were asked to present an overview of their programs, emphasising how synergy between the two industries could be generated. Additionally, producers covering both industries as well as irrigation and dryland farming spoke in several of the sessions. Each session was concluded with a period for questions and discussion. Broad areas covered included insects, weeds, diseases, soil management, modelling, water relations, crop rotations, best management practices and extension.

At the conclusion of the seminar a 'steering committee', representing CRDC, GRDC and growers, met to consider findings from the seminar and identify key areas where the two corporations would benefit by coordinating their respective investments. Arising from this, the steering committee decided on an action plan, which you will find on the opposite page.

ACTION PLAN

Present at the Steering Committee meeting were: David Hamilton (Chair); Ewan Colquhoun (Facilitator); Bruce Pyke; David Alexander; Ian Buss; Ralph Schulzé; Helen Dugdale; John Harvey; Stuart Kearns; Vic Edge; Keith Alcock*; Dave Anthony

At the completion of the seminar the following areas were identified for further action and are either in progress or will commence as soon as practicable:

1. **Area Wide Pest Management**
   - ⇒ NSW Agriculture will request GRDC to fund a grains focused entomologist for the north west. A coordinated Farming Systems Institute/NSW Agriculture project on sucking pests will be put forward. GRDC and CRDC need to ensure synergy, especially on mirids.
   - ⇒ A subgroup was established to maintain the collaboration needed for Area Wide Pest Management: Bruce Pyke (convenor); Keith Alcock*; Ian Buss; Vic Edge.
2. **Spray Applications**
   - ⇒ Other R&D corporations, plus the University of Queensland, may need to be involved; however CRDC and GRDC should lead.
   - ⇒ CRDC is focusing on this through Best Management Practice but GRDC is yet to begin work in this area; however GRDC has supported related Kondinin work.
   - ⇒ CRDC is organising a rewrite and update of the SPRAYpak manual and will fund this work. It was decided there was probably no need for separate manuals for cotton and grain growers but this should be discussed further. If a manual common for cotton/grains is developed, it may need adapting for southern and western regions.
   - ⇒ Training sessions to be organised for grain growers. GRDC to discuss with the University of Queensland and CRDC.
   - ⇒ Kondinin to update manuals for southern and western regions.
   - ⇒ A subgroup was formed to progress these issues: Keith Alcock* (convenor); Bruce Pyke; Vic Edge, David Alexander.
3. **Modelling/Farming Systems**
   - ⇒ It was decided these should be a consequence, not a driver, of research.
   - ⇒ A subgroup was formed: John Harvey (convenor); Helen Dugdale; David Hamilton; John Sykes.
4. **Minimum Tillage/Controlled Traffic/Precision Agriculture**
   - ⇒ Coordination is on track in this area, with CRDC and GRDC researchers working closely.
   - ⇒ John Harvey and other GRDC members are to be invited to the 'Soils and Farming Systems' Seminar to be held by CRDC on 2–3 December, 1998.
5. **Environmental Impact Management (Best Management Practice and Quality) Assurance**
   - ⇒ There are two main issues:
     6. Atrazine and Endosulfan in river systems
     7. Off–target spray drift of various pesticides
   - ⇒ GRDC is funding research to assess how much the grain industry is contributing to environmental damage
   - ⇒ The NRA and Novartis are working together on the Atrazine issue
   - ⇒ GRDC to resolve with grain growers which should come first: BMP or Quality Assurance. Grain growers at the seminar appeared to favour a BMP approach. It was suggested the benefits of BMP could best be demonstrated as "Total Catchment Management".

** Note: since this meeting took place, Keith Alcock has left GRDC. His replacement on these sub committees remains to be confirmed.*

CHAIRMAN'S OVERVIEW

Cotton and Grains: Working together for the future of broadscale cropping

David Hamilton
Director, CRDC
Director, Farming Systems Institute, Queensland Department of Primary Industries

Historically, the grains and cotton industries have operated independently. This is particularly true of the research effort, where we have separate funding arrangements and largely separate research programs.

Recently, issues which confront both industries have been highlighted: sustainability, farming systems, environmental quality and generic issues such as seasonal forecasting and the benefits to the system from improved soil and water management. Pest management has also become a universal issue.

To gain the best results for both industries, each needs to use research outputs from the other and work cooperatively to develop a total farming systems approach. The need to take this grains and cotton approach is highlighted in dryland production areas like the Darling Downs and the Liverpool Plains. To maximise productivity (and sustainability) in these regions, grain and cotton crops are best grown in rotation; however, the benefits of a grain/cotton system over much of the region, from the Macquarie in the south to Emerald in the north, are as apparent in irrigated situations as in raingrown situations.

Some of the specific topics that require careful integration are as follows:

- Region-wide pest management
- Movement of pesticides in the environment
- Managing the total water resource
- Minimising adverse impacts on the land resource.

Heliothis are pests of grain crops as well as cotton. The control of this pest is an enormous cost to both industries, particularly when we rely so heavily on insecticides. Insecticide resistance and the resultant poor pest control has impacted severely on cotton and pulse crops in recent seasons. By taking a region-wide approach, we may be able to more effectively control this pest for both industries.

The cotton industry has attracted a good deal of attention on issues of pesticides in the environment; however, when pesticides are measured in our inland waterways, insecticides and herbicides in both the grain and cotton industries raise concerns. A joint, concerted approach will solve this problem. By using winter cereals to generate surface cover, by not using pesticides in sensitive areas and by using the most environmentally sound pesticides for the job at hand, these pesticide issues will be solved. We now have sufficient research input from both the cotton and grains industries to solve problems with pesticides in the environment.

Surface irrigation water feeds the cotton industry. Rainfall feeds the grains industry. Both cotton and grains research activities have identified ways to maximise the efficiency of use of the water resource: the technologies of surface management, soil water storage, maximising infiltration, minimising compaction and maximising water use efficiency can be applied to the whole farming system.

By appropriate use of these research ideas, farmers will be able to minimise soil erosion, minimise turbidity in our inland rivers, sustain the water resource and maximise crop productivity and farm profitability.

GRDC and CRDC have taken the initiative to draw research teams together and help researchers share their knowledge. It is now up to the research leaders to plan projects for the benefits of both the grains and cotton industries.

EXECUTIVE SUMMARY

Dave Anthony
Director, CRDC

The Dalby workshop provides a unique chance for two of Australia's leading field crop research & development corporations, CRDC & GRDC, to come together to share information about research needs and production challenges facing the industries.

Grains and cotton farming systems have many features in common. Most cotton growers are significant grain producers while many grain producers take opportunities to grow cotton when conditions and prices are favourable. Cotton and grains in northern NSW and Queensland are grown in the same environment, often along side one another. The interaction between cotton and grains farming systems involves weed, insect and disease management, moisture conservation, land preparation and stubble management, crop nutrition, crop modelling systems and risk management. The activities of one industry can have implications for the other, the most noteworthy being insect management.

Both industries are developing quality assurance/best management practices systems and need to maintain a strong level of communication to avoid duplication.

Research in both industries has provided huge benefits to producers; however work and investment in the areas of machinery, weeds and harvesting were not seen to have kept pace with other factors. This has been addressed in recent years with more resources directed to these areas. Good research data and effective communication are the keys to the adoption of improved farming systems by both industries.

While both industries are interested in developing farming systems, gaps in many of the individual elements of farming systems still require more work and shouldn't be overlooked. These include insect, weed and disease issues, machinery, rotation crop analysis, stubble handling and integrated pest management.

Crop and systems modelling at both the farm and catchment levels are proving useful. Significant successes have been achieved with risk assessment models using soil moisture, rotation options and economic factors as key parameters. The thrust of this work is to provide tactical analysis with "what-if" questions allowing producers to make more informed risk management decisions.

Forecasting and networking of insect data across the cotton and grain growing regions need reviewing. Insect problems in one crop or area can have important impacts on other susceptible crops and regions. Crop scouts, consultants and researchers currently collect significant field information on a day to day basis. A means of quickly collating and disseminating this data may enhance insect management decisions.

Area wide management of pests is an exciting development. While there are many challenges to such systems the potential to decrease the reliance on traditional pesticides and encourage greater adoption of cultural, host plant resistance and biotechnology solutions is enormous.

Soil and nutritional management are seen by both industries as being critical for long term sustainability. Mycorrhizal issues, nutrient strategies, erosion control and moisture conservation have widespread applicability. There are some potential technology conflicts to be addressed such as the challenge of balancing moisture conservation, conservation tillage and Heliothis pupae destruction.

Precision agriculture is developing rapidly and cotton and grains stand to benefit enormously from this technology. CRDC and GRDC need to coordinate their efforts to ensure the most efficient and focused use of funds and resources.

Environmental concerns, particularly pesticide movement off target, are a big issue for both industries. While the community focus on pesticides has been largely on cotton, all farmers have to realise that pesticide application and the professional use of chemicals are the responsibility of all agriculturalists. The best management practices system currently under development is one of the key vehicles for enhancing environmental performance and technology transfer. It is important that both industries are recognised by the community as having world-class and responsible agriculturalists who are focused on the stewardship of natural resources to deliver prosperity and security to regional and national Australia.

Brazil Farms, Brookstead: a Darling Downs case study in farming cotton and grain crops

Lyn Brazil

Brazil Farms are all broadacre farming and there are three farming systems:

1 Black clay furrow irrigated;
2. Condamine clay non irrigated; and
3. Box plain non irrigated

1. Black clay furrow Irrigated

- Cotton is the most profitable crop and the system is built around that
- Irrigation is a mix of bores and surface supply
- Slow distribution rate limits the area of any one crop
- Growing cotton for seventeen years with an accumulation of diseases – Verticillium wilt and now Fusarium wilt
- Also harder to control weeds, bladder, ketmia, nutgrass and bellvine
- Rotation 1:1 or 2:1
- Previously sorghum/cotton, now direct drill wheat/cotton/long fallow
- Three tonne per hectare increase on wheat – one irrigation in dry year
- Decision to pupae bust or not

2. Condamine Clay Non Irrigated

- Same locations as irrigation; about 40 per cent of total area and uses a lot of the same equipment
- We use a lot of 2 metre permanent beds
- Either river adjacent which floods and would not be appropriate to level for furrow irrigation or areas of bad drainage or ridges with slopes not economical to level.
- Generally grow cereals on a low management input so that we can concentrate on cotton areas.
- Moisture availability is a major determinant of cropping frequency – moving towards zero till.

3. Box Plain Non Irrigated

- No irrigation water available – flat and overland flow.
- Strip farming and zero till.
- Soil does not lend itself to cultivation, dries quickly and comes up cloddy.
- Zero till increases moisture infiltration and soil stays wet longer, giving us a wider planting window.
- Have had a challenge to find appropriate equipment – we use disc planters.
- One difficulty in timeliness of operations is that the wind is always too strong or in the wrong direction to spray.
- Generally grow about 40 per cent each of summer and winter cereals and 20 percent skip row cotton. The frequency depends on available and expected moisture.
- This program allows good use of machinery and labour and the cotton allows us to pick up a sweetener without too much risk.
- The rotations and long fallows allow us to keep on top of weeds
- We have grown oilseeds and pulses but our budget and management considerations exclude them now

Summary

Overall, our cotton and grain operations are quite integrated, with impact both ways. I think that our three different operations reflect most of the situations on the Downs, recognising that there are variations in management. Most farmers would like to have the flexibility to adjust their programs to capture market opportunities and manage for risks that present themselves.

Farming Systems: a scientific view

Greg Constable
Executive Director, CRC for Sustainable Cotton Production

It makes sense for GRDC and CRDC to coordinate, not the least because about 30 per cent of cotton grown in Australia (130,000 hectares) follows wheat as the previous crop. That rotation has evolved in the past 25 years as a disease break (verticillium wilt) and as an ameliorant for soil compaction: the wheat rotation allows good drying of the soil profile and the following long fallow has a number of benefits including capture of rainfall.

The coordination between R&D Corporations should be for more reasons than endorsing current practice. Many of the fundamentals of farming systems research are common to most crops: factors such as weeds, compaction and soil fertility are constraints affecting all crops. It is at the area of scientific principles where coordination of research effort/funding should be established.

Figure 1 summarises the interaction of many aspects of a cropping system. Each factor may have a different magnitude of importance for each soil type and climate, but the fundamental scientific principles for each box or line are very similar in most crops.

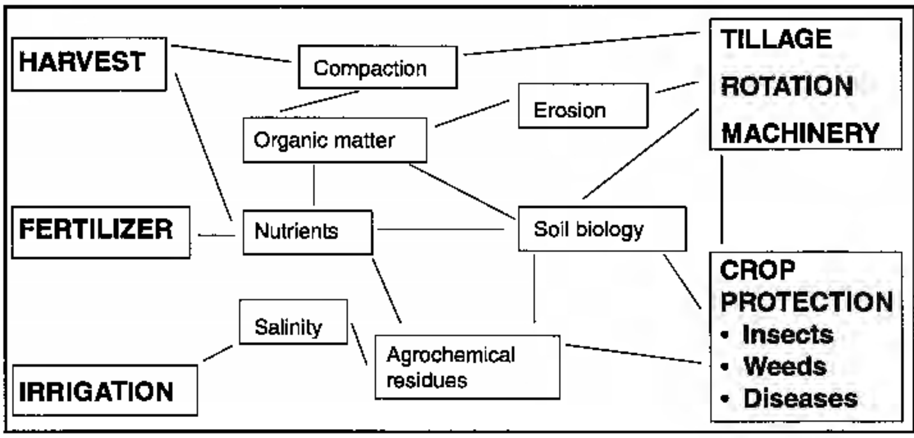


Figure 1. *Interrelationships between management issues and impacts in a cotton cropping system.*

Research and extension have a role to play in many of these factors to develop and promote a sustainable and productive system.

There has been considerable success in cotton cropping systems in developing reduced tillage on permanent beds; on development of high yielding fertiliser–irrigation practices; and on breeding varieties with good disease and insect tolerance. There are still gaps on suitable (profitable) rotations; stubble handling and Integrated Crop Protection.

The science of Cropping Systems is more in the experiments studying the elements of the system than in large systems experiments.

Modelling and Decision Support Systems

Peter Hayman
NSW Agriculture, Tamworth

The cotton and grains industries both have a long tradition of modelling and decision support systems. The application of models and Decision Support Systems (DSS) to farming has been more challenging than the predictions I heard when I left University in the mid 1980s. It is important that we learn from and build on the past. To that end, rather than present a list of models, I have provided a biased overview of some lessons. In the compression to one page it may seem a bit cryptic.

Brian Hearn (C.M. Donald Oration, 8th Australian Agronomy Conference, Toowoomba, 1996)

1. Seek to develop models for problem solving as opposed to "have physiology will travel – solutions in search of a problem".

Agronomy is to plant sciences what engineering is to the physical sciences... Science is about finding out how the world works, engineering is about solving practical problems... Modelling for problem solving is an essentially pragmatic activity. The scientist may say there is not enough data, let's get some more. The engineer makes best use of what data is available ... The tension between science and engineering surfaces when we seek funding. The researchers want to do science and the funding bodies want problems solved, and so we invoke the 'better understanding' argument. We must find appropriate levels of resolution.

David Woodruff & Graeme Hammer

2. Using models to help managers deal with a variable climate

One of the factors that make decision making complex is the uncertainty. In dryland farming systems, decisions and outcomes are not directly linked. There has been a tradition of analysing and presenting management options in the deterministic form of choice–consequence (if you put on x amount of nitrogen your wheat yield will be Y). To allow for the uncertainty of climate variability the analysis needs to consider choice, chance, consequences (if you put on x amount of nitrogen there is a range of outcomes depending on the season).

Bob McCown, Peter Carberry, and Mike Bange

3. Rigorous and purposeful engagement of agribusiness and farmer clients in the application of modelling tools

FARMSCAPE has operated since 1992, working with 200 farmers and 15 advisers. This approach is distinguished from DSS by taking the base models out into the field and asking farmers and advisers to design and test applications for their own situations. This approach has helped in integrated cotton and grain farming systems.

Peter Cox

4. To be more reflective about modelling

The need for an analytical phase to study the sensitivity of possible outcomes to the way a system is managed. There are different requirements of resolution for those studying the system. Agricultural science tends to use economics at the end of a research, development and extension program to add dollar signs to biology. In doing so we ignore economics as the science of choice. There are different requirements of resolution for scientists studying the system and farmers managing the system.

Conclusion

We cannot avoid modelling, as all debate depends on shared representations of the world (models). Daily time step simulation models, Water Use Efficiency (WUE) models and whole farm bio-economic models are likely to play a role in the debate on improvements to, and integration between, the cotton and grains industry.

Overlapping Pest Management Needs of Cotton and Grains

Gary P. Fitt
CSIRO Cotton Research Unit and CRC for Sustainable Cotton Production

Much of the entomological research of CSIRO and of the CRC for Sustainable Cotton Production at Narrabri is directed towards the management of *Helicoverpa* spp. – *H. armigera and H. punctigera*. While our focus has been in cotton, our approach to these pests has always been to seek sustainable management strategies based on the regional ecology of the species, recognising that their regional abundance is influenced by many host plants in addition to cotton.

Helicoverpa spp. are well adapted to exploit diverse cropping systems such as those provided in northern NSW and Queensland. Both species are polyphagous, highly fecund, highly mobile and have well adapted diapause strategies. Our efforts to develop a regional population dynamics model for *Helicoverpa*, HEAPS (*Helicoverpa Armigera* and *Punctigera* Simulation), reflects these attributes and the need to focus at a regional (area-wide) and multi-cropping scale to effectively manage these pests.

Cotton oriented Research

Within CSIRO, our research on *Helicoverpa* has many elements:

- basic ecological studies of population dynamics
- patterns of host use of cultivated and non-cultivated plants
- overwintering abundance and survival,
- adult movement and behaviour
- spatial population modelling
- genetics and evolution of pesticide resistance
- sampling systems.

Coupled with this is comprehensive research on the ecology of key beneficial species which may be manipulated as a component of Integrated Pest Management (IPM) systems, and research on host plant resistance in cotton, including transgenic cottons. This research seeks to develop more tolerant or resistant varieties and the management strategies needed to ensure their long-term viability.

Management Research

Management research includes:

- host plant resistance (conventional and transgenics)
- physiology of compensation
- sampling systems
- beneficial insects (ecology and manipulation)
- IPM (food sprays, beneficials, thresholds, selective chemistry, entomoLOGIC
- optimal use of pesticides
- genetics and evolution of pesticide resistance
- resistance management (conventional and transgenics).

Within the CRC we have projects on attractants for *Helicoverpa*, genetically modified nuclear polyhedrosis virus (NPV), novel Bt toxins, adult mobility and host selection behaviour.

Opportunities for Collaboration

There are many opportunities for coordinated research between the cotton and grains industries and I applaud the initiative of CRDC and GRDC in getting together to assess these possibilities:

1. Area-wide management

Area-wide management refers to management systems for pests applied at a regional scale covering many crops and farms, rather than individual fields. For Helicoverpa this is the appropriate scale to tackle the problem, but it demands close cross-industry coordination.

The Darling Downs experience of 1998 has renewed interest in area-wide management and shows the acute need for industries to work together in coordinated management of *Helicoverpa*. This is now happening on the Darling Downs and several other area-wide 'experiments' are beginning in cotton regions (Central Queensland, Border Rivers, Bourke, Macquarie), often using grain crops as trap crops.

2. Modelling of area-wide issues linking APSIM and HEAPS

APSIM (Agricultural Production Systems Simulator) provides a well developed simulation capacity of the productivity and phenology of many crops, most of which are *Helicoverpa* hosts. APSIM could easily be coupled with HEAPS to allow simulation of *Helicoverpa* population responses to historical cropping patterns and to the changed practices introduced as part of the area-wide approach.

3. *Helicoverpa* Information Network and Forecasting

This issue has been raised in many forums but there remains only partial support for the concept of an information gathering and dissemination system for *Helicoverpa* in all crops. An important element of such a system is the capacity to forecast potential Helicoverpa problems using well developed software. Some elements of the Helicoverpa Information Service are included in the current Downs area-wide project. A key point about such a system is that it would provide the opportunity to respond to *Helicoverpa* problems in real time rather than in hindsight, as we do now.

4. Host plant resistance research

This area has two components: conventional host plant resistance (HPR) and transgenics – cross-industry coordination would be beneficial in both. With conventional HPR we have well established bioassay and field techniques for screening cotton germplasm, which could be easily applied to various grains where *Helicoverpa* is a potential pest (grain legumes are an obvious opportunity). With transgenics there are real issues associated with the need for resistance management strategies. These will be essential for all insect-resistant transgenic crops. The threat of resistance to Bt genes or other transgenes highlights the real need to coordinate the use of transgenes in all crops where the target pest is the same. These issues are dealt with exhaustively in Fitt (1997)[1]. Research is also needed to identify and develop new insecticidal proteins.

5. Other pests

Apart from *Helicoverpa* the other major group of common pests between cotton and grains is sucking bugs. The green vegetable bug (*Nezara viridula*) is a problem in some grain legumes and has the potential to be a problem in transgenic cotton. GVB and a suite of similar sucking bugs can severely damage cotton bolls. Research on biological control of *Nezara* is under way in grains and could usefully be extended to cotton regions.

The green mirid (*Creontiades dilutus*) is another significant pest of several crops. For control of mirids, we need coordinated research and management involving trap crops, HPR and seasonal ecology and forecasting.

6. Cultivation as a pest management tool

Management of overwintering *H. armigera* in cotton has focused for some time on the use of cultivation to destroy diapausing pupae (pupae-busting). This is a mandatory requirement for transgenic Bt cotton (INGARD) and is also an element of the area-wide approach for the Downs trials this season. However, cultivation for *Helicoverpa* control is often contrary to the best management of soil or soil moisture. This conflict is well recognised but more could be done to explore other means of controlling pupae through modified tillage equipment or through other approaches, such as with insect pathogenic nematodes.

7. Monitoring of pesticide resistance

Some monitoring takes place in cotton and other crops at present; however this could be better funded and coordinated. There is a need for consistent and representative data over time from broad cropping regions with all crops in those regions being sampled.

[1] Fitt, G.P. (1997) Risks, Deployment and Integration of Insect Resistant Crops Expressing Genes from *Bacillus thuringiensis*. pp. 273-284, in G.D. McLean, P.M. Waterhouse, G. Evans and M.J. Gibbs (Eds), Commercialisation of Transgenic Crops: Risk, Benefit and Trade Considerations. Cooperative Research Centre for Plant Science and Bureau of Resource Sciences, Canberra.

Prisoners on Our Own Farms

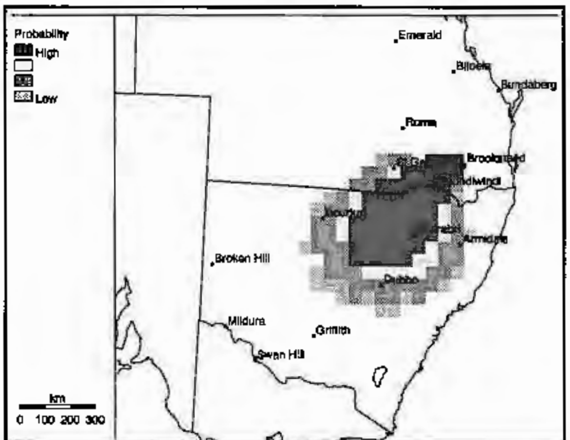
David Murray
Farming Systems Institute, Queensland Department of Primary Industries

The Darling Downs agroecosystem presents a challenge for managers of our most serious agricultural pest, heliothis. It is cold comfort knowing the seriousness of our predicament; it is something else to take positive actions to ameliorate the problem.

While chemicals have provided the mainstay of our management approaches, it has become clearly evident that this approach is simply not working. *Helicoverpa armigera* has developed resistance to the major insecticide groups and our battery of new insecticides is slow to recharge. There are several research activities that address the heliothis problem on the Darling Downs and, importantly, these are linked to current or planned research on pest problems.

In favourable years a suite of crops can provide heliothis with a succession of host plants that allow breeding of several successive generations. Heliothis does not recognise boundaries between fields, be they grain or cotton. To heliothis, they are mostly resources that should be exploited. It is this knowledge that underpins the regional or area-wide management approach that is entering a research phase on the Darling Downs. This project builds on the initiatives of the Central Queensland program led by Richard Sequeira which has two pilot areas: at Brookstead/Cecil Plains and Jimbour floodplain.

The aim of the regional management strategy is to keep heliothis numbers at more manageable levels. To achieve this aim the strategy has targeted three well-defined elements. The first is to reduce the carryover of local overwintering pupae by tillage (Pupae busting). The second is to reduce the size of the first spring generation by careful crop management and use of trap crops. The third is to apply best management practices in order to keep summer generations at levels that can be managed within the limits of insecticide resistance and available chemistry.



The potential fallout area for heliothis moths migrating from Brookstead on 13 January 1998, estimated by the CTPM heliothis migration model
(Wayne Rochester, University of Queensland)

This study is complemented by two University of Queensland projects. The first will investigate heliothis populations to determine whether DNA microsatellite markers can be used to identify local versus distant contributions to heliothis populations. The second will examine the potential for movement and migration within and between regions.

These activities are supported by a project on heliothis management for IPM in grains. This project has a major focus on the role of biopesticides and, in particular, Helicoverpa nuclear polyhedrosis virus (NPV) for the selective management of heliothis. Other components of this project will investigate biotic and abiotic factors affecting heliothis survival, thresholds, and the role of new chemistry. Several other projects complement these activities.

Conclusion

It is very obvious that if we are to succeed in our efforts to improve management of heliothis it will demand a more informed farming community: one that understands the complexities of the pest and its interactions with the environment. To achieve this end an increased emphasis must be placed on the development and extension role. Equally important, in my opinion, is the need to understand spray application and coverage demands of today's insecticides.

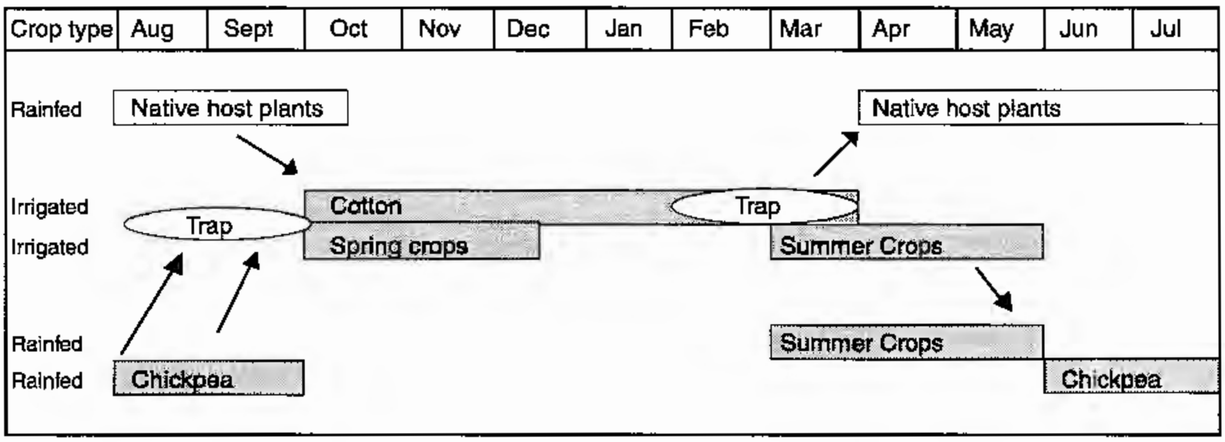
Preliminary discussions have taken place to integrate the current modelling expertise on heliothis population dynamics (HEAPS) and crops (APSRU). Such synergy will benefit the broader farming community and may help quantify the relative contribution of different crop hosts in the agroecosystem to the heliothis problem.

Development of an Area-Wide Management Program for Heliothis in Central Queensland

Dr Richard Sequeira
Entomologist, Farming Systems Institute, Queensland Department of Primary Industries

Heliothis is one of the most important pests of field crops in Central Queensland (CQ). The two species of heliothis occurring in Australia, *Helicoverpa armigera* and *Helicoverpa punctigera*, are both major pests of cotton and most of the other field crops grown in CQ. Traditionally, the heliothis problem in cotton has received much more attention than that in other crops partly because of the long period, extending over several months, during which cotton remains attractive to heliothis. However, in recent months grain crops have been devastated by heliothis in many cropping areas, particularly in parts of southern Queensland and New South Wales. This has served to focus attention on the heliothis link between cotton and other field crops.

In response to the worsening heliothis problem on cotton in CQ, a detailed examination of the population dynamics and ecology of heliothis in the local environment was undertaken at the start of the 1996/97 season. The results of the study reveal the intricate nature of the heliothis link between cotton and non-cotton crops in the area. This link is summarised in the figure below.



Winter chickpea crops provide a significant component of the first spring populations of heliothis. A variety of spring crops (in years when these are grown) such as sorghum, corn and legumes allows the populations to swell. By the middle of summer, cotton in turn becomes the single largest nursery crop for heliothis. Toward the end of the cotton season, other summer crops such as sorghum, sunflower and legumes again provide continuity of host plants for the heliothis populations coming off cotton. The final link in the heliothis chain is migration from these late summer crops to chickpea or other winter crops. Thus, cotton as well as non-cotton (grain) crops are clearly implicated in the rise of the heliothis juggernaut every season.

The ubiquitous pest status of heliothis, encompassing all cropping areas in CQ, implies that any measures adopted must be strategic in nature and regional or area-wide in scope. Of equal importance is the need for concerted efforts by the cotton and grains industries to combat the problem. The cotton industry in CQ has recently embarked on an ambitious area-wide heliothis management program. The program involves growing chickpea trap crops at the beginning and pigeon pea (or any other suitable) trap crops at the end of the cotton season. Implementation of the program is currently confined to the irrigation area.

The current stage of the program involves mainly irrigated cotton growers within the Emerald irrigation area. The involvement of the grain growing community has so far been minimal for two reasons. The first is that development and implementation of the program was easier in a small, well-defined area that produces a significant proportion of the local heliothis population. The second reason is that grain crops in the Emerald area tend to be largely rainfed and grown outside the irrigation area.

The next stage of development of the program calls for the involvement of grain growers across the broader CQ cropping zone. The area where grain growers can contribute substantially to the program is in the implementation of the chickpea trap-cropping component. As the program develops, the distinction between cotton and grain growers in the Emerald area will become obscure. This is because both industries feed the heliothis juggernaut as the figure above indicates, and any strategic heliothis control measures adopted by the one will directly benefit the other.

Insect Pests on the Darling Downs – a Grower Perspective

Geoff Hewitt and David Alexander

Background (Geoff Hewitt)

The 1980s

- Heliothis activity mainly in cotton
- Insect Resistance Management Strategy (IRMS) introduced to the cotton industry
- Midge major pest in sorghum
- Midge control with low rate synthetic pyrethroids (SP)
- IRMS did not completely correspond with SP usage in sorghum

Early 1990s

- Chick peas became a major winter crop
- Dramatic increase in dryland cotton
- Midge-resistant sorghum enabled summer-long sorghum growing

Mid 1990s

- Zero and minimum till in grain and cotton
- Resistance to most groups of insecticides
- Promise of new era in pest control from INGARD®

Late 1990s

- Huge heliothis population
- Very high resistance to most chemical groups
- High activity in most field crops
- Failure of INGARD® to control high populations
- Major control failures and crop losses

Heliothis Working Group (David Alexander)

- How it started: In-field discussions; Neil Forrester's predictions
- Formation of strategy group involving QGGA, DDCG Inc, CA and Farming Systems Institute
- Identify limitations in Farming Systems Institute: shortage of scientists, funds and equipment
- Group areas set up with rounds of meetings to get grower co-operation
- Campaign to increase farmer awareness
- Lobby Government by joint Chairmen and others
- Implement "Diapause Watch" campaign
- Plant trap crops, pupae busting; pheromone traps
- Change of Government - MORE lobbying
- Develop region-wide IRMS

Cotton and Grain Collaboration (Geoff Hewitt)

- Collaboration in cotton and grains research would mean:
- Far more political influence, combined
- Greater support from farmers
- Better communication and awareness of the other's problems/needs
- Grass roots farmers will follow the example of the industries working together
- More appropriate and comprehensive research programs
- Heliothis is but one example of an overlap in the challenge of producing cotton and grain, and the need for R & D joint ventures

Weed management program – Farming Systems Institute

Dr Steven Walker
Principal Agronomist, Leslie Research Centre, Farming Systems Institute, Queensland Department of Primary Industries

The overall aim of this program is to minimise the impact of weeds in field crop production by developing strategies for effective and sustainable weed management. Recent research has been in the following broad categories.

Herbicide residues

Specific re-cropping intervals are being defined for the major residual herbicides specifically for Queensland soils, climates and crops. The herbicides include atrazine, chlorsulfuron, metsulfuron, triasulfuron, imazethapyr, metosulam and flumetsulam.

The persistence and movement of the common residual herbicides are being measured to increase the understanding of their environmental fate in Queensland soils and climates. Also being investigated is relationships between crop response and soil and climatic factors, as well as residue levels.

Specific 'problem' weeds

A survey of the extent of herbicide-resistant weeds in the northern grain region (southern Queensland and northern NSW) is continuing, particularly for the Group A, B and C herbicides. Strategies to help prevent the development of further resistance have been developed and promoted. Strategies for managing resistant weeds are also being developed.

Two PhD studies have commenced on the ecology of the weeds paradoxa grass (*Phalaris paradoxa*) and sowthistle (*Sonchus oleraceus*). A Master's degree on the biology of raspweed (*Haloragis aspera*) has recently been completed.

On-farm development of integrated management strategies will commence this year for a range of perennial weeds in central Queensland and for nutgrass (*Cyperus rotundus*), Johnson grass (*Sorghum halepense*) and wandering Jew (*Commelina benghalensis*).

Ley legumes

Herbicide recommendations for the establishment of new ley legumes and dryland lucerne are being developed. As well, methods for terminating dryland lucerne are being investigated.

Integrated weed management

Strategies with reduced costs and reliance on herbicides are being investigated using both formal and on-farm research. This involves the use of lower herbicide rates and increased crop competition for winter cereal and summer pulse systems.

The impact of on-farm participatory research on weeds is being monitored in central Queensland, which will potentially be part of a PhD study.

Weed management on whole farms is also being monitored in order to identify improved practices.

Collaboration

The majority of this research is in collaboration, particularly with the Queensland Department of Natural Resources, NSW Agriculture, University of Queensland, CSIRO, University of Southern Queensland, Central Queensland University and University of New England.

Integrated Weed Management Research: Potential CRDC/GRDC Linkages

Grant Roberts

CRC for Sustainable Cotton Production, NSW Agriculture, ACRI, Narrabri

Cotton is a broad acre crop that has an opportunity for a true integrated weed management strategy to be implemented. New herbicide chemistry, genetic engineering and new machinery, when combined, offer the prospects of achieving a more environmentally and economically sustainable weed management approach for the industry.

There are several areas where research into weed management in cotton overlaps with the goals of other grains industries. To achieve the cotton industry's goals, weed management throughout the entire rotation will need to be coordinated in a strategic approach such that there are no weak links. The following is a list of areas of overlap:

A. Herbicide experimentation

1. Herbicide incorporation in minimum tillage/stubble retained systems
2. Fallow weed control
3. Crop plant-back research on residual herbicides, particularly rotation crops

B. Engineering

1. Spot/patch sprayers
2. Shielded sprayers
3. Precision agriculture in general but specifically weed issues
4. Tractor and cultivator guidance systems
5. GPS mapping of weeds

C. Integrated Weed Management strategies: overall approach for both industries

Rotation crops

1. Cereals (summer and winter) – sorghum, wheat, barley
2. Legumes (summer and winter) – faba beans, chickpeas, field peas, lablab and lucerne.
3. Probably not oilseeds - canola non-VAM
4. Broad leaf weeds common to both industries

Dryland cotton areas

1. Risk - rainfall variability – locking farmers into one option
2. Herbicide types and use– including plant backs
3. Stubble/minimum tillage experimentation
4. Cotton may progress from being an opportunity crop to the main crop

Plant Diseases

Dr Joe Kochman
Principal Plant Pathologist
Farming Systems Institute, Queensland Department of Primary Industries

Plant disease research is conducted at several locations within the Farming Systems Institute in Queensland: Toowoomba (Leslie Research Centre and Tor Street), Hermitage Research Station, Indooroopilly, Kingaroy, Mareeba and the Queensland Agricultural Biotechnology Centre. The research covers diseases of winter cereals, summer field crops, grain legumes and pulses.

The Plant Pathology group at the laboratories in Tor Street, where I am based, conduct research on a range of field crop diseases. These include diseases of: cotton (fusarium wilt); peanuts (soil-borne diseases); sorghum (ergot); soybean (phytophthora rot) and sunflower (rust and alternaria blight). We also diagnose, and provide advice on, diseases of other summer and winter field crops (grain legumes and pulses).

The research projects covered by our group have staff located at a number of sites. We have three Plant Pathologists and four Technical officers at Toowoomba, a Plant Pathologist and a Technical Officer at Kingaroy, a Plant Pathologist (shared with Horticulture) and a Technical Officer at the Department of Primary Industries laboratories in Indooroopilly and a Molecular Biologist at the DPI's Queensland Agricultural Biotechnology Centre, University of Queensland. We have collaborative links with CSIRO, University of Queensland, University of Sydney and NSW Agriculture through the Cooperative Research Centre for Tropical Plant Pathology (CRCTPP) and the CRC for Sustainable Cotton Production (Cotton CRC). We also have collaborative linkages with private seed companies.

The major focus of our cotton disease work, supported by CRDC and Cotton CRC, is on the management of fusarium wilt, caused by the soil-inhabiting fungns *Fusarium oxysporum* f.sp *vasinfectum (Fov)*. Fusarium wilt can cause extremely high losses when susceptible varieties are grown on heavily wilt-infested soil and weather conditions are favourable. Our studies of the Australian isolates of *Fov* from cotton indicate that there are two strains of the fungus, which have developed locally and have not been introduced from overseas. This has particular implications for identification and development of more resistant cotton germplasm which will be a most important management tool for this disease. Crop trash management, crop rotations, weed management and other cultural practices are also being investigated for their effect on this disease.

Rust and alternaria blight are two of the most important constraints on sunflower production in Australia. Our sunflower work, supported by GRDC, CRCTPP and private seed companies, deals with the identification and development of rust and alternaria resistant sunflower germplasm. We use traditional and molecular methods to screen germplasm for rust and traditional methods to screen for alternaria resistance. We have found the first molecular markers for sunflower rust resistance in the world. This data is currently being used to evaluate resistance gene pyramiding strategies. We also continue to monitor the populations of both pathogens.

Conclusion

Many of the diseases are crop specific and require particular management strategies and research; however, there is likely to be room for collaboration to research the management of some of the less specific diseases. For example, we were able to utilise some of the techniques developed by the banana fusarium wilt research team in the DPI and CRCTPP, to quickly characterise the causal fungus of fusarium wilt of cotton.

There is a requirement for diagnostic capabilities which can be supported by both the cotton and grains programs. The effect of particular crop rotation sequences on disease incidence is another area of collaboration from both the research and extension angles.

Plant Pathology and Soil Microbiology

Stephen Allen
Senior Research Scientist*
CRC for Sustainable Cotton Production, Australian Cotton Research Institute, Narrabri

Since 1983 we have undertaken a comprehensive program of research into diseases of cotton and the development of integrated control strategies. Our group at Narrabri includes two plant pathologists and a soil microbiologist, along with five technical staff. Currently we have collaborative links with the CSIRO at Narrabri, Canberra and Adelaide, Queensland Department of Primary Industries at Toowoomba and Indooroopilly, University of Sydney, University of Queensland, University of NSW and CAMBIA. Our research interests include, or have included, bacterial blight, Verticillium wilt, seedling diseases, black root rot, Alternaria leaf spot, bacterial stunt, Fusarium wilt, biocontrol of soil-borne diseases, management of mycorrhizas and microbial damage to fibre.

The research at Narrabri is complemented by CRDC/CRC funded work on Fusarium wilt by Queensland Department of Primary Industries staff at Toowoomba and Indooroopilly, coordinated by Dr Joe Kochman.

Disease Surveys have been completed in November and March of each season since 1983. Cropping history, field preparation, seed rate, cultivar, plant stand and the amount of crop residue remaining from the previous cotton crop have been recorded for each field inspected. Between 80 and 100 commercial fields, selected from fields in the Macquarie, Namoi, Gwydir and McIntyre valleys and at Bourke, have been inspected in each survey. The results of these surveys provide a basis for prioritising research efforts and give an indication of the impact of farm management practices and rotations on disease incidence and severity.

Reduced Tillage/Permanent Beds/Trash Management Over 70 per cent of the irrigated cotton area in NSW is planted under a reduced tillage/permanent bed system. The adoption of this system has resulted in larger amounts of crop residues carried over from season to season and, consequently, increased incidence of several diseases. This has necessitated the development of alternative disease control strategies. Conversely, the Fusarium wilt pathogen survives as a saprophyte on buried crop residue resulting in a build-up of inoculum. Preliminary results indicate that it is better to leave residues on the surface as long as possible to minimise disease carry over.

A new project funded by the CRDC under the CRC banner will be concentrating on microbiological aspects of crop residue management.

Rotation Crops can sometimes be used to reduce the build-up or carry over of disease inoculum from season to season. A cereal fallow is the most common rotation with cotton and has been recommended for reducing disease build-up; however, there is evidence from US work which suggests that the Fusarium wilt pathogen is able to colonise and increase on barley residues after harvest.

There has been an increase in the interest in legumes as rotation crops with cotton. Unfortunately, most legumes are also hosts of the black root rot pathogen and may contribute to increased disease incidence. Legume residues have often been associated with increased cotton seedling disease.

We are also investigating the use of Indian mustard for biofumigation and ammonia production from incorporation of hairy vetch green manure crops for the control of soil borne pathogens.

Cultural Practices under investigation include summer flooding, time of planting, organic mulches, novel irrigation strategies, fertiliser inputs and various trash management alternatives.

*(Subbu Putcha, Soil Microbiologist; David Nehl, Plant Pathologist)

VAM Research in Cotton

David Nehl

CRC for Sustainable Cotton Production, Australian Cotton Research Institute

Research on VAM in cotton has been conducted at the Australian Cotton Research Institute from 1989 to the present and has included collaboration between NSW Agriculture, University of New England and the University of Sydney, with funding provided by the CRDC and the CRC for Sustainable Cotton Production.

The importance of VAM

Our surveys indicate that cotton is always colonised by VAM fungi. VAM fungi act as an extension of the root system, supplying cotton with extra phosphorous (P) and Zinc (Zn). If VAM fungi are absent from soil then cotton growth is reduced. The potential for VAM to increase cotton growth decreases as the P content of the soil increases, yet VAM are still essential to cotton in soils with P as high as 90 parts per million of bicarbonate P.

Soil P	Growth enabled by VAM
16	92%
44	78%
88	57%

When plots in a soil with 47 ppm P were fumigated with methyl bromide to kill the VAM fungi, yield losses were 0 and 23 per cent for cotton sown in October and November respectively. Hence, the effect was on maturity.

Fumigation of soil in the field does not eliminate all the fungi. Yield loss may have been greater if VAM were totally extinguished. In cotton fields, VAM follows the roots of cotton down the soil profile but VAM only survives near the soil surface after cotton. Hence, cotton growth and VAM may be reduced if topsoil is removed.

Rotation crops

VAM has been examined in fully-replicated field trials at five sites in NSW and one site in Queensland, including the ongoing CRC farming systems trials. VAM colonisation of cotton is adequate following a range of cereals and legumes sown in both winter and summer. At some sites but not at others, certain crops (such as faba bean and lablab) appear to lead to greater VAM development in seedling cotton than other crops. At some sites VAM is greatest in continuous cotton.

Fallows

The effect of fallowing on VAM has been examined in six fully-replicated field trials, including the ongoing CRC farming systems trials and by anecdotal observation in cotton fields. The density of VAM fungi in soil declines during bare fallows; however, the subsequent development of VAM in cotton roots may or may not be affected. Research at the University of Sydney indicates that rainfall events and cultivation reduce the survival of VAM fungi during fallows; nevertheless, only a small number of VAM fungi need survive bare fallows of one season (that is, 17 months) to establish in cotton. If VAM density is low enough to reduce crop growth the effects are usually transitory and do not reduce yield. This is because VAM spreads rapidly through the roots of cotton, even from very small numbers of fungi (see summary of work at Sydney University).

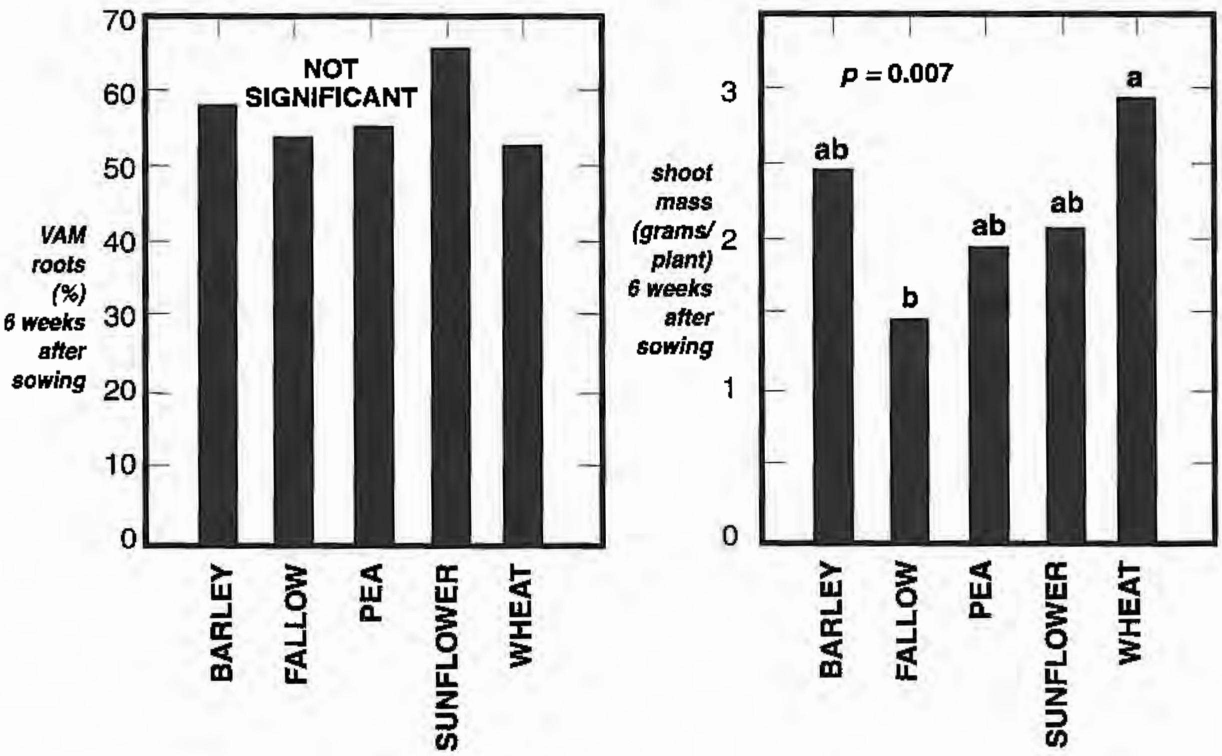
Management of VAM

Linseed has been used as an indicator plant for low densities of VAM in cotton fields at several locations in NSW and QLD. In a fallowed field on the Darling Downs linseed grew slowly and had low VAM. Various short-term 'nurse' crops were planted in an attempt to increase VAM fungi in the soil leading up to cotton; however, VAM in the subsequent cotton crop was normal, both in the fallowed soil and in the nurse crop plots. Cotton did grow better following some nurse crops but this effect appeared to be unrelated to VAM. The different levels of VAM in linseed and cotton in fallowed fields suggest that different species of VAM fungus are infecting different crops or that compatibility between plants and VAM fungi varies.

Linseed after 8 months fallow at Coondarra 1997-98

	-VAM soil	+VAM soil
VAM roots	3%	24%
Shoot mass	19mg	34mg

Cotton after 'nurse' crops or 11 months fallow at Coondarra 97/98



Future research

Integration of laboratory research with field research has enhanced our understanding of VAM in cotton; however, we have not examined VAM in other crops in great detail. Remaining issues include interactions between VAM and rotation crops, and a range of factors that may account for the variable effects of long fallows in different seasons and with different crops. Research on the use of nurse crops on VAM in cotton and interactions between VAM and cotton diseases is the subject of a current project at ACRI.

VAM in Grains/Cotton Systems

John P. Thompson
Senior Principal Soil Microbiologist
Farming Systems Institute, Leslie Research Centre, Toowoomba

Vesicular-arbuscular mycorrhiza (VAM) is the name for a crop root colonised by beneficial fungi. Most grain crops (cereals, legumes and oilseeds) and cotton have VAM and although there are many fungal species they have wide host ranges and can go from one crop species to another. VAM help crops access phosphorus and zinc from both soil and fertiliser sources. By doing this, they improve the nutrient content of crops, their vegetative growth and final yields. They may also increase nitrogen fixation of legumes and improve drought tolerance and disease resistance of all crops.

Some crop species depend on VAM for their nutrition and growth more than do others. Very highly mycorrhizal dependent species can lose 70 to 90 per cent of their dry weight when grown in soil with no VAM (cotton, maize, lablab, pigeon pea, faba bean and linseed). Highly mycorrhizal dependent species can lose 40 to 70 per cent of their dry weight without VAM (sorghum, mungbean, navybean, chickpea, soybean and sunflower). The dependency of crops on VAM is greatest in nutrient poor soils and diminishes as the phosphorus and zinc content of the soil increase.

VAM must have living plant roots to grow. Consequently, their populations decline during weed-free fallow periods or during growth of non-mycorrhizal crop species like canola. Excessive tillage of fallows can also hasten the decline of VAM.

MYCOIRRHIZAL DEPENDENCY	WINTER CROPS	SUMMER CROPS
Very High	Linseed Fababean	Cotton Maize Pigeonpea Lablab
High	Chickpea	Sunflower Soybean Navybean Mungbean Sorghum
Low	Fieldpea Oats Wheat Triticale	
Very Low	Barley	
Independent	Canola Lupins	

Crop rotation key factors:

VAM inoculum low after: clean fallow, non-host crop, waterlogging → Sow crops of low VAM dependency

VAM inoculum high after: host crops → Sow profitable crops of high VAM dependency

Soil–borne fungal and nematode pathogens present → Rotate host crops to keep VAM high but pathogens low

Crop species differ in the residual amount of VAM inoculum they leave in the soil to colonise a following crop. Legumes like chickpea and pigeonpea appear to leave more inoculum than do cereals. These considerations are important in sequencing crops in rotations so that highly mycorrhizal dependent crops are sown where there is a good supply of VAM inoculum.

Factors for management of VAM populations in soil

1. Length of fallow
2. Surface management
3. Topsoil removal
4. Fires
5. Waterlogging
6. Chemicals
   - Fertilisers
   - Fungicides
   - Herbicides

Future research

- Duration of crop growth to build VAM inoculum for VAM-dependent crops (cotton, grains, legumes, etcetera).
- Optimum use of legumes and cereals in cotton rotations. Preservation of VAM through fallow periods.
- VAM/Phosphorous/Zinc response surfaces for cotton and grain legumes.

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Cropping Systems Issues Common to Grains and Cotton

Wayne Strong
Principal Agronomist
Leslie Research Centre, Toowoomba

Mounting evidence of declines in soil fertility, particularly of nitrogen (N) status, has generated the need for sound N management in cropping systems of northern Australia. Poor management of N in dryland production systems can lead to poor water management and below–optimal water use efficiencies; a problem of serious concern to grain and cotton producers. Of as much concern to grain growers is the reduced frequency for producing wheat of a high protein content(>13 per cent) to achieve Prime Hard classification. Although buyers of malting barley do seek lower protein levels of 9.5–11.5%, producers of such low protein barley should be aware that these barley crops may also display lower water use efficiency than barley crops of a higher protein content.

The budget approach to N management has been promoted to estimate supplementary N needs of cereal grain and cotton crops in northern systems. Major inputs of N to supply crop needs are its release from soil organic matter, its carryover after other crops, particularly after legumes, and N application in fertilisers. Major outputs are N removal in cereal grains or cotton seed. The N budget approach has been encouraged to estimate supplementary N needs where the grain or cotton producer is prepared to forecast or target the desired production level. There the budgeting approach appears to provide a useful strategy to manage N without reducing water use efficiency within the cropping system.

Spatial variation in crop production occurs over most grain and cotton producing areas, arising from variations in one or more production–limiting factors such as soil moisture, soil characteristics, compaction, pests, diseases, nutrients or crop management practices. Technology is now available to monitor cotton and grain yield during crop harvest, enabling yield variation to be interrogated to discover most probable cause or causes. Australian grain and cotton producers are eager to use this technology to benefit profitability and the environmental impacts of their cropping systems.

A GRDC–funded research project will commence this year to devise and develop strategies which systematically identify production–limiting factors as probable causes for observed variations in grain yield of cereal crops. Outputs of this project in the form of software or an information package significantly increase the value of the grain yield map for use as a diagnostic tool to improve cropping system management. Direct or indirect use of the findings of this project will benefit cotton and grain production systems similarly.

In the northern cereal producing region grain yield and grain analysis (percentage of protein) have been used retrospectively to separate crop responses to low water supply from responses to low N supply. Crops with a combination of low yield and low protein are usually produced in response to low N supply, whereas a combination of low yield and high protein is usually in response to low water supply.

Using maps of grain yield and grain protein in combination will allow recognition and separation of qualitative effects of low water supply and low N supply, two yield–limiting factors for cereals occur with high frequency in this region. Although effects of other yield–limiting factors, like phosphorous supply, may be similar to the effect of low water supply, analyses of yield variation in conjunction with the GIS databases and climate data, supplemented by selective soil sampling, will enhance the value of spatial information to diagnose constraints to crop production.

Cropping Systems and Soil Process Issues Common to Grains and Cotton

David Freebairn & Mark Silburn
Agricultural Production Systems Research Unit,
Queensland Department of Natural Resources

The following is a list of areas where Queensland Department of Natural Resources (DNR) staff have developed skills and have experience which has application to both grain and cotton systems. These areas overlap with Department of Primary Industries and CSIRO staff.

Description of soil resources and their capability

- basic description and interpretation of soil capabilities and limitations (land resource mapping, development and management advice)
- action learning skills targeted at improving understanding of soil and environmental processes
- provision of advice on land resources based on previous surveys
- database management

Managing rainfall - infiltration and water storage strategies

- infiltration processes
- soil surface management
- role of leys in management of soil structure and nutrition
- crop rotations -water use patterns

Management of erosion and movement of nutrients and agrichemicals

- soil surface management
- crop rotations
- controlled traffic
- irrigation

Prediction of stream and overland flows with new climate signals

- analysis of relationship between water flow and the Southern Oscillation Index
- analysis of management options to manage risks associated with irrigation

Development and application of models for analysing:

- short duration experimental records > longer term estimates of responses
- extrapolation of experimental results to broader range of conditions
- exploring consequences of different management options on soil processes (infiltration, erosion, drainage, pesticide movement, crop production)
- reliability of cropping, tactical and strategic decision analysis
- assessment of effects of erosion and soil structural changes on production (crops and pastures)
- off-site transport by runoff of sediment, nutrients and pesticides

Development and application of action learning modules and decision support aids

- improved understanding of water dynamics
- use of rainfall records in farm decisions, for example HOWWET? and HOWOFTEN
- whole farm analysis

Understanding and management of dryland salinity

Understanding and management of mice populations

Optimising Management of Water Entry on Cracking Clay Soils in Cropping Systems GRDC Project DNR3NR

Mark Silburn and Philippa Tolmie
APSRU, Department of Natural Resources, Toowoomba

The objectives of this new GRDC project are to:

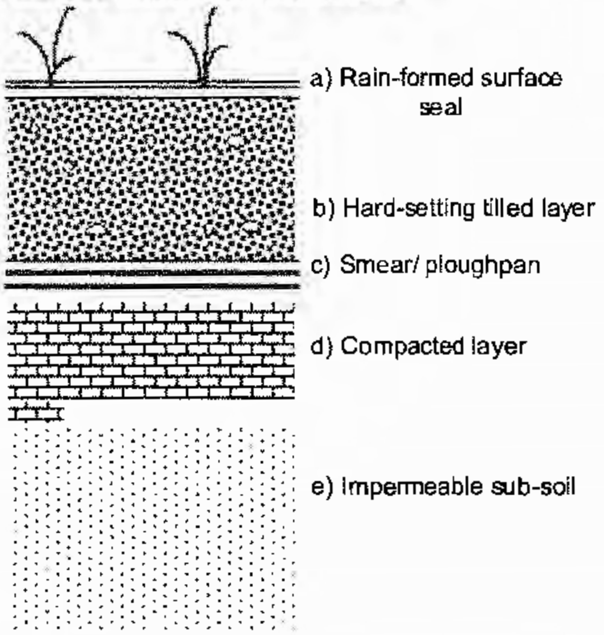
a) define role of various ***soil layers*** in controlling water entry and drainage

b) determine how much these water entry properties are changed by ***farming practices***

c) determine impact of these water entry properties on ***crop yield***

d) optimise learning and ***communications*** by collaborating with farmers and other research projects

Potential infiltration restrictions



Management practices that may have an impact:

a) maintaining stubble cover

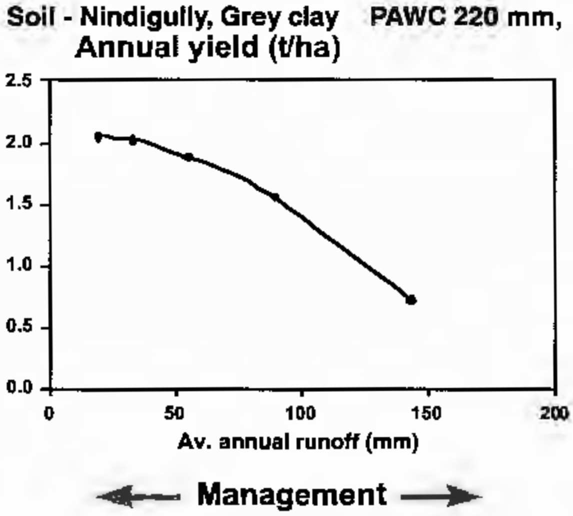
b) gypsum application; cultivation treatments

c) restricting traffic

d) controlled traffic

As part of a scoping study, effects of runoff on yield were modelled for 50 years of wheat at Nindigully, using APSIM. The graph below illustrates the significant impact of runoff on yield. The actual runoff that occurs will depend on specific soil properties, age of cultivation and management practices used.

Soil - Nindigully, Grey clay PAWC 220 mm, Crop - Wheat, APSIM



Therefore, considerable scope to improve soil management

↓

yield & profit improvement

Cotton Nutrition

Ian Rochester
CRC for Sustainable Cotton Production,
CSIRO Plant Industry, ACRI, Narrabri.

Nitrogen fertiliser is normally applied at rates between 100 and 200 kg N/ha for cotton and is usually applied in winter/spring months prior to sowing. Some legume crops have become important rotation crops in cotton cropping systems as growers realise the benefits of these crops to following cotton crops. The amount of N fertiliser required by the cotton crop is substantially reduced following legume crops. N rates have been reduced by at least 50 per cent following reasonable legume crops.

Faba beans have yielded 2.5 – 3 t/ha commonly and can fix up to 350 kg N/ha and return up to 250 kg N/ha to the soil in stubble. Normally, only about 40 per cent of the N fixed by faba beans is removed in the harvested seed. Many commercial faba bean, soybean, Dolichos lablab and field pea crops have been assessed for N fixation. Forage legumes (vetch, clovers and medics) grown between back-to-back cotton crops can fix more than 200 kg N/ha before being green-manured prior to sowing cotton.

Typical values of N fixation and N input into the cropping system for several legume rotation crops of importance in cotton farming are shown in the table below. All crops surveyed were grown with limited irrigation when required. N fixation and the contribution of legume crops to soil N may be severely impaired by water stress under dryland conditions. Further research and surveying of commercial crops under rain-fed conditions would improve our understanding of N cycling in these cropping systems.

Crop	N fixed	N balance (fixed – removed)
soybean	370	190
peanut	270	170
faba bean/ lupin	180	110
adzuki bean/pigeon pea	15	5
mung bean	50	10
vetch/lablab	170	170

Large inputs of N through legume cropping reduce the amount of N fertiliser required. Our data indicate that between 30 and 40 per cent of the legume N added to the soil is taken up by the next cotton crop. The remaining legume N will become available to future crops. Only a small fraction of legume N is lost from the soil system, compared with fertiliser N, as legume N remains in the soil in organic material. Soil structure is also improved following legume crops.

NutriLOGIC is a computer-based decision support program which is included in the CottonLOGIC program. It makes suggestions for N fertiliser application rates based on the input of soil nitrate test and petiole nitrate test results. This program has been developed over many years. NUTRIpak is the companion manual of cotton nutrition.

Research has been conducted on potassium nutrition over the past 6 years with the aim of resolving the problem of premature senescence in cotton. A further project to research phosphorus nutrition commenced in 1997. Although little response has been observed to applied P, the availability of applied phosphorous is severely reduced by fixation processes.

CROPPING SYSTEMS

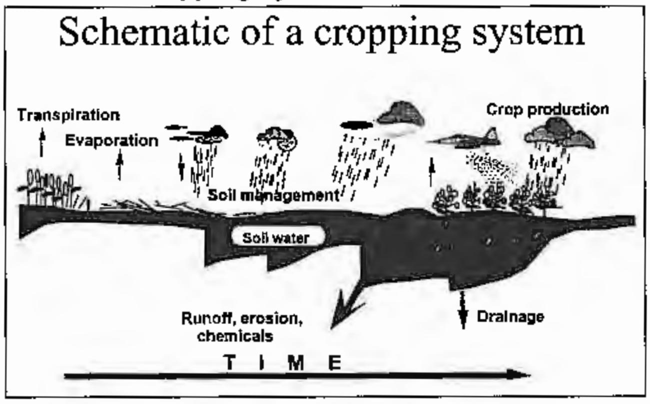
Cropping Systems – Pluralistic Systems Analysis

David Freebairn
Agricultural Production Systems Research Unit
Department of Natural Resources, Toowoomba

An overview of capabilities and possible synergies between cotton and grain growing

One of the factors that make decision making challenging is uncertainty: issues such as weather, pest pressure and changing commodity prices drive this uncertainty.

What is a cropping system, and what are its boundaries?

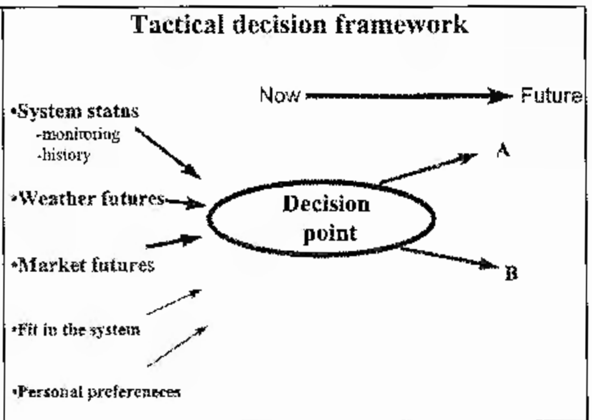


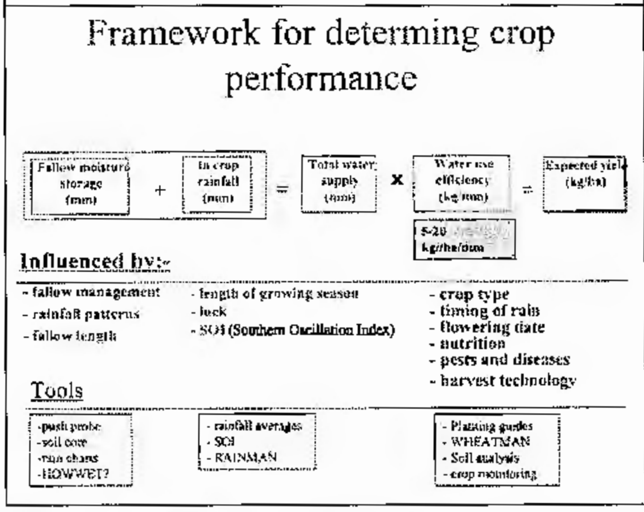
A cropping system includes multiple crops, water, nitrogen, yield, run-off, erosion and chemical movement. Modelling capabilities include crop choice, water & chemical movement, climate, stream flow and catchment issues.

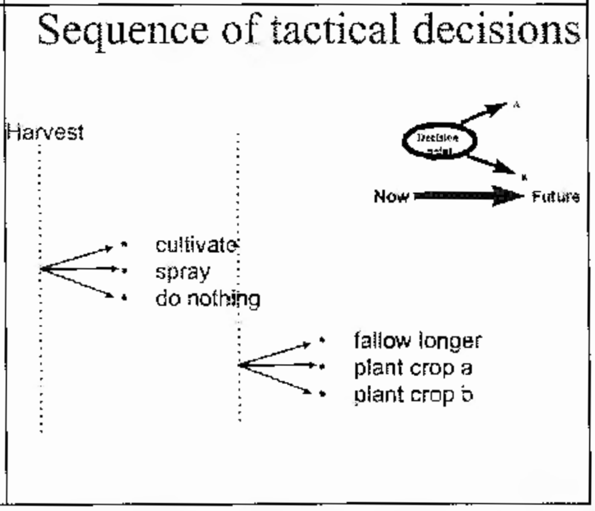
Possible Synergies: sharing knowledge and research on issues such as cotton/wheat rotations.

Application of Models

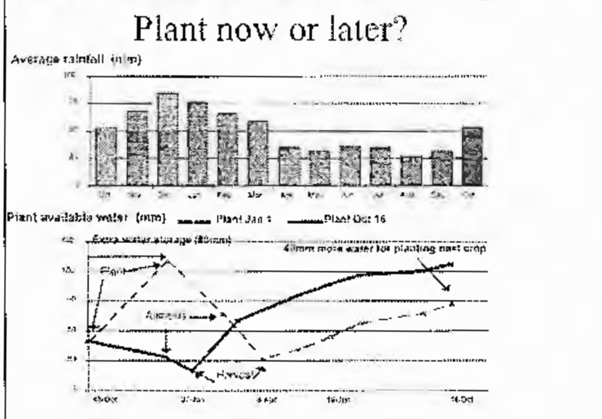
- data stretching and discipline integration
- tactical decision analysis: eg, what to plant, when, input rates
- strategic planning: eg, best bet rotations, resource maintenance (erosion, salinity, pesticide movement and retention)
- derivative products – information systems



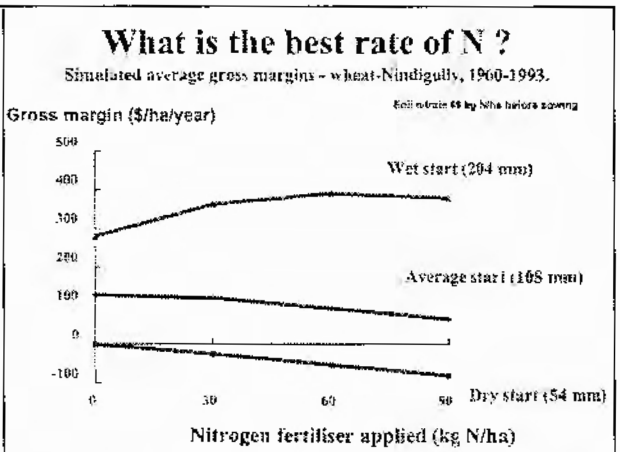




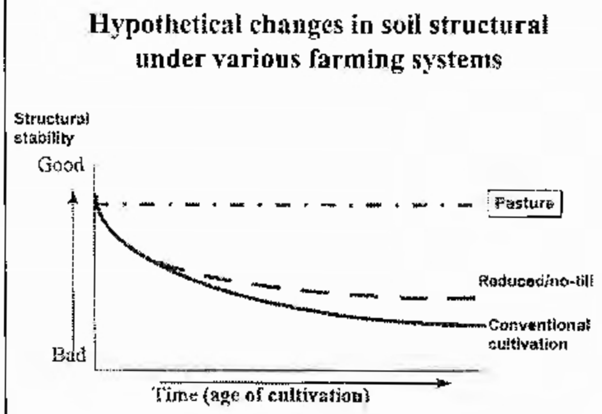
Tactical uses of models

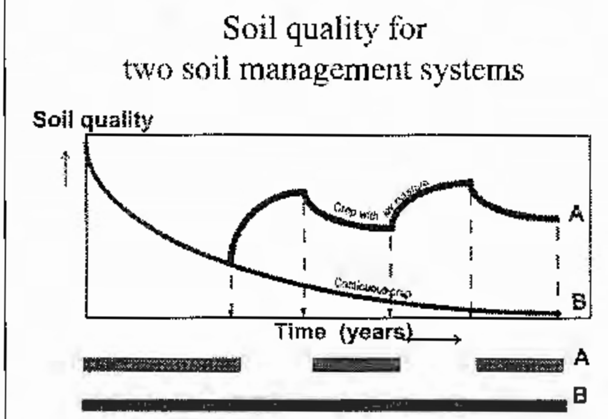


Different expectations from a dry earlier plant versus a later plant

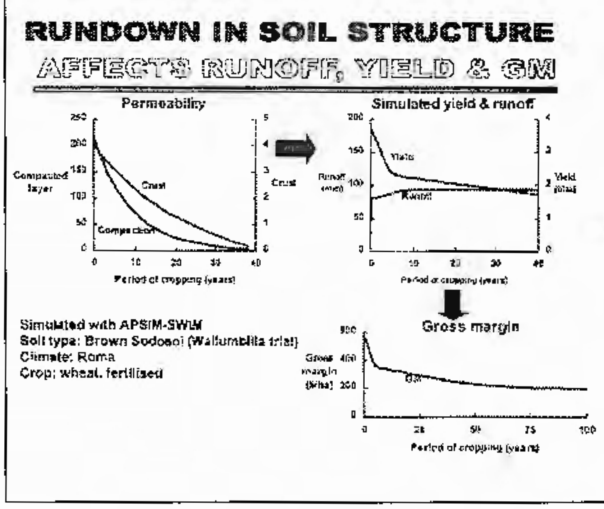


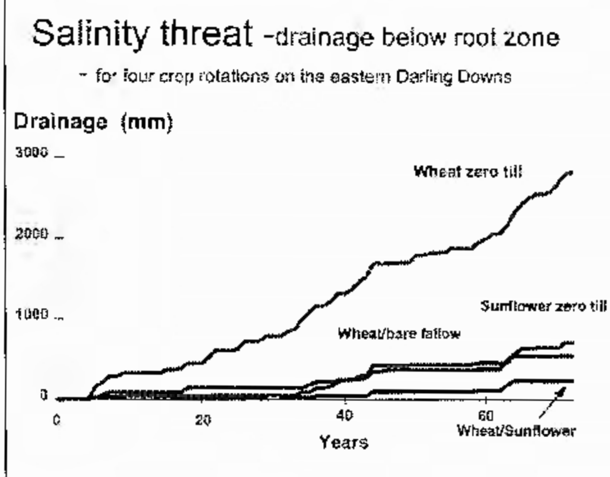
Long term nitrogen response , based on model tuned to 1 year's data)

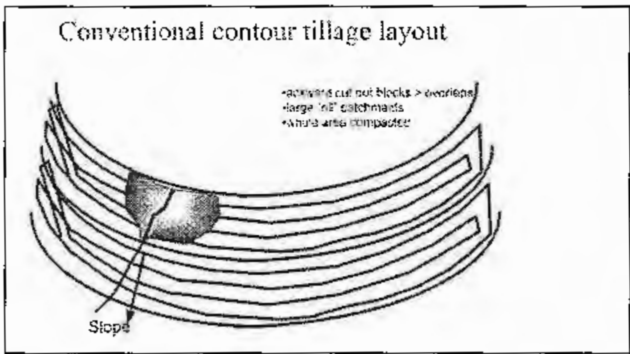


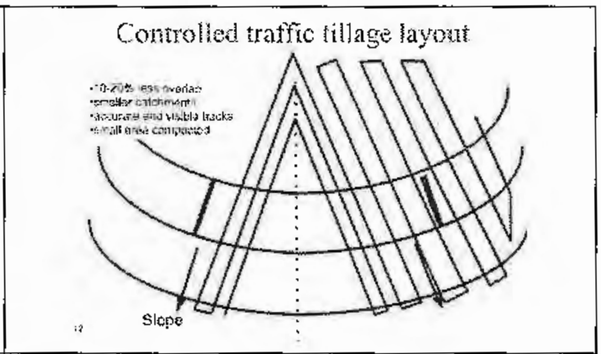


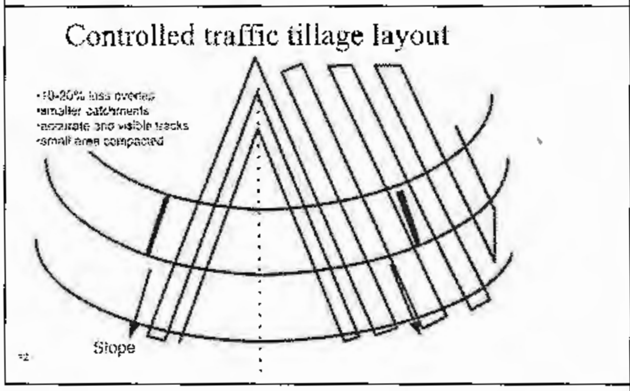
Cropping pattern





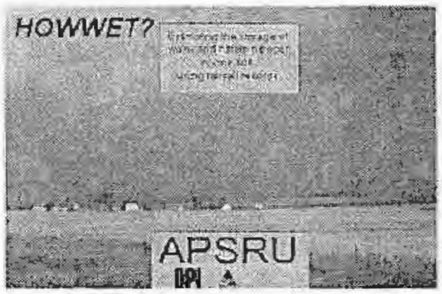




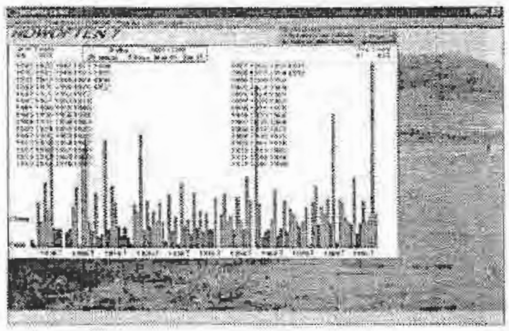


Derivative Products

HOWWET?



Howoften?



Summary

Modelling Capabilities

There is a range of approaches, such as WUE, APSIM, 'Howwet?', whole farm economic analysis using spreadsheets.

Possible synergies

- Building up case studies of analysis which will lead to models being refined through time.
- enable a wider range of approaches to problem analysis (pluralistic systems analysis)

Delivery of Information

- Data analysis: share data, experiences
- Decision analysis: not thousands of options, therefore can anticipate many issues before they arise
- There is a wide range of approaches to communication – use them all
  - SOI information by fax, radio
  - group learning
  - consultant analysis: for example, Farmscape
- Derivative products such as Decision Support Systems (DSS), 'Howwet?', Whopper Cropper

Modelling Initiatives

Initiatives which are being explored through the application of models include soil structure, interaction between crops, forecasting SOI, crop response, SOI stream flow, optimises crop mix, tactical analyses.

Modelling Opportunities

Opportunities provided by models include delivery of timely research results to industry, particularly those relating to broad acre cropping. There are also lessons to be learnt by the grains industry from BMP in cotton that will have wider application.

Cropping Systems

A. B. Hearn

Most synergy between grain crops and cotton occurs in cropping systems and involves the diversity of topics addressed by other papers. I will focus on two – irrigation management and management of cropping systems. Synergy happens not only among crops but also in research and technology on different crops; occurrences of the former and opportunities for the later have been identified and emphasised.

Irrigation Management

Although cotton is primarily an irrigated crop and grains are generally rainfed, there are synergies in irrigation, where technology developed for cotton is generic and applicable to irrigated grain crops. There is also synergy among crops where cotton benefits from rainfall stored in the long fallow after winter grain crops. In turn, winter crops benefit from residual irrigation water in the profile after cotton. Both these synergies influence whole farm water use efficiency in its broadest sense.

Water use efficiency (WUE)

CRDC has a current research program on WUE of irrigated cotton. WUE means different things to engineers, agronomists and physiologists.

- **The engineering component** – how much of the irrigation water received at the farm gate is used by the crop in ET; sub-components measured by Steven Raine (University of Southern Queensland) with farmer-friendly devices; deep drainage: a sub-component, also a component, of dryland systems ***with possibilities of synergy.***
- **The agronomic component –** conventional crop WUE; Steve Milroy and Sunil Tennakoon (ACRI) determining WUE components on-farm; methods of accounting for water inputs; farmer-friendly ways of measuring ET to separate engineering and agronomic components on-farm in order to assess performance against benchmarks, ***another potential area of research synergy.***
- **Rotations** – influence WUE on time scales longer than a single season; water stored during the fallow break after a winter crop may reduce irrigation requirements of the following cotton crop; some growers practised a 1:1 rotation, which maximises the potential for storing water; combined with zero-till planting of the cotton crop, resulted in saving of more than two megalitres per hectare of irrigation water for one grower; management of rotation crops and fallow to maximise efficient storage of fallow rainfall is ***an area of research synergy.***

Management of Cropping Systems

Simulation is a powerful tool for the study and management of cropping systems. R&D synergy is already occurring with the incorporation of OZCOT in APSIM, and its use in FARMSCAPE (growers participatory action learning groups). Valuable spin-off has been the identification of the need for new features in OZCOT: skip-row configurations and seedling establishment and mortality, as well as revision of existing components such as leaf area growth and waterlogging.

There is great ***potential for further synergy*** in the management of cropping systems using APSIM:

- **in management** – establish FARMSCAPE groups for irrigated cotton in rotation with rainfed crops; risk analysis and strategic planning with limited irrigation supplies taking SOI into account; explore effects of rotations and fallow management on irrigation requirements and WUE.
- **in research** – explore interactions and trade offs among actual and proposed practices in terms of short term effects and long term sustainability issues such as maintaining soil nitrogen and organic matter, water conservation, minimising run-off, soil structural degradation, pupae control and long fallow disorder; for example 1:1 rotation may conserve water, reduce soil structural degradation but burn up soil organic matter faster.

Western Farming Systems

Scott Cawley
Principal Agronomist, QDPI, Roma

Extending and enhancing IPM into non-cotton areas

- In areas where cotton is not grown or where individual growers choose not to grow cotton the use of IPM strategies is not as well advanced in either implementation or awareness.
- Although cotton may not be grown, other crops share the same pests eg heliothis in chickpea, mung bean and sorghum, so indirectly they end up carrying the same pest burden.
- The increasing momentum of weed resistance in reduced tillage systems. The most obvious sign of this is observing milkthistle in stubble fallows. This could be complicated by the withdrawal of certain chemicals from use for environmental reasons; For example, what would happen if atrazine was withdrawn?
- There is a need to target agribusiness and government service providers in these areas. These can then develop the appropriate methodology to pass the information and knowledge on.

Crop Rotations

- There appears to be a good opportunity to integrate farming systems trials: for example, the two grain and cotton farming systems trials at Warra. This could be achieved by combining data or staff. The four existing cotton farming systems trials (at Warra, Wee Waa, Warren and Emerald) and the farming systems trials within the three government/GRDC farming systems trials could look at some appropriate integrated activities.
- Stubble and the conundrum of 'retain for surface management' or 'get rid of for disease and pest reasons': for example, infiltration, erosion versus heliothis, yellow spot, crown rot. There maybe no single definitive answer but a combination of contributory factors like new machinery/points, new resistant varieties, educational programs like soil water workshops, understanding the heliothis cycle.

Developing an understanding of the growing information system

- It would appear that our capacity to generate information exceeds people's capacity to use it. *'Why worry about putting the cart before the horse if you don't even know what horse you are going to use?'* More resources should be used in developing an understanding into how to best integrate and use information rather than just generate it. A good example is the soil nitrogen workshops.
- How do you know whether people want an immediate answer or an understanding of an issue? This could depend upon ones role within the industry.
- How can you improve the shared information that lies within producers, agribusiness, government agencies? Who will take the initiative and/or responsibility in developing the system and its components? Why and how have Kondinin had the success they have had?

Dryland Cropping Systems: a case study

Charles Clark
Dryland Cotton and Grain Grower

The following information briefly describes the system on our property:

Environment

- 575 mm average annual rainfall with mean summer rainfall of 350 mm.
- 160 mm Plant Available Water Capacity (PAWC)
- At 25 per cent fallow efficiency, 144 mm of water is stored in twelve months
  At 28 per cent fallow efficiency, 161 mm of water is stored in twelve months

This system relies on water escaping below the top 1.2 metres to depths of 1.5 metres to sustain the cotton crop and allow access to the nutrient bulge. It takes considerable time to refill the soil profile at depth and is necessary to maintain soil cracks and stubble.

Rotation

- No more than two wheat crops consecutively
- Time to fill deep profile after cotton crop
- Winter legume crop for disease and weed break and nitrogen
- Cotton is the most profitable crop, with $440 per hectare gross margin
- Cotton utilises permanent labour in the summer months
- Rotation could be reduced to five years by eliminating wheat in year six

  The rotation is:

Year 1:	Cotton/sorghum
Year 2:	Double crop or fallow
Year 3:	Wheat
Year 4:	Legume crop
Year 5:	Wheat
Year 6:	Wheat

- High rates of nitrogen and phosphorus on winter crops, low rates on cotton
- Plant summer crops into standing stubble – shielded spray weeds
- Digital Global Positioning System (DGPS) to tramline on 24 metres for spraying fallow and cotton crop
- Glyphosate used to condition cotton pre-defoliation and significantly reduce regrowth.

Areas for Research

From a dryland farmer's perspective, these are:

- Pupae busting (early harvest and no regrowth can result in very few, if any, pupae) and sampling techniques
- More persistent cereal stubble
- Improved water efficiency in plants
- Improved fallow efficiency.

Neighbours, the Environment and Spray Application: a grower perspective

Harley Bligh
Cotton Grower, "Brookstead"

In addressing this topic from a grower perspective, what is needed from research and extension can be summarised in four words: Communication; Knowledge; Equipment; Co-operation.

Communication

A single word with enormous meaning in everything we do in life, but in this instance absolutely ALL parties involved need to have been consulted. The neighbouring farms should be contacted to explain what, where and when you intend to apply, ascertaining where there are sensitive areas with environmental concerns - for example, water habitat, proximity to rivers and streams, people residing in dwellings, animals de-pastured nearby, and so on. A full understanding by both parties is essential; so often when problems arise there hasn't been sufficient dialogue between both parties. Really, what is required is consultation and empathy about others' concerns.

Good communication should also be extended to those who are actually carrying out the spraying application, be they farm operators or spray contractors. All the information should have been discussed before commencing the operation. Plans need to be in place to deal with any changed circumstances. These practises are thoroughly documented in literature that is readily available and the cotton industry's BMP manual will highlight this.

Knowledge

This is obviously the area for research and extension. All the people in the "spraying loop" should have a thorough knowledge and understanding of the compounds they are using, their effects on other plants and animals and also what effects atmospheric conditions will have on them. 2,4–D is a classic example The other consideration in the future will be the preservation of beneficial insects for the assisted control of heliothis. Farmers need to be cognisant of what pyrethroids will do and everyone needs to know and understand the big picture. Consultation to better identify the correct choice is essential. The era of the 'glug' farmer has definitely passed.

Equipment

Being set up correctly for the application that is being undertaken is a major point. Understanding the complexity of wind, humidity, droplet size and velocity is crucial - a competent operator must fully appreciate all these parameters. As mentioned before, 2,4–D is a classic with inversions and volatilisation. We use 2,4–D a metre away from cotton because we operate the correct equipment and nozzles in the right atmospheric conditions. Drift and drift reduction is a whole area of work that all who participate in the spraying game need to more fully understand. Air shear technology is an area that I believe needs to be encouraged. We certainly have achieved far superior insecticide application terms of coverage in our broccoli, and herbicide applications on hard to kill weeds has been improved with better coverage.

Atmospheric monitoring equipment should be a compulsory kit for spray operator. Wind speed and direction, humidity and temperature are all essential information to commence any job.

Co-operation

Co-operation between all parties will be essential for better outcomes, particularly when looking for regional strategies to deal with issues such as heliothis (pupa busting and adherence to chemical resistance management strategies) and more comprehensive Integrated Pest Management. Farmers in general need to come to terms with the fact that what they are doing on their farms will have an impact on other operations in relation to issues such as resistance.

Public perception will improve if we get everything 'ON THE FARM' correct and to achieve this we will need the support of research and extension from both CRDC and GRDC.

Neighbours, the Environment and Spray Application: a research perspective

Nicholas Woods
Director, The Centre for Pesticide Application & Safety, (C-PAS)
Gatton College, The University of Queensland

Protection of the environment and the close proximity of neighbours are issues that concern both the cotton and grains industries. Spray droplets do not stop at crop boundaries, as was demonstrated in the Goondiwindi area last season when spray drift allegedly moved up to 20 or 30 kilometres away from the source of application. Although grain industries can claim that they use pesticides and agricultural aircraft less frequently than the cotton industry, it is not the quantity but the quality of application that is significant. A single spray drift incident has the potential to severely disrupt industries, particularly where a product might be destined for export markets. Thus, both cropping systems share responsibilities regarding the safe and effective application of pesticides.

Research Priorities

The cotton industry has contributed significantly to research on the aerial transport of pesticides in recent years. Much good information now exists and the best management program is developed as a model for delivering change in the industry; however significant work is now required to support further development in both cropping systems. The following research priorities are identified as being mutually beneficial to both industries:

- The coordinated extension of best management practice into sectors of the grains industry in harmony with the cotton industry initiatives.
- The development of drift management strategies for the application of herbicides using boom sprayers.
- The development of improved nozzle technology for agricultural aircraft.
- The investigation of downwind drift levels at one kilometre and beyond.
- Optimisation of tree vegetative areas for spray drift control, including the investigation of the effects of defoliants and common herbicides on tree health and viability.
- The incorporation of drift algorithms into aircraft Digital Global Positioning System (DGPS) to enable real time calculation of pesticide drift potential.
- The investigation of the effect of selected adjuvants (pesticide formulations) on the drift potential of water based sprays.

The University of Queensland has committed resources to the development of a new state-of-the-art wind tunnel for pesticides research. The new laboratory will complement services and facilities already available through the Centre for Pesticide Application & Safety. C-PAS is a national research and training group specialising in application technology and environmental issues, staffed by scientists from the University of Queensland and the Queensland Department of Primary Industries.

The setting of such research goals and objectives will establish grain and cotton industries at the forefront of pesticide drift management technology and pave the way for adopting state of the art application programs in Australian agriculture.

Neighbours, Environment and Spray Application: an extension perspective

Peter Hughes
Extension Officer, Farming Systems Institute, Queensland Department of Primary Industries

The present program is a development/extension program to optimise the application of pesticides. It is mostly funded by CRDC.

Key Issues

Getting more pesticide to the target

Getting more pesticide to the target improves the pest control, decreases the total load of pesticide placed on the paddock, decreases the level of spray drift and slows the progress of resistance.

All application should be carried out under optimum conditions; however this is not always possible and pest control strategies must be developed to improve spray deposition on the target under adverse conditions. Waiting for optimum conditions often is not an option because the longer the delay, the less susceptible the pest. On the other hand, application under adverse conditions with equipment set up for optimum conditions often provides poor control.

Some of the pest management difficulties attributed to resistance to insecticides probably have been due to poor application technology rather than to failure of the insecticide. Factors such as targeting the pests at the optimum time and under optimum application conditions with well set up equipment all contribute to the success of the spray operation.

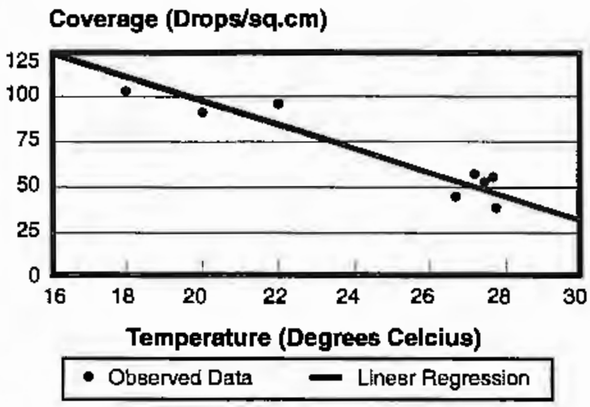
Other management issues include communication between all parties concerned; product selection; equipment selection and setup; conditions; good record keeping; and Workplace Health & Safety issues such as operator training and chemical handling.

Ground rigs have been shown to put more pesticide on the target with less drift when compared to aerial application when both were operated under optimal conditions. The technique of banding pesticides using ground rigs improves the economics of the spray operation and decreases the pesticide load on the environment.

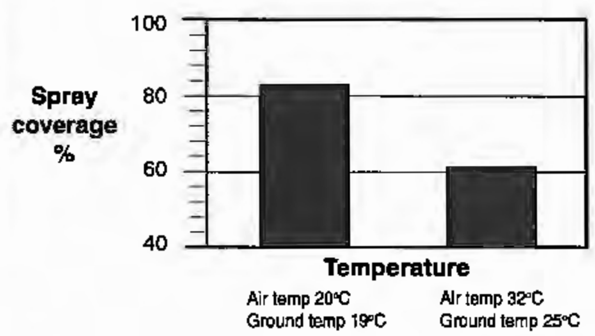
Reducing spray drift

Maximising the amount of spray reaching the target minimises the amount of spray that can be lost due to spraydrift. The drift problem would be significantly reduced with changes in the management of the spray operations. Drift occurs with both aerial and ground application of both insecticides and herbicides. Herbicide drift and OP drift onto sorghum result in visible responses, whereas most insecticides are only detected by residue analysis.

Deposition of insecticide in top cotton canopy, aerial applications of insecticide by air in water



Spray coverage with temperature (boom spray)



Issues of Integration/Synergy between the Cotton and Grains Industries

- The cotton/grain mix
- The potential impact both ways
- Competing needs
  - Spray contractors
  - Timing of applications
- The cotton industry is ahead with best practice and guidelines

Future Research and ExtensionPossibilities

- Research and development trials comparing various application methods to define the best setup procedures for different environmental conditions.
- Extend best management practices for pesticide applications by running a small group hands-on action learning activities for farmers and spray applicators.
- Benchmark spray application knowledge and practice.
- Extend spray application guidelines and best management practice to ensure applications are carried out under conditions that are monitored and with equipment that is specifically set up for the conditions.
- Accredit stakeholders in best management practice for pesticide application

Trees for Cotton and Grain Producers

Peter Voller
Queensland Department of Natural Resources, Dalby

There are a number of strategic roles for tree planting and vegetation retention in the cotton and grains industries. Many of these relate to maintenance of land condition, crop production enhancement, drift amelioration or nature conservation.

Retention of native vegetation, either as regrowth or standing forest, has the greatest capacity to provide benefits because the trees already exist or are regenerating at no cost. In some cases such areas may need to be modified. For example, thinning thick regrowth to make it more effective for drift capture or thickening up some bush to make a better habitat for beneficial insects.

Managing areas of trees or bushland can be very rewarding and it can provide diversity in a landscape dominated by farming. Such areas can be good for recreation as well as being functional for the farm.

Identifying economic and evironmental justification for retention of these areas within a regional framework is a priority for DNR. Such activity includes:

- Integrated vegetation management planning through Property Management Planning
- Evaluation of commercial products from native forests such as craft woods, oils, timber
- Understanding the roles of shadelines as windbreaks, firebreaks and wildlife habitat areas
- Evaluating the potential for carbon storage
- Identifying indicators for, and causes of, decline of vegetation condition
- Practical ways to integrate trees into modern farming systems.

Tree planting as a component of improved land management requires specialised planning to identify: correct species; establishment and management systems; design criteria for specific uses; and basic infrastructure, such as local nurseries, for supply of trees.

Planted trees are in demand for use as spray drift buffers, farm woodlots, wildlife habitat enhancement, visual screening and amelioration of land degradation.

Modern farms need to run as efficiently as possible, so any investment should be made with a clear goal and based on good information. Planting or retaining trees and other vegetation can be an investment in the future of a farm. Trees and vegetation have the capacity to provide positive benefits for farming, but if they are not included into an overall property plan their benefits may not be optimised.

In planning to make the most of trees on a farm, the follow questions need to be asked:

- What are the main roles trees could play on the farm?
- What design principles are needed to make sure the trees do these jobs well?
- How much will it cost and how can it fit into existing farm layouts?
- How long can the land planted with trees or left under native bush be left that way?
- How much information on management and establishment is needed to make sound decisions before committing labour, finance and land for tree planting and retention?

Costs for planting trees are estimated at between $2.00 and $10.00 per plant in the ground and growing. Such costs indicate that large scale planting is a sizeable investment.

Information on tree management for cotton farms is presently being compiled into a single publication for distribution by the funding agency, CRDC.

A Cotton Industry Perspective

Mike Logan
Cottongrower; Director, Cotton Australia

The people in the cotton and grains industries all realise that we have a choice to survive in agriculture as the new century arrives. The choice is: get professional or get out.

Either we are world competitive or we are on the way out. Either we grow our products better and cheaper than everyone else or we will not survive in the long run.

The Best Management Practice (BMP) is about just that. It is about being professional farmers who are trying to be the best in the world so we can survive the coming changes. The BMP is a formal, documented set of procedures for cotton farmers. If most industries are adopting these formal, documented procedures to ensure their management systems are world class, then so is agriculture.

The BMP has three main benefits to the cotton industry and these benefits are interlinked:

1. Improved environmental performance
2. Communication of research
3. Improved public perception and political support.

Improved environmental performance – real measurements

The BMP has really focused on the riverine environment as the measure of our environmental performance. If you think about the river as the lowest point in the valley, then any practices on farm are going to show up in the health of the river.

The issues of farm design, pesticide application, Integrated Pest Management and pesticide storage and handling are dealt with in the manual. These are the ones that can have the most effect on river health.

By way of example, the design of a farm can very quickly affect the way contaminated water runs from our cotton fields to the river. By having a good tailwater system, and even gravity filled buffer storage, we can manage that water and lessen our impact on the river.

We can also reduce our impact by considering the weather when spraying pesticides by air. The factors of surface temperature inversion conditions, turbulence, wind speed and direction, relative humidity and the likelihood of rain in the subsequent day or two are all part of the BMP to improve our environmental performance.

Communication of research – good science is the key

The cotton research and development effort based at Narrabri is probably the best in the world. Without this research the cotton industry in Australia would not be where it is today. Cotton growers have been very quick to pick up this research because it has made us so much money; however, we still needed a vehicle to extend the research that was not as profitable, but still as necessary. The BMP fills this gap.

On the other side of the ledger, BMP has been a great vehicle for farmers to tell researchers what is practical and affordable on their farms. For example, the farmers all know that changing to ground spraying of pesticides would save a lot of heartache. But we also know that we are on black clay soils that you cannot move on after you have irrigated – and this is when the insects usually arrive. We needed to come up with a system of aerial spraying that is as safe as ground spraying is thought to be, and as effective as aerial spraying. The BMP tries to achieve this.

This two way street of communication is what has made up the BMP. It is a combination of farmer requirements and researchers capabilities. This communication is the key to the further development of the new modules of the manual.

Improved public perception and political support – the "good neighbour" approach

It is well known that the cotton industry has a public perception problem. The cotton farmers in my region are more popular than politicians and used car salesmen, but only just. We certainly are liked less than our grazing neighbours. If the public do not like us, for whatever reason, they will begin to doubt what we do. We will lose their trust.

We all know that to be licensed users of a public resource – water – we are at the mercy of the regulators. If the public does not trust us to use those resources properly, the regulators will get rid of, or start to limit, our access as they have done.

We believe that we can win back that public trust by being a bit more open with our practices. The BMP is our way of opening up ourselves to scrutiny from the public by giving the various agencies input to the design of the manual. Agencies such as the Department of Land and Water Conservation, the Departments of Primary Industries and Natural Resources in Queensland, the Environmental Protection Agency in NSW and NSW Agriculture have all been involved so they can reassure the public of our practices.

Winning back that trust will not only help with access to water. Access to chemicals such as endosulphan, and biotechnology such as the Bt genetics, are critical for our industry. Without that public support, we will never keep these technologies or get access to the new technologies that will keep us at the leading edge of world competitiveness.

The BMP, then, is about ensuring the future of our cotton industry. We believe that improving our environmental performance, focusing research to be practical and useable for farmers and earning the trust of the public will be the strategies that achieve that goal.

The grains industry is in a similar boat to the cotton farmers. We are all professional farmers who are world competitive and looking to the future. The BMP may or may not be the model for the grains industry but the important thing is that we are all looking and communicating about our common areas of concern. This is what it is to be a professional farmer as the new century arrives.

Best Management Practice: the Possibilities for Research and Extension

Bruce Pyke
Research and Extension Manager, CRDC
Dallas Gibb
Program Leader, Plant Fibres NSW Agriculture, Australian Cotton Research Institute

The cotton industry's development of Best Management Practice (BMP) guidelines and its move towards the implementation of these is seen as a great opportunity for future research and extension in the industry.

The current BMP manual and program focuses on minimising the impact of pesticide use on the environment. It contains guidelines and self-assessment worksheets for integrated pest management, pesticide application, pesticide storage and handling and farm design and management.

The BMP process provides the following benefits to growers:

- It helps to build awareness of on farm risks and hazards
- It helps to identify legal requirements
- It provides a framework to plan and improve management
- It documents the process

Cotton growers who fully apply the BMP manual will conduct their own hazard analysis relating to pesticide use and develop action plans to deal with areas in which they can improve their operation or where they can reduce risks. The key to the whole process is that growers can work on their own specific issues at their own pace.

Widespread adoption of BMP will:

- Provide opportunities for extension
- Identify the need for certain research results
- Improve feedback on growers' needs to researcher
- Improve feedback to the BMP manual developers

In the future some of the BMPs will be auditable which means that growers who wish to have their farm accredited under some industry, national or international standard will be able to do so. The benefits of being an accredited BMP farm will become increasingly more evident over time, but of particular importance will be the positive effect on public perception and on political support for individuals and an industry that is not only doing the right thing but can demonstrate that it is.

The current BMP manual provides a framework for growers to become aware of certain potential environmental risks associated with pesticide use and then to document their practices and action plans for improvement. Research provides an important underlying basis for BMP because without the knowledge that certain practices do reduce environmental risk, they are only best guesses.

It is a framework that encourages continuous improvement based on the outcomes of research and is one that can be extrapolated to other aspects of research. Consequently, there is great scope for expanding the current BMP manual to include a whole range of farm management issues that require choices between different options, some of which will be better than others. What the BMP framework provides is an industry standard way to introduce new options derived from research, build awareness of how those new options compare with older practices and provide a pathway for improvement.

For example new BMP modules could be developed for aspects of farm management such as: farm hygiene for weeds and diseases; water use efficiency; IPM with a greater focus on biological control; crop rotation choices; and stubble management.

In terms of an extension vehicle, the BMP framework could become a centrepiece for the activities of the cotton industry's extension team. Currently the team is committed to the implementation phase of BMP by assisting with workshops for the introduction of cotton growers to the manual and its concepts. The team is also planning the establishment of BMP demonstration farms and monitoring programs for the next cotton season that will support adoption of pesticide application best practices.

TOPCROP Queensland

Michael Cahill
TOPCROP Coordinator, QDPI

TOPCROP Queensland (TCQ) commenced in 1997 as a joint project funded by QDPI and GRDC. Its aim is to provide group resources that will assist growers achieve potential production and profit through the development of Best Practice Management technologies at the individual paddock level. To achieve this, growers must be in a position to define their resource base and identify improved practices with the potential to maximise the sustainable profits of each crop and crop rotation sequence.

By benchmarking key soil, agronomic and economic indicators growers are encouraged to develop beyond the application of simple regional, or local district recipes, and develop an understanding of individual practices which are enhancing or constraining the production and profits of each paddock and each farm.

TOPCROP is therefore not just about monitoring. If a grower is to be in a sound position to analyse past crop performance and develop improved practices for future cropping seasons, key data sets are needed for those management practices of interest to each grower and/or to the group. Monitoring and benchmarking must have a purpose. The challenge for TOPCROP is to provide group resources and a process that will assist create the incentive for growers to develop best practice technology for each paddock on their farms.

Importantly we see TOPCROP as one of a number of activities being conducted by an active, *grower owned* and run group. Each group determines the issues they want to investigate and develop through on-farm activities. TOPCROP activities should be seen as complementary to other group activities such as PMP, On-Farm Research and FB2000.

TOPCROP assists groups by providing:

Crop Monitoring Support with a range of crop monitoring CheckCards and Best Management Sheets to simplify the monitoring of key management practices over time:

Software package which compiles group data and provides each grower with a season report and also provides intra and inter group comparative analyses

Technical Support assists group members identify those practices which enhanced or constrained profits and develop on-farm testing of likely improved agronomic practices.

APSRU modelling provides support for pre-season 'what-if' analyses and post harvest benchmarking against calibrated model output.

Group funding support:

- TOPCROP Queensland can provide up to $1500 per group to assist cover the cost of crop monitoring and on -farm testing of likely improved agronomic practices.
- TOPCROP group activities can qualify for QRAA funding under the Rural Adjustment Scheme, Group Training for the Acquisition of Skills and Professional Advice (Group Training). Group consulting and operating costs can qualify for a 75 per cent subsidy.

Link to Agribusiness and public and private research and development projects

Future development of extension materials and group module training activities on key issues identified by groups.

Research Opportunities

1. To collaborate with specialist cropping industries, both dryland and irrigated, to develop a set of integrated resources. For example, this would build on the resources being developed by TCQ and COTT~CHECK being developed by James Quinn, Moree.
2. The development of coordinated Best Management Practice Modules to support groups address identified constraints to production and profits at the individual paddock level on their own farms.

OVERVIEW

Grains and Cotton Synergy: a GRDC Overview

Norm Marran
Chairman – Northern Panel, GRDC

From the GRDC standpoint, the joint seminar was a resounding success, in part due to the very well organised and managed program.

The topic areas that were the subject of the seminar (such as pests, weeds and diseases) were those which were considered by a joint GRDC/CRDC steering committee to be of most value to cotton and grain growers.

The program was essentially Cotton RDC driven and consequently Grains RDC probably derived more from the seminar than did cotton people – certainly GRDC participants came away with a good understanding of Cotton RDC research aims, priorities and current activities.

As I pointed out in my summation at the conclusion of the seminar, the overriding message from virtually every segment of the program was the similarity of problems faced by both cotton and grain growers in the Northern cropping region. Had Horticulture RDC been a participant it is likely that they would also have been struck with the similarity of a number of mutual research problems.

Where do we go from here and how can we achieve better research cooperation and coordination between the two research corporations?

As indicated above, it is perfectly apparent that a great deal of research (cotton or grains) is generic. Speakers at the seminar, whether on pests, weeds, diseases, soils, cropping systems or spray techniques, confirm this fact. It seems therefore obvious that there should be much more joint research conducted by Cotton and Grains RDC.

Following the seminar, the GRDC/CRDC steering committee met to discuss future developments. A series of working committees were established to determine :

- Research now being conducted by one corporation which could (or should) be extended to the other
- Priorities in that sub–program of both organisations
- Based on the above, research which should (or could) be conducted jointly in future years

The question of future funding of research is not the issue at this stage. I believe that will sort itself out quite logically once agreement is reached on research priorities and projects.

In conjunction with the above seminar and the 'working committees' set up thereafter, representatives of Cotton RDC were invited to discuss these issues with the Northern Panel of GRDC at its October 1998 meeting. It may also be useful for GRDC Northern Panel to attend a Cotton RDC meeting at some future date.

GRDC Northern Panel embarked on a major research initiative in recent years which is now coming to fruition. I refer to our heavy investment in long term farming systems research for the sub–regions of Western NSW/Queensland, Central Queensland and Eastern NSW/Queensland. GRDC investment in these programs exceeds $2 million per annum.

In my view, these programs will not reach their full potential until such time as they incorporate the other major summer crop – cotton – within their rotation research. The benefits must surely be both obvious and extensive for both present and future grain and cotton growers in the northern cropping region and is perhaps the best possible example of, and reason for, closer research work between Grains and Cotton.

Cotton and Grains Synergy: a CRDC Overview

Ralph Schulzé
Executive Director, CRDC

The seminar highlighted the interrelationship and interdependency of cotton growing, grain production and 'whole of farm' management. This reflected the reality that an increasing number of farmers, dryland and irrigation, produce both commodities. That trend has continued this spring, making the seminar highly relevant.

Possibly the strongest message coming from the seminar was that individual farmers who grow both cotton and grain crops are searching for answers to apply to their whole farms – not separately to each crop.

CRDC and GRDC are funding considerable research with crossover benefits that could be regarded as 'generic'. It is wrong to assume that this leads to duplication in isolation; in fact, the knowledge of what 'other' researchers are doing was quite evident at the seminar. This is probably as a result of the employing institutions, such as the CSIRO or the Queensland Farming Systems Institute, playing an effective cross-communications role; however it was also evident that GRDC and CRDC could individually and collectively play a more effective role in this field.

The seminar and, in particular, the steering committee which followed, identified some common problems, some common concerns and some common opportunities. The question is how we address these issues.

The working committees established to bring collective expertise to each issue should assist in two ways. Firstly, just by virtue of their operations, cross communication should be improved and secondly, the definition of shared problems and the development of proposals to address them should be of great value to both CRDC and GRDC.

Each problem and each issue will be different, so there is no common formula to follow. In appraising these problems, CRDC and GRDC must remember that there are other significant players out there – state government departments, Cooperative Research Centres, federal agencies, universities and so on – each with its own funds and its own agenda.

The management options include:

1. Joint Projects with agreed joint funding

a) **With GRDC:** an example of a full GRDC/CRDC joint project could be support for CSIROSCARM in strengthening such things as a national plant genetics resource centre or the National Insect Collection.

b) **With other R&D Corporations and research institutions:** an example in this category could be "Bioremediation of agricultural chemical contamination".

c) **In concert with government:** for example, the development of a national strategy regarding biotechnology and intellectual property.

2. A Coordinated Program with individual participants undertaking and/or funding agreed components

This management option is the most transparent and accountable. An example is the current Heliothis area management program, involving GRDC's Northern Panel and CRDC.

This type of work could extend to other common pests and to common problems such as pesticide application. Minimising tillage/crop rotation work is also well suited to coordinated programs.

3. Individually funded separate projects with no coordination apart from a commitment to cross communicate and to adjust projects as necessary

Some research could lose its focus if we attempted to broaden or complicate it too much: for example, the cotton industry's Best Management Practice and grains' Quality Assurance. Here, communication and the exchange of information is essential; however, trying to blend all this work into a joint or coordinated program would be daunting and probably counter productive.

Finally, communication is certainly the key and both CRDC and the GRDC Northern Panel must follow up on the outcomes of the seminar. To test our progress we should both commit to a similar follow up seminar – possibly expanded to include more farmers – in less than two years' time.

OTHER CONTRIBUTIONS

Sustainability of Cotton Soils

Nilantha Hullugalle
Soil Scientist, NSW Agriculture and CRC for Sustainable Cotton Production

Research Highlights/Summary

Continuous Cotton is Most Profitable

- Yields are decreasing
- Disease intensity high
- Soil compaction is common in irrigated soils; can be managed by appropriate tillage systems and their timing and by good traffic management
- Least resilience to drought
- Uptake of potassium reduced in some sites

Compared with Legumes, Wheat is a better rotation crop due to:

- Higher profitability
- Quicker amelioration of soil compaction and better stability
- Better nutrient uptake by following cotton crop
- Ease of management
- Biodiversity (Ants and Collembola)
- Better soil structure (pore continuity, porosity) and water extraction better
- Better soil fertility (organic C, ESP)

Addition of N fertiliser to Wheat has Major Benefits in Sites with Higher Organic C.

- Re. above points
- Breakdown of cotton stubble
- High grain protein content
- Drying/cracking of soil profile
- Higher soil faunal numbers
- Higher gross margins compared to unfertilised wheat

Some Points Regarding Leguminous Rotation Crops

- High levels of N fixed
- Increases in exchangeable K (generally in sites where kaolinite is present in significant amounts)
- Lower profits compared with wheat ($700-2000/ ha./ 2 cycles)
- Significant management constraints (including marketing)
- Aggregate stability and aggregate porosity improved
- Allelopathic effects on cotton .
- Susceptible to salinity (ECe $\geq$ I dS/m)

General Trends in Soil Quality

- Organic C is declining in irrigated CRC sites but has stabilised in other irrigated sites
- In the short-term, soil quality is dominated by tillage and traffic management
- Generally, in irrigated sites soil quality under continuous cotton is poorer than that under rotation cropping. This does not hold true in dryland sites
- Although sub-soil structure in all cropping systems had improved or stabilised in all CRC sites, significant deterioration occurred at Warren in 1997 due, we believe, to pupae-busting over a wet subsoil.

Research on VAM

Dr P. A. McGee
School of Biological Sciences, University of Sydney

Over the past 5 years we researched VAM fungi at the University of Sydney using laboratory-based systems, with the field-based research being completed by Steve Allen and David Nehl at the Australian Cotton Research Institute. This report concentrates on our results, and the overall collaboration will be presented by David Nehl at the seminar.

VAM are mutually beneficial associations between some fungi in soil and the roots of most crops, excluding brassicas such as Canola. The association is obligate for the fungi; they eventually die in the absence of a host plant. We have found a range of species of VAM fungi throughout the region (Warren to Emerald), with three being common.

Each fungal species influences growth of cotton in different ways. The fungi also appear to have different survival mechanisms. In normal soils at the end of the cotton season, we found huge populations of VAM fungi (more than 1000 survival units or propagules per gram of soil). Maximum colonisation of roots can be achieved by 100 propagules. The population declines extremely rapidly with depth, less than 0. 1 propagules per gram at 50cm. We do not know what occurs under other crops.

VAM form rapidly in roots of cotton. VAM may be initiated anywhere in the root system and the fungi spread to the rest of the root system of cotton within 8 to 12 weeks. VAM cause the roots of cotton to proliferate at the point VAM are formed. However, we also know that VAM fungi will only spread beyond the root into soil in the top 30cm. Reasons for lack of soil colonisation lower in the profile are unclear.

Lack of soil colonisation down the soil profile has serious implications for long fallows when host plants are absent. We found that long fallow disorder (LFD) was probably induced by germination of the fungi after falls of rain in the absence of host plants. Surface soils, where VAM fungi are most common, were most affected. Cultivation also reduces the fungal population. Cotton recovers rapidly from LFD.

The questions remaining include the following:

1) Crop rotation: How rapidly do VAM fungi recover under different crops? We know what happens with cotton, but not with other crops. Comparative studies in the field to examine crop yields, and the lab to determine the population of VAM fungi are needed. Densities of the fungi and the nature of the fungal propagules, in the profile, must also be considered.

2) Why is LFD more common in heavy soils? From early results from our lab, we suggest examination of soil anoxia as it relates to texture, irrigation or flooding release of manganese, and VAM function. VAM fungi must have oxygen to function and cotton does not appear to provide sufficient oxygen. Other crops may have greater transport of oxygen, and comparative rates of function under anoxia will indicate which crops are better suited to heavy clay soils to maintain VAM. If important, the role of organic matter in increasing growth and survival of the VAM fungi should be considered.

The suggested research aims to clarify the changes in VAM fungi associated with normal cropping practice, to enable better management decisions to be made.

A framework to monitor sustainability in the grains/cotton industry

R. C. Dalal et al
Farming Systems Institute, Toowoomba, and Resource Sciences Centre, Brisbane

A framework is proposed to benchmark and monitor resources in the grains/cotton industry. The primary objective of this framework is for growers to develop and practice profitable and sustainable farming within an Environmental Management System (EMS), using ISO 14000 series. The steps required to achieve this objective are:

- identify local/catchment/regional issues by creating economic and environmental awareness and highlighting farm and community benefits;
- structure the issues in biophysical, farm, community and institutional context through community and stakeholder consultation;
- identify indicators (measurable attributes, properties or characteristics) through consultation with stakeholders, experts and community members;
- derive sustainability indicators of:
  (a) crop productivity;
  (b) resource maintenance;
  (c) biodiversity;
  (d) economic viability;
  (e) community viability; and
  (f) institutional structure.
- use selection criteria with a multi criteria methodology so that stakeholders can evaluate the appropriateness of the various sustainability indicators. The selection criteria address issues of: responsiveness to change; ease of capture; community acceptance and involvement; interpretation; measurement error; stability, frequency and cost of measurement; spatial scale issues; and mappability in space and time;
- involve stakeholders and the community in selection and definition of benchmarking and monitoring targets and goals for sustainable farming;
- take remedial action as required by stakeholders;
- assess and evaluate adoption and effectiveness of environmental management framework; and
- revise indicators and adopt a continual improvement principle to achieve profitable and sustainable farming systems.

The major recommendations include:

Implement the framework for the resources benchmarking and monitoring which integrate with the current activities so that awareness, evolution and implementation of sustainable resource management practices become the norm in the grains/cotton industry.

Empower the grains/cotton industry to take the lead on benchmarking and monitoring the resources, using sustainability indicators, which are relevant to grains/cotton growers. Long term trials such as Warra Cotton Trial and *soon to be closed down* Warra Farming Systems Trial provide an irrefutable benchmarking resource for validating and evaluating sustainability indicators.

Adopt a collaborative approach integrating various industry, community, government and grower groups. Skills and resources be utilised to minimise implementation time.

Promote the awareness and utility of multiobjective decision support systems (MO-DSS) as a participatory decision and evaluation process among growers and industry representatives to encourage ownership and adoption.

Examples of suitable monitoring activities include:

- *Sociological processes and evaluation* – link with individual growers, grower groups in the Sustainable Farming Systems program, as well as wider community groups and apply participative decision making processes to select appropriate sustainability indicators and to evaluate their implementation by growers and community groups.
- *Benchmarking and monitoring of resources in the grains industry using sustainability indicators.* A suite of indicators is suggested to benchmark and monitor resources for sustainable farming systems. Selected indicators can be used at the scales of paddock, farm and catchment and among rural community groups and validated and evaluated against long-term managed trials.
- *Identification of Best Management Practice* – based on MO-DSS to optimise a set of sustainability indicators and to identify Best Management Practice in sustainable farming systems for the grains-cotton industry.
- *Knowledge Interchange and Evaluation.* Co-learning, and joint participation by stakeholders are the salient features of the resource benchmarking and monitoring project. The evaluation of monitoring the sustainability of farming systems and community follows the EMS model (policy, planning, implementation, measurement and evaluation, review and continual improvement). This way, stakeholders are directly and continually evaluating the activities of the program.

Analytical Chemistry Capabilities at the Leslie Research Centre, Toowoomba

Dr John Standley and team

Leslie Research Centre, Farming Systems Institute, Queensland Department of Primary Industries

Staff of the Analytical Chemistry Section continue to provide vital soil and plant analyses for research projects. Since the Queensland Wheat Research Institute was established in 1962, industry has continued to support the development of the analytical laboratories, most recently with GRDC funds. Of the 41 projects from central and southern Queensland with samples for analysis, 30 have been GRDC projects in 1997/98. Indeed, the laboratories could be considered as a GRDC facility.

A key to the success of the Section has been the close personal collaboration between laboratory staff and project members. In 1997, 22,546 samples were received for analysis and 36,566 results were reported. All analyses have received accreditation through participation in the recent National Soil and Plant Quality Assurance Programmes organised by the Australian Soil and Plant Analysis Council. Emphasis on rapid return of analyses to project staff continues.

Equipment

Four segmented flow autoanalysis systems now operate. A new automated atomic absorption spectrophotometer system for trace element analyses of soils extracts and plant digests has been installed recently. Other equipment includes a spectrophotometer, autotitrator, pH and electrical conductivity meters.

Routine analytical capabilities

Plants: total nitrogen (N), phosphorous (P) and trace elements zinc (Zn), copper (Cu), iron (Fe) and manganese (Mn).

Soils: pH, electrical conductivity, chloride, nitrate, ammonium and total nitrogen, organic carbon, bicarbonate and acid extractable phosphorous, DTPA extractable Zn, Cu, Fe and Mn, particle size analysis; waterlogged mineral N and microbial biomass measurements with Dr Dalal's group.

New initiative - pesticide facility

To meet regional environmental demands for analyses for insecticides, herbicides and fungicides in soils, sediments, waters and plants, a Hewlett Packard gas chromatograph/mass spectrometer system has been installed recently. This both analyses and unambiguously identifies the pesticides. Method verification is proceeding. Staff are keen to become involved in new projects requiring this analytical capability.

Staff and contacts

The analytical team comprises Dr John Standley, Principal Chemist; Kelvin Spann, Senior Laboratory Technician; John Hagedoorn, Laboratory Technician, and Scientific Assistants Ainslie Pumfrey, Jo Wiedmann and Maria Harris. Contact them at the Leslie Research Centre, P.O. Box 2282, Toowoomba, Qld 4350, phone 07 4639 8888 or by email standlj(@dpi.qld.gov.au, spannk@dpi.qld.gov au and hagedoi(@dpi.gld.jzov.au. They are keen to become involved in new projects.

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